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SCANBACK ANTENNA CONTROL FOR RE-ENTRY PHYSICS PROGRAM

A. H. Flink

[redacted] (Publications Office).

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LEXINGTON MASSACHUSETTS

ABSTRACT

This report describes the scanback subsystem installed at the MIT Arbuckle Neck Site. The machine is capable of storing 1500 points in range, azimuth and elevation, permitting the antenna to be repositioned along a previously traversed path.

Accepted for the Air Force
Franklin C. Hudson
Chief, Lincoln Laboratory Office

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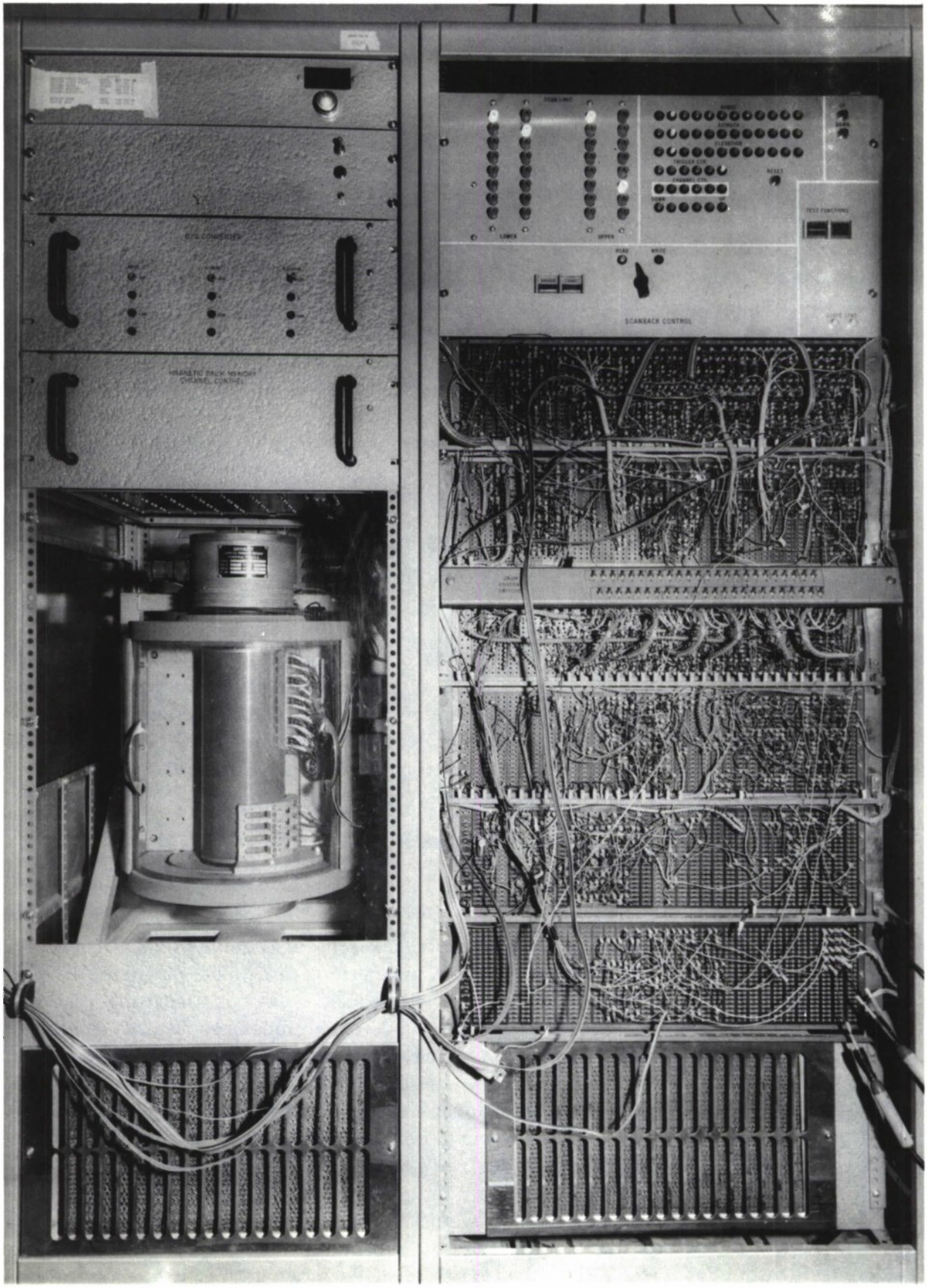


Figure 1 Scanback System

I. INTRODUCTION

A. Requirements

One of the requirements of the Reentry Physics Program is to re-examine the track of the reentry body after the body has passed through the atmosphere in order to make observations on any residual ionization. This requirement calls for some means of repositioning the radar antenna through the final stage of the trajectory. The requirements for this repositioning or scanback function are as follows:

1. Points along the trajectory are defined by range, azimuth, and elevation; individual points must be sufficiently close together to permit smooth operation in each of the servo systems.

2. The total delay in switching from the function of tracking the reentry body to the repositioning function must be minimized. This is necessary because of the expected rapid decay of the ionization.

3. The control of such a repositioning function must be such that an operator can examine any portion of the trajectory in which the collected and observed data shall warrant sufficient interest.

The scanback system performs the functions described above with a device capable of storing enough points in azimuth, elevation, and range to accurately control the radar antenna. The significant time of flight occurs between apogee and splash or burnup. Fifteen hundred points collected at the rate of ten per second is sufficient to accurately and smoothly reposition the antenna through this portion of the trajectory. A photograph of the scanback equipment is shown in Figure 1.

B. General Description

1. System Operation

During a firing of a rocket the scanback system receives data from the primary recording system and stores it on a magnetic drum. The data is collected and stored at a rate of 10 points per second where each point contains range, azimuth and elevation information. A block of 150 seconds of the most recent data is stored on the drum. At the end of the active tracking, a command is given to the scanback equipment to reposition the antenna along a selected portion of the stored trajectory. When this command is received, the scanback equipment compares present antenna position data with stored position data and generates a servo error voltage with its sign which directs the antenna to the desired position.

A provision has been made for selecting certain portions of the stored trajectory data. Scan limits can be selected corresponding to a block of any one or more sequential drum channels. This selection is made with two sets of push-button

switches (upper and lower). This corresponds to the earlier and later portion of a recorded trajectory.

The scanback equipment also delivers an output for use by the teletype (TTY) equipment. This output has two modes of operation. One is real time operation in which the primary data is made available to the TTY equipment with only minor buffering functions performed by scanback. The other mode is a non real time operation in which the entire contents of the drum is delivered to the TTY equipment at the rate required. This is called the "Drum Dump" mode and requires about fifty times as long to read out the data as it took to collect it.

Test circuits have been incorporated to enable the drum to be loaded with any configuration of words desired and then to select any word or group of words for constant output signals.

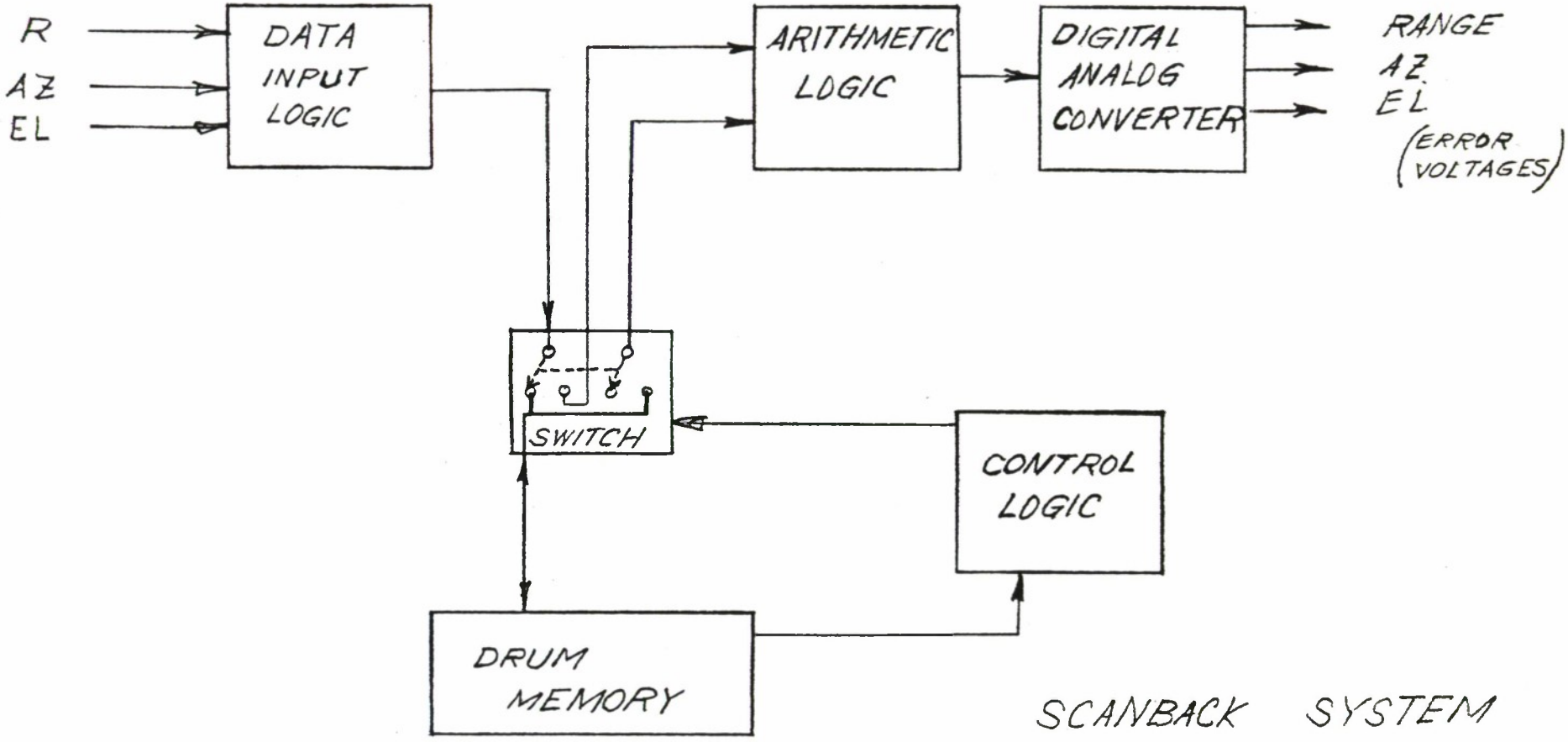
2. Brief Description of Major Sections of Scanback Equipment (Figure 2)

a. Data Input Logic

The primary recording system, described in another report (21G-0006), samples range, azimuth, and elevation shaft encoders at a rate of forty times per second. The data input logic accepts only every fourth data sample, providing the scanback system with words at the rate of ten per second. (A word is defined as forty-eight bits, sixteen eachof range, azimuth, and elevation). The shaft position data is received from the primary recording system, high-order bit first. It is necessary to invert the order of bits to low-order bit first for serial subtraction in the scanback arithmetic logic. This inversion is done in the data input logic section.

b. Memory

A magnetic drum memory was chosen as the most efficient storage device for this application. Magnetic tape storage was rejected because of access time; core storage was rejected because of cost. The requirements of the system are such that the read and write function are independent and need not occur simultaneously. The drum capacity is fifteen hundred words arranged in groups of twenty-five words per channel with a total of sixty channels. Data is recorded sequentially starting with word one, channel one, progressing upward to channel 60. Upon completion of word 25, channel 60, the next word is written on channel one, word one, and the process repeated. Each time a word is written on the drum, the new word replaces anything which may have been written previously. In order to collect the last fifteen hundred points between apogee and end of track, the recording may be started anytime before or slightly after T = 0 and stopped at end of track. The required information will be recorded on the drum.



SCANBACK SYSTEM

GENERAL BLOCK DIAGRAM

FIGURE 2

c. Control

In the write mode of operation, data from the input logic is written onto the drum. In the read mode, data read from the drum is compared with data from the input logic in the arithmetic unit. The control of scan limits and various other modes of the scanback system operation function through the control logic.

d. Arithmetic Unit

When the write function is stopped and read/write switch is placed in the read position, both present and recorded position data are presented to the arithmetic logic. The present encoder-defined position data is subtracted from the drum data, and the difference represents a position error.

e. Output Unit

The arithmetic unit delivers a binary word corresponding to a position error with sign, to the output unit. A ladder network is used in the output unit to perform a digital to analog conversion. The limits on the error voltage are set by three adjustable regulated power supplies.

II. BASIC CIRCUITS AND NOMENCLATURE

A. Basic Circuits

The following abbreviations for the basic circuits will be used in referring to all subsequent system description and diagrams:

FF	Flip Flop
ZB	Zener Buffer
MV	One Shot Multivibrator
SB	Slicer Buffer
PS	Pulse Shaper
N/N'B	Buffer and Inverter Combination
R/A	Read Amplifier
OSC	Oscillator
BF	Bessel Filter
TF	Timing Filter
MTX	Diode Matrix
CD	Clock Driver

Schematic diagrams of these units are included in the Appendix.

B. Unit Definition and Nomenclature

1. The physical location of a basic unit in the scanback equipment is defined in terms of the subrack (a letter) and its position in the subrack (a number). Thus "C3" represents a unit in the "C" subrack in position 3 counting from left to right.

2. The type of unit is denoted by the abbreviations listed in section A above.

3. Some printed circuit boards have two or more identical units per board. Thus a block diagram may list two flip flops with the same location. The terminal numbers associated with input-output connections in this case indicates which flip flop is referred to.

4. A group of flip flops connected as a counter or shift register is sometimes designated with a single letter to aid in written descriptions. Thus a counter might be called the "K" counter with K_1, K_2, K_3 indicating individual flip flops. K_1 would be the least significant bit (LSB). In some cases other individual units are given unique letter designations to aid in referencing.

5. The interconnecting points between block diagrams are indicated by a small rectangle surrounding the unit and terminal designation.

6. A diode matrix is shown on block diagrams as a triangle with a dot ("and" matrix) or a triangle with a plus ("or" matrix).

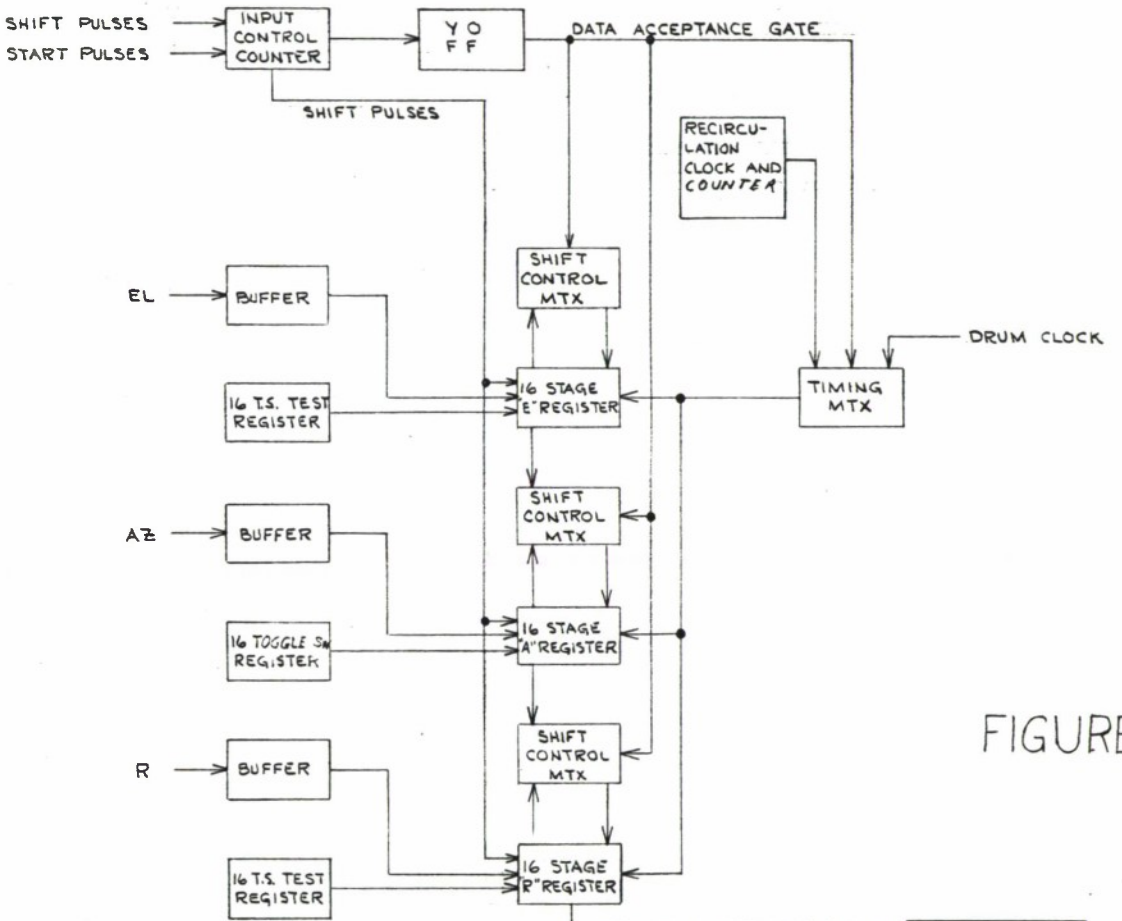


FIGURE - 3

CHANGE LETTER	D'W'R BY	APP'D BY	DATE	CHANGES

REQ. NO.

SHOP NOTES

UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCES ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
30° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR P.J. HARRIS
DRAWN BY C.M. DICKEY
CHECKED BY
APPROVED BY
APPROVED BY
DATE OCT. 5, 1960
SCALE NONE

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BLOCK DIAGRAM
DATA INPUT LOGIC

FILE 61 | CHANGE / | DWG. NO. B- -

III. DATA INPUT LOGIC

A. General Functions

The Baldwin encoders in the primary recording system are sampled at the rate of 40/second. However, as the scanback system requires only 10 points a second, the start pulses are counted down to obtain a lower data rate. The primary recording system shifts out data bits with the high order bit first. In order to perform the scanback digital servo function, the desired antenna position must be subtracted from the "present" antenna position. This is accomplished through a serial subtraction which necessitates the inversion of the incoming data bits so that the low order bit will be shifted out first.

Figure 3 is a functional block diagram showing the major elements of the data input logic. The shift and start pulses received from the primary recording system are counted down in the "Input Control Counter" to produce an input Control Timing Signal. This signal allows words at 10 per second to be inserted into the respective 16-stage shift registers. The "Y_o" flip flop is shown in several other block diagrams and it is shown here for reference. The number of stages in the input control counter can be changed easily, thus permitting a variety of read in rates to the scanback system.

Range, azimuth and elevation signals are received from the primary recording system as a set of serial binary numbers. These signals are buffered and then provide one of the inputs to the 16-stage shift registers.

To re-order the bit sequence of the incoming word, a high-speed clock and counter is provided. This is called the Recirculation Clock Generator and Counter. Each data bit that is received is recirculated in the appropriate shift register to reverse the bit order. At the end of this set of operations the three 16-stage shift registers are connected serially through the shift control matricies to form a 48-bit register containing properly-ordered range, azimuth and elevation numbers.

Three asynchronous timing signals are present in the scanback system - input word timing, high-speed recirculation timing, and drum timing. These are distributed in proper logical order to the input elements by the timing matrix.

A set of toggle switch test registers is provided as another input to the 16-stage shift registers. Any word configuration can be read into the scanback system by appropriate settings of these switch registers to provide for system testing.

During the write (recording) mode of operation the output of the 48-bit shift register is fed to the drum. During the read (playback) mode of operation the output is connected to the arithmetic unit.

B. Inputs from Primary Recording System

1. Start signal. This is a square wave with a period of 25 milliseconds which represents the sampling period of the shaft encoders.

2. Shift pulses. This signal is a train of 23 pulses at an 8.2 Kc frequency which start with the falling edge of the start signal.

3. Azimuth data. This is a logic voltage with the +5 volt level representing "ones" and the -5 volt level representing "zeros". The level changes are in phase with the shift pulses which are used as clock pulses. There is a set of 16 "ones" and "zeros" represented by this signal which defines the instantaneous value of this parameter.

4. Elevation data. Same as azimuth.

5. Range data. Same as azimuth.

C. Input Control Element

The input control element is shown in Figure 1A and consists of two counters and associated phasing elements. A four-stage "S" counter counts shift pulses to define a 16-bit word interval and another four-stage counter counts down the start signal to control the rate at which words are read into the scanback system. At the rate of ten words per second, only two of the stages of this counter are used. Rates of 5 and 2.5 words per second can be obtained by using successive stages of the counter. Timing diagrams in Figures 2A and 3A show the signal relationships in these counters. The principle output of this input control element is the Y_0 flip flop which defines the sixteen shift pulses and indicates that data has been received and properly assembled.

D. Recirculation Clock Generator and Counter

The recirculation clock generator and counter are shown in Figure 4A. The clock generator is a 160 Kc gated oscillator. A four-stage parallel "G" counter gates off the oscillator at count fifteen so that fifteen high-speed shift pulses are produced for each input shift pulse.

E. Input Shift Register

The input shift register is a 48-stage flip flop register which consists of three groups corresponding to elevation, azimuth, and range. (Figures 5A, 6A, 7A) E_{16} through E_1, and A_{16} through A_1, and R_{16} through R_1. Data is read into the register through the reset terminals. There are two modes of operation. In the operate mode the input receives data from the primary recording system. In the Test mode the input receives data from a 48-bit toggle switch register which is described in a later section of this report.

In the Operate mode the input shift register initially is divided into three registers corresponding to elevation, azimuth and range numbers. (Figures 5A, 6A, 7A), and each register is recirculated in order to reverse the bit sequence of the incoming word. Figure 8A shows the general operation of the recirculation function. When the input data has been recirculated and assembled as determined by the Y_o flip flop, the register inputs and outputs are connected as a single 48-bit shift register by the shift control matrices.

F. Timing Matrix

During the initial "3 register mode" of the input shift register, as determined by Y_o, the timing matrix admits the high speed shift pulses as the basic clock. After recirculation of the bits has been completed, the timing matrix transfers the drum timing as the shift register clock in accordance with the state of the Y_o flip flop. Thus the final operation of the shift register is to shift the 48-bit composite word onto the drum in write mode or into the arithmetic unit in the read mode.

IV. MEMORY

A. General

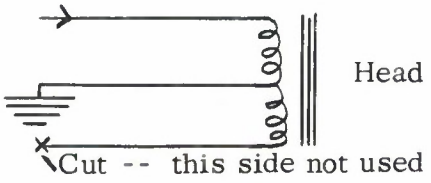
The scanback memory is considered here to consist of the drum, channel selector switch, read-write amplifiers, and read-write switch. The general functions of the memory are as follows: data words from the data input logic are distributed in proper sequence to the drum channels where they are written on the drum surface in a suitable format. Upon command from the control element, the data on the drum are distributed through the channel selector switch to the read amplifier and then to the arithmetic element. In addition to these functions, the memory provides a source of control timing for the system in the form of synchronous sync and clock pulses. A functional block diagram of the memory is shown in Figure 4.

B. Magnetic Drum Specifications

Type:	512A - Bryant Chucking and Grinding Company Computer Products Division Springfield, Vermont
Diameter:	5" (inches)
Length:	12 1/4"
RPM:	3600
Coating:	Ground Magnetic Oxide (.001-0015)"
Runout:	.0001 T.I.R. Maximum
Mounting:	Vertical
Bit Capacity:	240 tracks, approximately 625,000 bits
Weight:	115 pounds

Read/write heads have 150 turns. However, only 75 turns are used with one side grounded:

i.e.:



One head is used per track since read and write functions do not occur simultaneously.

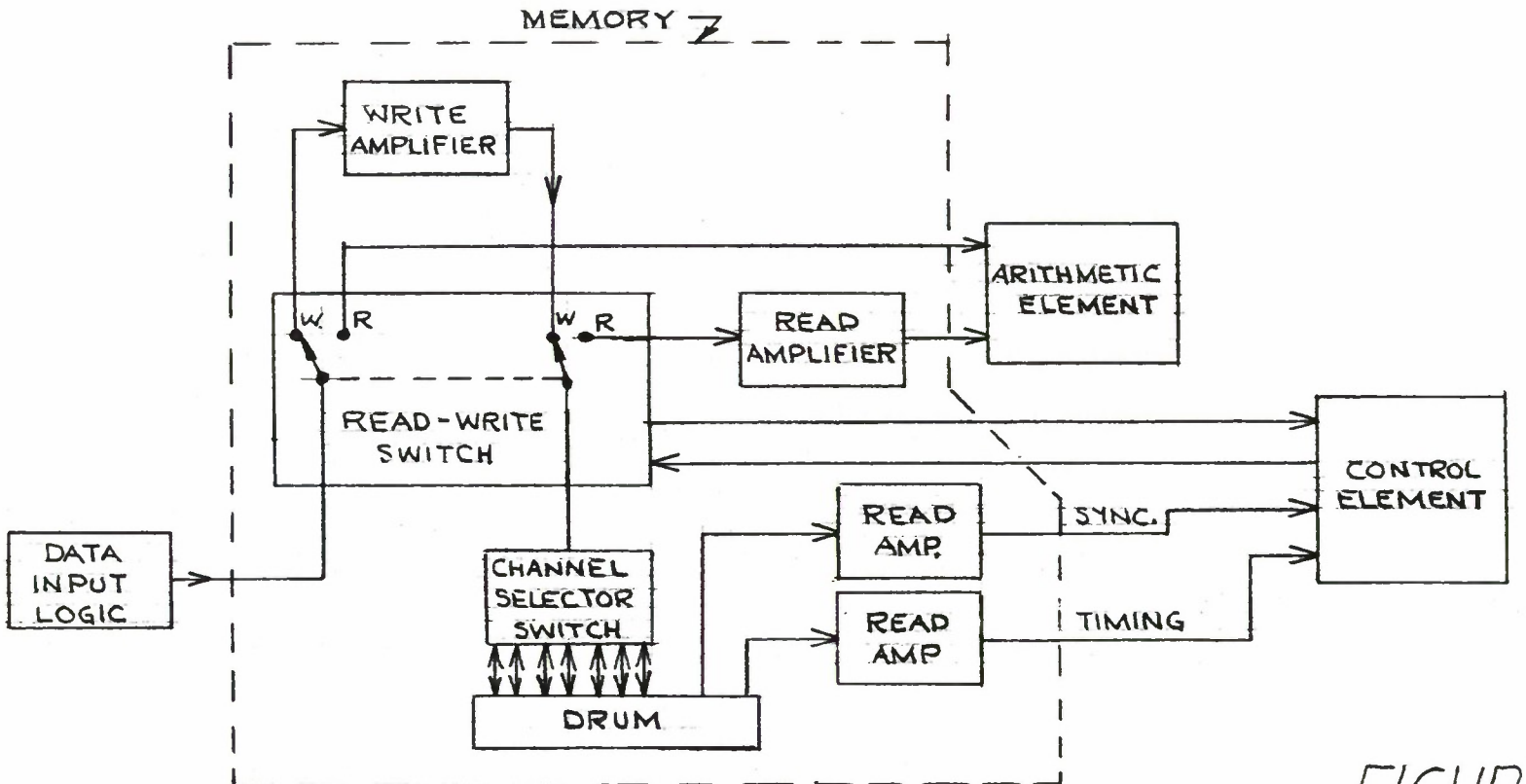


FIGURE - 4

REQ. No.

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES

SHOP NOTES

UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
   FRACTIONAL ± 1/64"
   DECIMAL ± .005
   ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
   30° CHAMFER ENDS
   1½ PITCH THD. RELIEF

DRAWN FOR	P.J. HARRIS
DRAWN BY	C.M. DICKEY
CHECKED BY	
APPROVED BY	
APPROVED BY	
DATE	OCT. 4, 1960
SCALE	NONE

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LEXINGTON, MASS.

Functional Block Diagram of Memory

FILE	CHANGE	DWG. NO.
21	/	A- -

Note: The head-to-drum gap was pre-set by the manufacturer and under no circumstances should any attempt be made to tamper with the gap settings. If a failure makes it necessary to replace a head, only a person thoroughly familiar with the manufacturer's procedures and tools should attempt to re-adjust the head-to-surface gap.

C. Channel Selector Switch

A sequential recording method is used for its simplicity and flexibility. A set of sixty mercury-wetted relays in a "relay tree" configuration (Figure 11A) allows any channel to be chosen by appropriate control of the relays. This control is easily effected by digital logic techniques, as described in later sections of this report. An expansion of the present drum utilization can be accomplished by adding more heads, relays and associated control logic. The drum has 240 tracks available, of which only 62 are being used.

D. Read-Write Amplifiers

The memory requires three read amplifiers and two write amplifiers. One read and one write amplifier are provided for input data and two read and one write amplifiers are provided for the sync and timing drum channels. The data write amplifier is provided with a gated clock input to provide a drum input signal of the correct shape and size. Figure 13A shows a schematic of the read amplifier and Figure 14A is a schematic of the write amplifier.

E. Read-Write Switch

This switch is a manual 7-pole, two-position switch located in the upper control panel. It is the control for changing from a recording (write) mode to a playback (read) mode. The following is a list of the switched functions.

Input	Write	Read
1 pole - input timing matrix	Drum timing MV(5B1)	Read logic
2 poles - data input shift register	Write amplifier	Arithmetic unit
1 pole - channel selector switch	Write amplifier	Read amplifier
1 pole - +30V	Write indicator light	Read Indicator
		Scan limit lights
1 pole - Up-down counter matrix	+5V	Up-down control FF
1 pole - Up-down counter matrix	-5V	Up-down control FF

A diagram of the read-write switch is shown in Figure 15A.

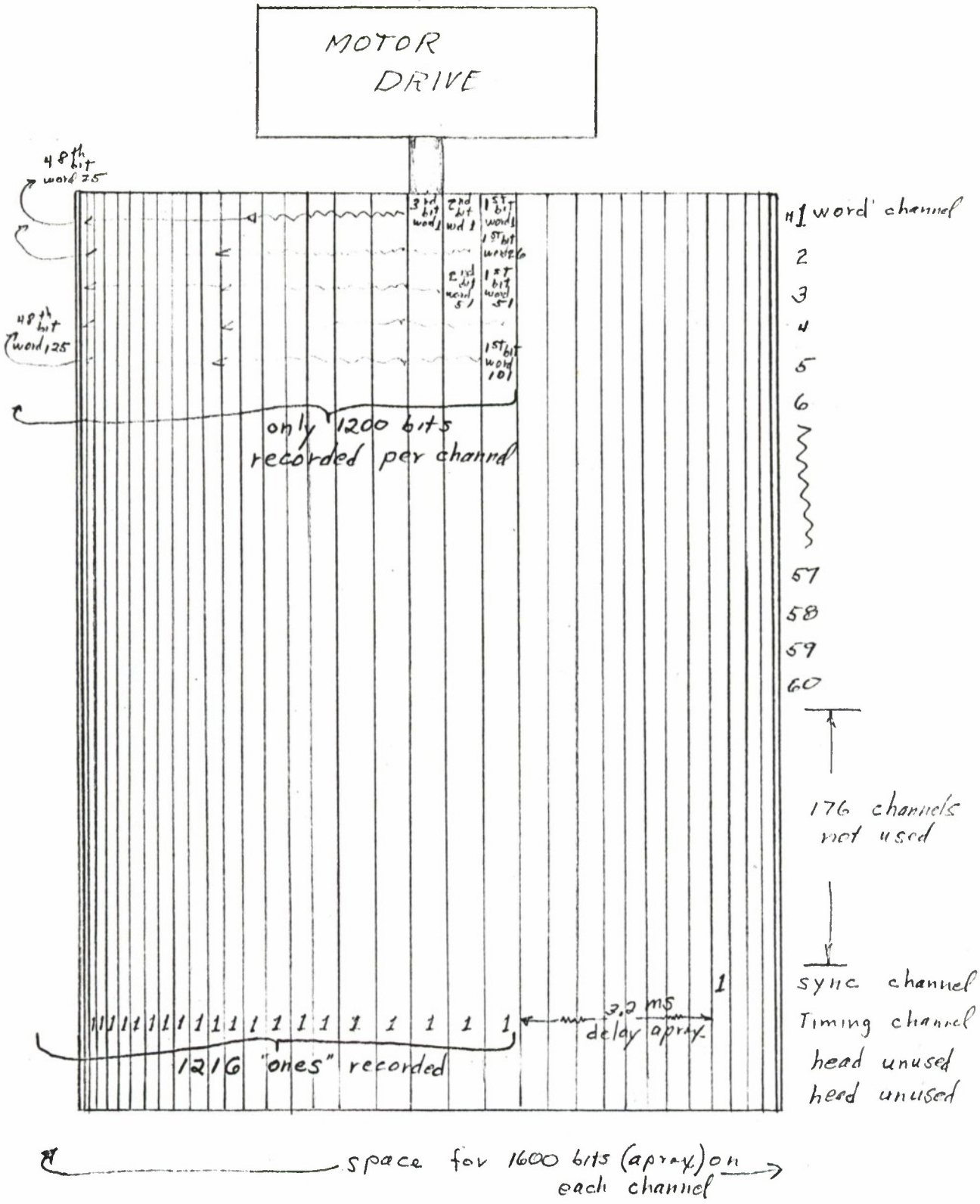

Figure 5 - DRUM DATA FORMAT

F. Drum Data Format

The drum data format is shown in Figure 5. The delay of approximately 3.2 Ms between the sync pulse and the start of the timing pulses provides the necessary time to allow the relay switch to switch drum channels without using any additional delay logic. Data as it is put on and taken off the drum appears as in Figure 6.

G. Sync and Timing Track

A sync pulse and a timing track written on two separate channels provide the basic clock rate of the system. The sync pulse is recorded first; then, using this sync pulse, the proper timing track is recorded. Although in theory this need be done only once, in practice it is necessary to repeat the process in case of accidental channel erasure or other trouble which might cause either or both of these channels to be partially destroyed or damaged. Provision has been made to include permanently into the system the necessary logic needed to write either or both of these channels, at any time. (Sync and timing derivation, block diagram, Fig. 18A)

The method for recording the sync and timing channel is as follows:

Sync Channel: With the drum brought to a complete stop, the sync channel is recorded by simply touching a battery or DC power source briefly across the sync channel head using no more than 120 Ma of current. The drum is then started and brought up to full speed. The output of sync channel read amplifier (A6, Pin 6) must then be examined with an oscilloscope to be sure that only one pulse has been recorded (top line), Figure 6.

If a bad pulse or more than one pulse has been recorded, the channel will require erasing. This can be done by connecting the output of an audio oscillator to the head using about 60 cycles with 120 Ma of output. The amplitude is then slowly decreased to erase the channel, or a magnetic eraser may be used.

Timing Channel: The 100 Kc timing oscillator located at A15 is turned on by a jumper wire from Pin 9 to Pin 10. After a single clean sync pulse has been written onto the drum, the button at unit position 1A is pressed and the timing track is written.

The timing channel logic and timing diagram is shown in Figure 16A. The timing clocks are gated in and are recorded on the timing channel for a part of a drum revolution. Since only 1200 timing bits are required for the 25-words per channel, an eleven-stage counter (J_0 - J_{10}) provides the nearest count of 1216 clocks which are recorded. Flip-flops A_0-A_4 gate in the clock

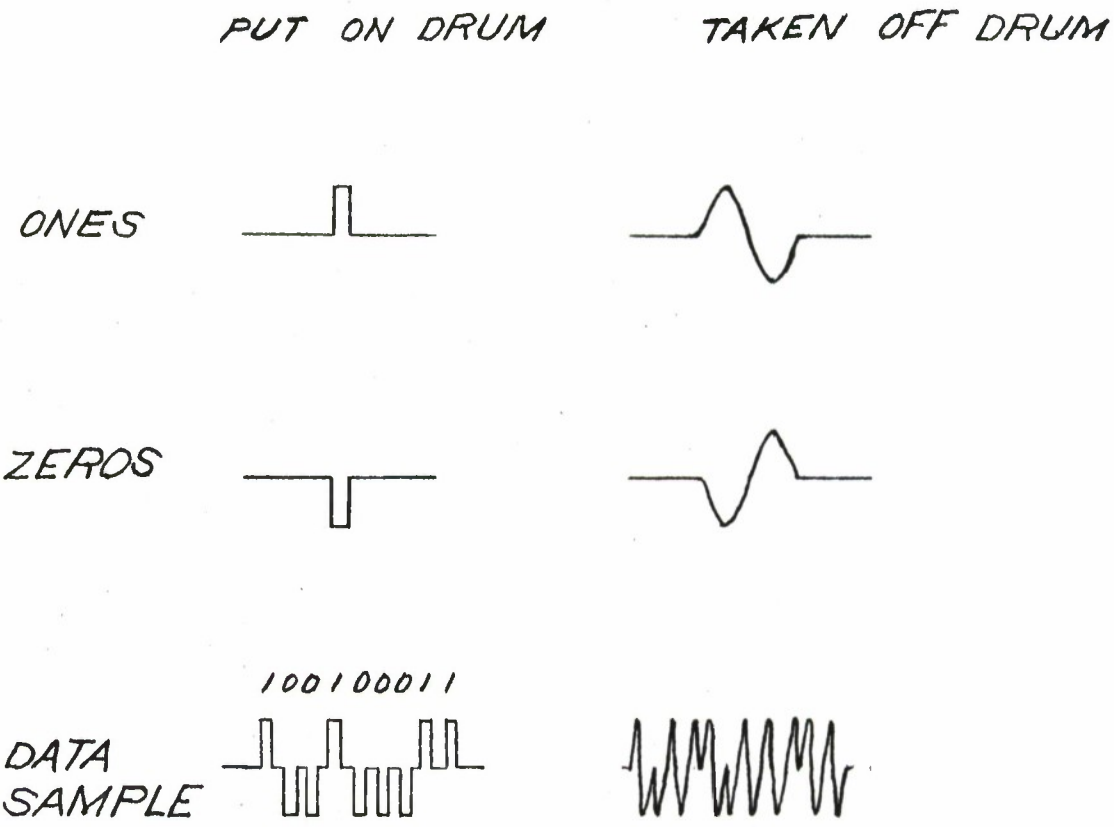

FIGURE 6 - WAVEFORMS

pulses at the count of 320 and closes the gate at count 1536. The 100 Kc timing pulses are fed to the drum recording head through a timing driver. Figure 17A in the Appendix shows the driver schematic.

H. Record and Playback Modes

1. General

The read and write function of scanback is mutually exclusive and is switched by means of a manual switch (Figure 15A). In the write mode the data input is continually stored on the drum. In the read mode the data input register is switched from the drum to arithmetic unit. Figure 20A shows read/write switch logic block diagram.

2. Write Function

In the write mode the write driver (B3) is effectively an extension of the input shift register shifting data onto the drum directly at the 100 Kc shift rate. The proper voltage is substituted for the up-down flip-flop to insure the T counter and C counter count only in the up direction. The 60 relay tree switch is connected to the write driver.

A return to zero (RZ) recording technique is used with a packing density of approximately 1600 bits per channel or 106 bits per inch. A writing frequency of approximately 100 Kc is used.

When data is written on the drum, the write driver samples the data flip flop (located in the data input section). If the data FF is in the "one" state, a two-microsecond wide pulse is gated through the WD to produce a negative pulse of current to the head. The two-microsecond pulse comes from an MV (B5) whose input is timing from the drum.

120 Ma of write current is optimum for writing on drum. Greater current will cause the drum to saturate, reducing the allowable recording frequency and hence the resolution. Head current can be measured approximately by placing a 100-ohm resistor in series with the head and calculating the current by measuring the voltage drop across the resistor using an oscilloscope with a difference amplifier package.

3. Read Function

The drum data is read out through read amplifier into the data flip flop (A27). Timing pulses are delayed to permit sampling near the center of the data as shown in Figure 21A. Timing is properly switched from write to read mode (Figure 22A - Timing Diagram Read/Write Logic.)

V. CONTROL

A. General

The problem is to place the input data word in the right slot on the drum as it rotates. It is first necessary to keep track of word slots on the drum. This is done with two counters which count the words and the separate bit locations on the drum. The second step is to deliver input data words at the proper time to the memory. Data from the primary recording system is arriving and being stored in the input register at the rate of a 48-bit word every 1/10 of a second. During this 1/10 second the drum rotates six times. Another counter keeps track of the incoming data (T counter). When a word is ready for recording, this counter is compared with the counter (W counter) which is keeping track of the position of word slots on the drum. When the numbers match, the next slot in sequence on the drum is under the recording head, and the word is recorded. After twenty-five words have been written on a particular drum channel, it is necessary to switch to a new channel. When a channel is full, a channel counter sends a signal to the relay "tree" which switches to the next available channel.

B. Block Diagram

A functional block diagram of the control element is shown in Figure 7. The "B" counter counts drum timing and delivers an output pulse every 48 bits to define the drum word length. The "W" counter counts the word pulses from the "B" counter and defines the channel length by counting to 25 and then re-setting itself. The "T" counter counts data input word start pulses and thus contains a binary number indicating the number of input data words which have arrived. A comparator matrix connected to the "W" and "T" counters generates a read command when the numbers of the two counters match. This read command determines the proper time for delivering the data word to the drum. Since the "T" counter recycles after 25 words, its output defines the length of the drum channels. A "C" counter counts the drum channels and provides a "relay tree" control function.

The "T" and "C" counters are parallel up-down counters and are both controlled by their associated matrices and an up-down control FF. The "T" matrix causes its counter to recycle after 25 word counts and thus defines a channel length. The "C" matrix causes its counter to recycle after sixty channels have been counted and thus defines the presently available drum storage capacity. In the write mode these counters count up only; however, in the read mode the counters can count in either direction. The direction of counting is determined by the up-down control flip flop. This flip flop is controlled either by the scan limit switches or manual up-down push buttons. There is an upper and a lower scan limit switch which is used to select the channel or set of channels to be read. The control logic is arranged so that upon completion of the channel reading, the sequence of scan will reverse and the same data will be read out in the reverse order. This up-down scanning will

B-

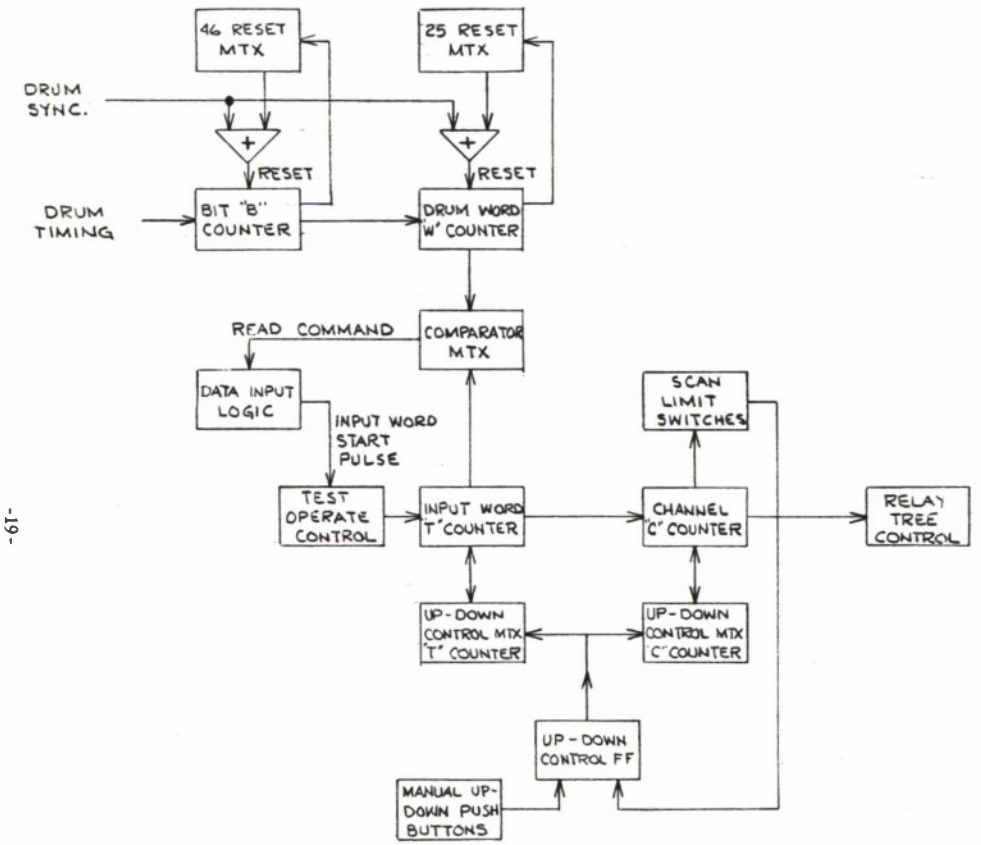

FIGURE 7

CHANGE LETTER	D'W'S BY	APP'D BY	DATE	CHANGES

REQ. NO.

SHOP NOTES

UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
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APPROVED BY
DATE OCT. 4, 1960
SCALE NONE

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FUNCTIONAL BLOCK DIAGRAM of CONTROL ELEMENT

FILE 21 | CHANGE / | DWG. NO. B- -

continue until some over-ride command is given. The test-operate control is used to select the kind and mode of data to be fed to the "T" counter.

C. Drum Clock "B" Counter

A six-stage serial counter is used to count the clock pulses from the drum timing track to provide the basic 48-bit word length. Flip flops B_0 - B_5 in Figure 23A make up this counter. Since a serial counter using falling edge logic may not be reset to zero without generating spurious carry pulses, it is necessary to reset the counter to all "ones" at the end of count 46. The next timing pulse resets the counter to all "ones" at the end of count 46. The next timing pulse resets the counter to zero which is the first count for the next cycle. Figure 24A shows the timing diagram. Sync also resets the "B" counter to "ones" once per channel. Timing begins 3.2 ms after the sync pulse and ends on timing pulse 1216. The timing diagram, Figure 16A, illustrates how the timing pulses originate and are gated in for only a portion of the drum rotation.

D. Drum Word "W" Counter

A five-stage serial counter (W_0-W_4 in Figure 25A) counts the output of "B" counter. The word counter is reset to all "ones". Figure 26A shows outputs from the word counter. The number in the "W" counter indicates which word in the channel is under the heads. The word and bit counters are in continuous operation as long as the drum rotates.

E. Data Input Word "T" Counter and Comparison Matrix

The counter (T_0-T_4 in Figure 27A) is a five-stage, parallel, up-down counter which counts start pulses from the data input logic. The pulses from the input section are generated after a 48-bit word has been assembled in the input registers and are ready for processing. This pulse, occurring at the rate of one every 1/10 second advances the T counter one up or down depending on the up-down control.

The T counter is reset under the following conditions: When counting up and the count reaches 24, the counter resets to zero; when counting down and the count reaches zero, the counter resets to 24; either at the start of a scanback recording or for test purposes, a push button located on the front panel also resets the counter to zero.

The number in the T counter is compared in the matrix to the number in the W counter; when the counters are identical, a gate is generated which is 48 bits long. When this gate occurs, data is recorded on the drum from the shift register or data is read off the drum for further processing. Thus, the W counter identifies the word slots on the drum; the T counter provides the sequence, up or down.

Since the W counter counts its full cycle six times for one complete cycle of the T counter, an inhibit function at position D31 allows only one word gate out of the comparator matrix for each count of the T counter. Sync' inhibits the comparator to prevent a spurious output during sync reset of the W counter.

When data is being placed on the drum, the T counter counts only up providing a sequence of 1500 words; when data is being taken off the drum, the counter may be set to count either direction depending on the scan limits of trajectory to be examined. The T counter counts up or down along with the channel counter. The direction of counting for both of these counters is determined by the up-down control FF.

The Start/Stop FF located at B32 gates off pulses to the T counter. This shuts off the 48 gate and stops data from being recorded or taken off the drum. Since the T counter is tied to the channel counter, the latter also stops along with the relay tree.

F. Test-Operate Control

The scanback system has a built-in facility for completely testing the machine from the input shift register to the output of the ladder netword independent of any external signals. This is accomplished by means of a 48-bit toggle switch register which is used to simulate any desired input word.

In order to use this test function, the Test-Operate switch (on front panel) must be placed in the Test position. In the Test position, the toggle switch register becomes the input source.

On the front panel, under the section labeled Test Function, there are two switches:

1. Auto-Manual (Figure 30A)

In the Auto position a five (5) stage counter is used to count sync pulses. The rate of test writing and reading may be selected by choosing one of these stages as a source pulse input.

The manual position is connected to a push button so that one word, upon command, may be written or read on the drum.

2. Recirculate Push Button (PB)

The purpose of this PB is to disconnect the inhibit gate from the comparator matrix so that the same word from a single channel may be continuously read off the drum. In test operation, a single channel may be selected by means of scan limit switches. The manual PB then may be used to select any given word on a particular channel. The read out of the word can be examined continuously on an oscilloscope.

The up-down switches on the front panel, upper right hand corner, may be used to reverse direction of counting of C counter and T counter at any given time as explained in section on channel counter.

The reset PB resets T counter and C counter to 0. Since ther is no way by which a particular channel or word may be directly selected, it is necessary to use the reset PB and/or the up-down switches in conjunction with the scan limit switches to control the C counter and T counter so that when the desired channel is reached by counting up or down, the channel may be examined in detail.

Example: It is desired to examine channel 44 (Octal)* in detail

1. Stop/Start switch in STOP position
2. Test/Operate in TEST position
3. Reset switch pushed - resetting C and T counters
4. Read/Write in READ position
5. Up switch is depressed
6. Upper scan limit switch set 44
7. Auto/Manual switch in AUTO position

Upon pushing start switch, the channel counter will count at some arbitrary fast rate until channel 44 is reached. Since the upper and lower scan limits are set at count 44, upon reaching count 44 the counter will continue to count up-down only within this channel. The auto-manual switch is or is then placed in manual, and the recirculate switch is put in the On position. The manual push button and up-down switches enable examination in detail of said channel up through and including the output shift register.

Caution: In the write position the toggle switch register may be used to write any desired arbitrary words onto the drum register. In the read position, however, the word in the output shift register is the result of Subtraction A - B

where A is drum register
B is toggle switch register

This includes a one (1) bit error as a result of omission of end around carry in all cases except one which is explained below.

Note: Indicator lights on front panel indicate only 10 least significant bits and sign which represent inputs to D/A converter

---

* Scan limit switches and channel counter lights read in octal

In addition, the complimenting function occurs in the ladder network. Therefore, in order to interpret the indicator lights properly, care must be taken to determine the proper word configuration at the output shift register.

The most direct way to read the drum contents is to set the toggle switch register to all ones (1). (This method is used in TTY drum dump provision). Since the input register is complimented at ladder input ($A - B = A + \overline{B}$), the resultant then becomes $A_{drum} - 0$ = Drum contents.

G. Channel "C" Counter

1. General

A six-stage, parallel, up-down counter ($C_0 - C_5$, Figure 31A) keeps a count of "25 word carries" from the T counter. When a drum channel has been used up, the "C" counter switches the relay tree (Figure 11A) to the next drum channel. The C counter is reset under the following conditions: when counting up and the count reaches 59, the counter resets to zero; when counting down and the count is zero, the counter resets to 59; a push button on the front panel (the same one that sets the T counter to zero) also resets the "C" counter to zero for test purposes or, if wanted at the start of a scanback operation.

2. Read-Write Mode

When data is being written on the drum, the C counter counts only up, i.e., 0 - 59; in the read mode, the counter counts either up or down and may be set to count between scan limits. The direction of counting is determined by the up/down flip flop at position D2 (Figure 34A); the output of this flip flop is also sent to the U-D matrix of the T counter so that both counters count up or down together. This flip flop is set by either the U-D push button on the front panel which allows an operator to take control immediately of scanning direction; or, the flip flop is set by the upper and lower scan limit switches on the front control panel which feed the matrices in D4 in Figure 34A. The channels to be scanned may be selected in the machine with these switches which are octally coded for convenience. "C" counter indicator lights on the front control panel indicate the drum channel being used. The six lights, being marked off in groups of three, permit easy conversion to octal. For example, if the darkened circles indicate the lights are on, octal channel No. 25 would be in use.

Channel Counter

Numerical Value = 4 2 1 + 4 2 1 Therefore, number = 25

The five T counter lights (the last one on the right is blank) directly above the channel counter lights shows how many words have been used up in the particular channel. When the scanback command is given, the C counter indicator lights indicate the last written channel. This channel becomes the upper limit of scanning and the next higher channel number the lower limit of scanning.

3. Scan Limit Switches

Two scan limit switches are used to set the upper and lower limits of the playback scan. Actually they set the limits on the drum channel to be sampled.

The scan limit switch in Figure 34A consists of two rows of push buttons. The right hand row represents the least significant and the left hand row represents the most significant bit of a two-digit octal number. The octal number (when converted to its decimal equivalent) represents the channel number (1 through 60) selected by the switch. Each row has eight push buttons numbered 0 through 7.

In the write mode the drum channels one through sixty are filled in sequence. After the sixtieth channel is full, the relay tree is switched back to channel one, and the writing continues with the previous data in channel one being erased as the new data is written. Thus there is a block of 150 seconds of past data on the drum. This block of data may not be in exact channel sequence. For example, if the writing mode is terminated, on channel 15, then channel 16 represents the earliest data and channel 15 the latest data. In this case, if it is desired to scan over the entire recorded data interval, it is necessary to set the upper scan limit switch on channel 15 and the lower scan limit switch on 16. It should be remembered that the channel selector switch is arranged in octal numbers. For example, channel 60 (decimal) would be selected by inserting the number 74 (octal) into the scan selector switch. Numbers higher than 74 (octal) have no meaning since the maximum number of channels is 60 (decimal).

4. Relay Tree Control

The relay tree control is a bank of sixty relays so connected that there are sixty separate paths available to the memory drum. These relays are controlled through sixty relay drivers which are connected to the "C" counter; thus for every one of sixty counts of the channel counter, there is a different path and head available. Figure 11A shows a schematic of the relay tree, and drivers; Figure 12A shows the location of the relays.

5. Manual Up/Down Push Buttons

The manual U/D push buttons control the U/D flip flop in addition to the control matrix. The buttons permit an operator to examine only part of a channel. For example, if it were desired to look at the data running from the middle of channel 23 to the middle of channel 24, he would "ride" the buttons to cause the machine to count up and down between the desired limits.

VI. ARITHMETIC UNIT

A. General

The function of the arithmetic unit is to determine the difference between the present antenna position, represented by the contents of the input register, and the new desired position, represented by the contents of the drum. This difference represents the error signal which then drives the antenna servo. This entire closed loop may be regarded as a digital servo system.

A functional block diagram is shown in Figure 8. The input data and drum data are fed to the subtractor which is a diode matrix. A carry "K" flip flop is used as an integral part of the subtraction function. The output of the subtractor is a binary number which represents the difference between the two input numbers and is connected to the output register. The output register is a 47 flip flop shift register which contains the composite 48 bit word representing the range, azimuth, and elevation error numbers. (The 48th bit is stored in the adder). The arithmetic control counter is a five-stage counter and matrix used to define the 16 bit words. This is needed, since the desired operation is to determine the difference between 16 bit words; not 48 bit words. The sign control unit contains a matrix and phasing flip flop to deliver a signal to the output which indicates the direction of the error.

B. Subtractor

This unit is actually a simple serial adder which performs subtraction by the "ones" complement method (Figure 35A). It can be shown that a subtraction can be performed by adding the complement of the number being subtacted. Thus $A - B = A + \overline{B}$, where A is the magnetic drum data and B is the input register data. $\overline{B}$ is obtained by reversing the input of the B register flip flop to the adder. If A is greater than B, there is a final end-around carry which has been ignored in this design for simplicity. The result of this is a one-bit error equal to one part in one thousand which is too small to be resolved by the servo system. The following example shows the principle of operation.

Assume a number A = 1100101101011100 and B = 0110111001011001

Connections to adder matrix

a = $\underline{A}$
b = $\overline{B}$ (input register output is reversed at matrix (Figure 35A))
c_1 = carry from previous addition
c_2 = carry from present addition
S = sum

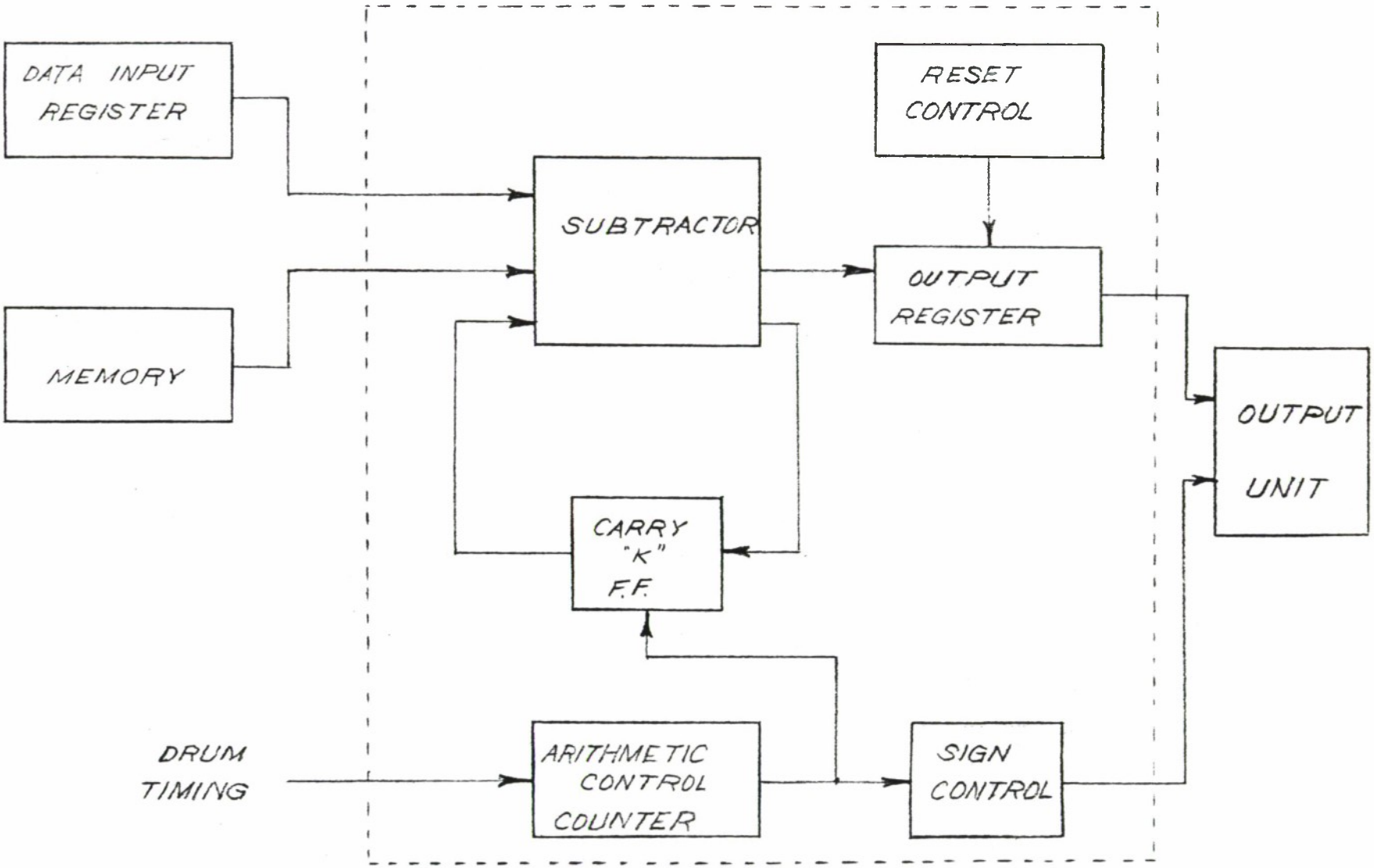


FIGURE 8 - FUNCTIONAL BLOCK DIAGRAM OF ARITHMETIC UNIT

Logic equations for matrix

$$S = a'b'c_1 + a'bc_1' + ab'c_1' + abc_1$$

$$c_2 = a^1bc_1 + ab^1c_1 + ab$$

	MSB LSB		
a =	1100101101011100	=	52060 Drum
b =	1001000110100110	=	28249 Input
c =	1000001111111100		
S =	10101110100000010	=	+23810 Difference

The final carry in the sum (17th bit) indicates the sign of the error. If it is one, the difference is positive and if zero, the difference is negative. Another rule which applies to the above method of subtraction is that when A is less than B, the answer is negative and must be complemented to obtain the correct difference. This is accomplished in the digital to analog converter in the output unit.

C. Sign Control

The output of the adder must indicate the direction (sign) as well as the magnitude of the difference number. This is required to properly direct the antenna motion. The sign is generated in accordance with the following criteria.

1. If A is greater than B, the sign is plus and the end around carry = 1.
2. If A is less than B, the sign is negative and the end around carry = 0.

At the proper time the carry flip flop is sampled and the range, elevation and azimuth sign flip flops are set to a zero for a positive sign and a one for a negative sign.

In the azimuth plane, it is necessary to provide instructions which would enable the antenna to seek the shortest path. In particular, if the two points being subtracted from one another happen to be on either side of north, it is obvious that the subtracted difference would be a large error. This would tend to cause the antenna ordinarily to swing through nearly 360^{o}. The same would be true of any situation in which the error was greater than a hundred and eighty degrees. The solution

is to fully complement the number including the sign so that the antenna will select the shortest way to go between the two points. (See Figure 37A - R, Az, El Reset Mtx).

A sign relay performs the function of complementing whenever necessary (i.e., negative numbers, values greater than 180°), by floating the power supply that produces the voltage source of ladder network and grounding either side as a function of sign relay.

D. Arithmetic Control Counter

This is a five-stage counter and matrix which has two functions. One is to define the 16-bit words, and the other is to provide timing signals for the sign function control (Figure 38A).

E. Reset Control

A maximum limit on the error signal is set by a matrix connected to the output register. Thus, if any of the six most significant bits of an error word is a "one" or a zero, the entire word is reset to all "ones" or "zeros" depending on the sign function. The digital to analog converter (ladder network) senses only the 10 least significant bits and thus receives a maximum error if any of the other bits is a one. The matrix is shown in Figure 37A. In addition to the above function, the azimuth reset matrix provides for the "shortest path function" mentioned in Section C above.

F. Output Register

The output register is a 48-bit serial shift register containing 47 flip flops. The 48th bit is considered to be the contents of the adder output at the time of sampling. The three error signals (range, azimuth and elevation) are defined by the sign function control and arithmetic control counter. Figure 40A is a block diagram of the output register.

VII. OUTPUT UNIT

A. General

The purpose of the output unit is to change the contents of the arithmetic unit to a form suitable for use by the antenna and range tracking servo systems. To do this, a digital to analog conversion is performed. Figure 9 is a functional block diagram.

B. Ladder Network

The ladder netword's function is to perform the necessary digital analog conversion and to provide the DC voltage necessary to control the azimuth, range, and elevation servos. Although the total sixteen bit difference is sampled, the ladder is only connected to the least significant ten bits. This provides an accuracy of one part in a thousand and is greater than the accuracy that can be expected from the servo system. The ladder network is a constant impedance relay control resistance network. (Figure 41A) Because the output of the output register flip flops are only used to switch relays, it is possible to use any calibrated voltage depending upon the need of the particular servo system. Each of the three ladder networks has a variable regulated power supply from 0 to 18 volts DC. The three individual supplies make it possible to calibrate each of the servos independently such that a one-for-one correspondence will exist between the original trajectory and the reposition trajectory.

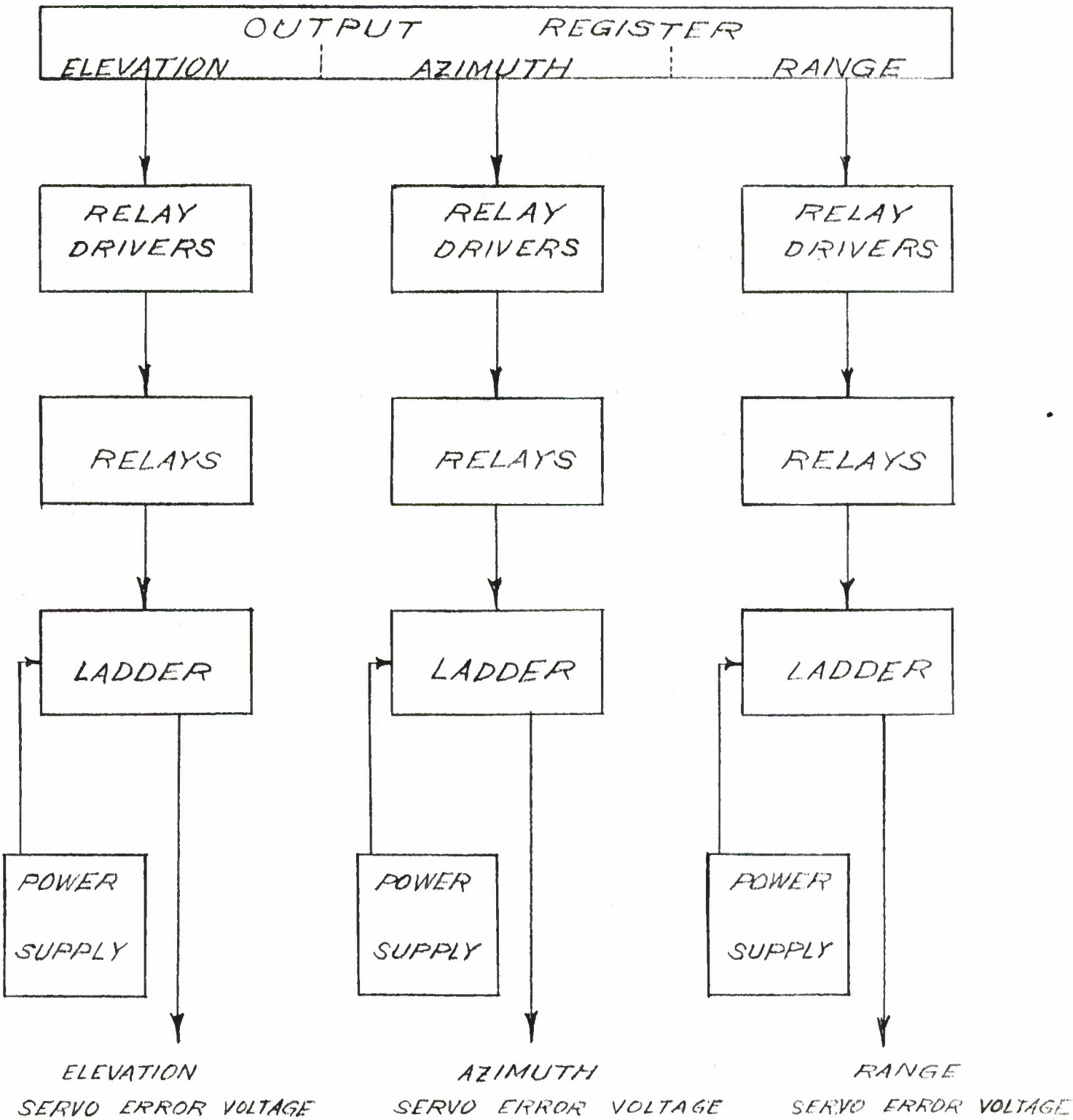


FIGURE 9 - FUNCTIONAL BLOCK DIAGRAM OF OUTPUT UNIT

VIII. TELETYPE

When the TTY is being used to transmit real time data, the scanback must be turned on to provide power to the buffers. Provision has been made to enable the teletype logic to sample the drum contents and transmit the contents to some remote position such as Lincoln Laboratory. (See Group Report 21G-0007 "Real Time Clock and TTY Data Transmitter for Reentry Physics Program") The TTY operates at a very slow rate; therefore, the scanback read rate is under control of TTY logic. The following procedure to "dump drum" must be observed:

1. Test/Operate in TEST position
2. Auto/Manual in Manual position
3. Scanback/TTY switch (Figure 30A, B7) in TTY position. (This is source of input Read Command from TTY)
4. Toggle Switch register set to all ones (1).
5. Start

The interconnections between TTY and scanback are as follows:

TTY/Scanback Switch - read command (Figure 30A)

48 leads from Output Shift register for parallel sample (Figure 40A, E8-E32)

T_{48} gate (Figure 27A, B20). The falling edge of this gate indicates the word has been completely shifted into output shift register.

IX. CALIBRATION PROCEDURES

Before proceeding with the calibration, it is necessary to place the control of the antenna in the scanback mode of operation. This is done at the antenna control console. (Three bipolar error voltages, range, azimuth, elevation from the scanback equipment are sent to the antenna control console.)

Each of the three servo systems are calibrated as independent units in polarity and magnitude.

A. Polarity

(A complete description of a single servo such as elevation will be described; the method for the other two is identical).

1. The brake is applied to azimuth control and range may be disconnected from scanback.

2. The antenna is at a full stop and the encoder elevation position is written onto the drum 50 or 75 times. (The exact number does not matter; however, 50 words or two full channels should be the minimum).

3. The antenna is then moved off the fixed position approximately 5^{o}. Antenna control is then given to scanback which should bring the antenna back to the previous fixed position. Should the antenna move in the wrong direction, the polarity of the voltage to the ladder network at the scanback equipment should be reversed. This process is repeated for both the range and azimuth servo units.

B. Magnitude

A completely suitable test for calibration of the scanback error voltage has not been developed. Two types of tests have been used but each has limitations. The primary value of such a test is to adjust the power supplies for the ladder network so that an optimum re-positioning of the antenna and range gate occurs. There is a compromise involved, since a setting for minimum lag gives rise to over-shoot problems. A setting in the other direction creates a lag condition when high accelerations occur. The two tests are listed below:

1. The calibration for each individual servo consists of moving range, azimuth or elevation through some arbitrary path in which the reversal points are noted (i.e., an example in range would be to move from 50 NM to 75 NM back to 30 NM and stop.) Scanback is then given control and the path should continuously be retraced. The power supplies that provide voltages for the ladder network should be adjusted until there is a close correspondence between the original path and the scanback control repositioning function. The plotting board is used to indicate proper repositioning. Of course, this method is very limited in accuracy, but can be used to indicate a gross calibration.

2. The test for accurate scanback calibration is as follows: The antenna shall be moved, using the optical director, through some arbitrary trajectory. Coincidentally, the range operator shall move the range gate in and out in some arbitrary manner. The scanback system shall record this trajectory and at the same time the primary recording system shall make a magnetic tape of the trajectory. This trajectory should be no greater than two (2) minutes. The scanback will then take control and reposition the range gate and antenna. The repositioned trajectory will also be recorded on tape. It is important to mark the exact time at which the scanback mode changed from record to playback. This tape will then be processed by the 7090 computer and plots of the original and repositioned trajectories will be compared for accuracy. The results of this analysis should indicate if additional calibration is necessary and particular points of error noted and corrected. This test is capable of providing an accurate measure of scanback performance but is very time consuming and laborious.

X. OPERATIONAL PROCEDURE

A. Test Function

Much of the scanback circuitry may be tested by the following method:

1. Press Start-Stop to indicate stop
2. Place the Read-Write switch in the Write
3. Press the Operate-Test to indicate Test

In the Test position the Auto-Manual switch becomes active. The Auto position is the one usually used.

4. Reset Channel Counter (button marked reset)
5. Set up a known test pattern consisting of range, azimuth and elevation words on the switch bank
6. Start recording by pressing Start-Stop button to indicate start. Write several channels of the test data on the drum (15-25 seconds). When this has been done, press stop. (The bit, word, and channel counters will automatically count up)
7. Place Read-Write switch in the Read position
8. Leave Operate-Test switch in Test. Put scanback TTY switch in proper position (Sec V111)
9. Select channel limit if desired. The counter will then scan channels as determined by limit switches.
10. Reset channel counter or press down
11. Place all switches in switch bank in their "1" position (Up). This will make the display read out the same words that were recorded. Or set of different words can be set up on the switches for comparison with those previously recorded. The magnitude of error can then be read on neon lights connected to the output register.
12. Press Start-Stop button to indicate start and observe results.

B. Normal Operation

1. Set switches in the following positions: Stop, Write, Operate (In the Operate mode the auto manual switch becomes inactive in write channel - limit switches are inactive)

2. Encoders turned on

3. Press Start record several channels with antenna moving in all parameters

4. Press down switch

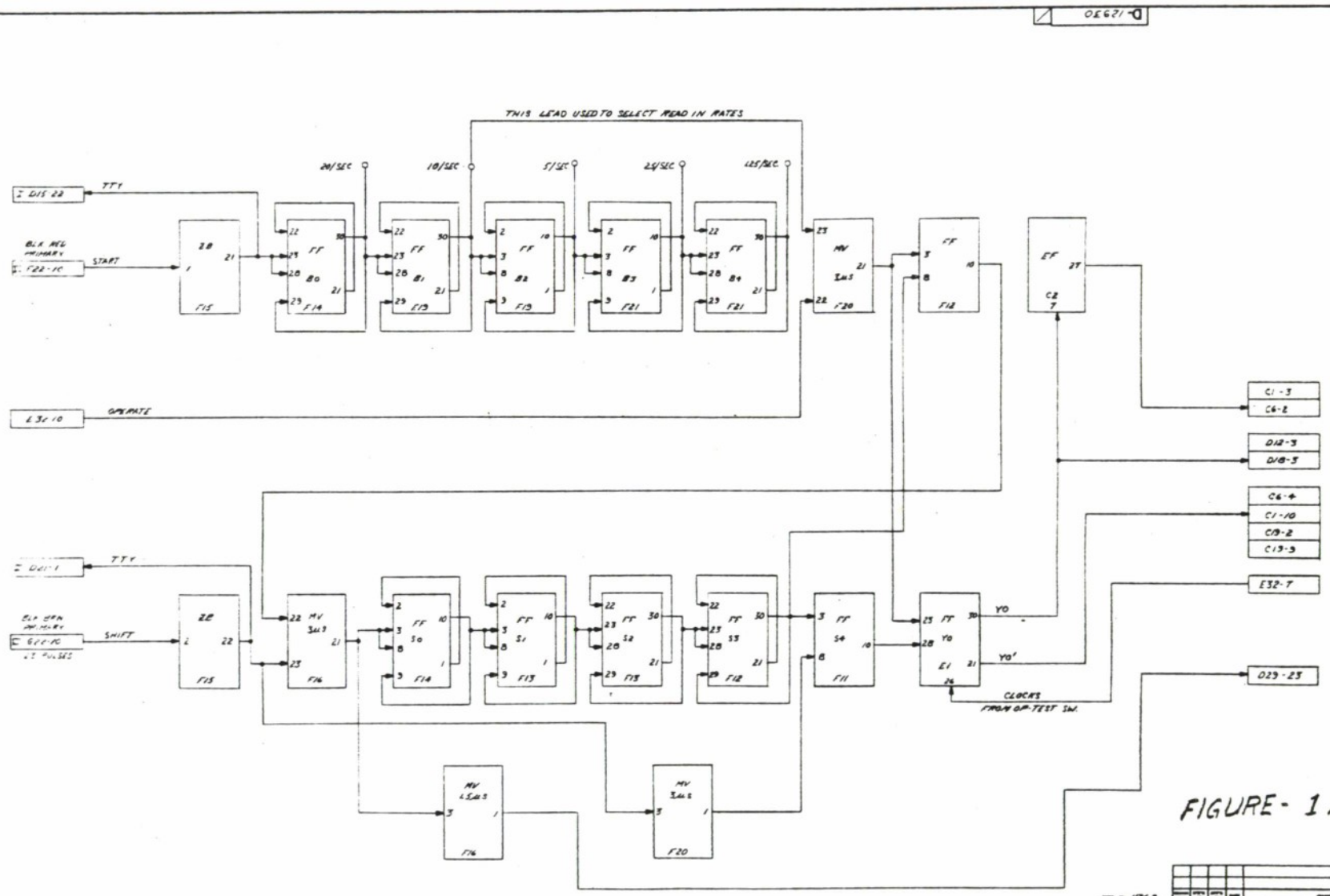
5. Make sure TTY scanback switch is in scanback position

6. Switch from Write to Read and immediately have an operator switch antenna console for scanback operation. When this is done antenna positions previously recorded on the drum will be compared with present antenna position and will provide an error voltage to reposition the antenna.

7. Set scan limits if desired. Error voltage power supplies should be calibrated. This is covered in another section.

XI. ACKNOWLEDGEMENT

Assistance in preparation of this report was given by P. J. Harris, K. H. Morey, and E. E. Schowengerdt, Jr.


D-12930
THIS LEAD USED TO SELECT READ IN RATES
20/SEC
10/SEC
5/SEC
2.5/SEC
.625/SEC.
TTY
START
SHIFT
OPERATE
CLOCKS FROM OP-TEST SW.
Y0
Y0'
C1-3
C6-2
D12-3
D18-3
C6-4
C1-10
C13-2
C13-3
E32-7
D23-23
FIGURE- 1 A
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
SCANBACK
INPUT CONTROL ELEMENT
BLOCK DIAGRAM
D-12930-

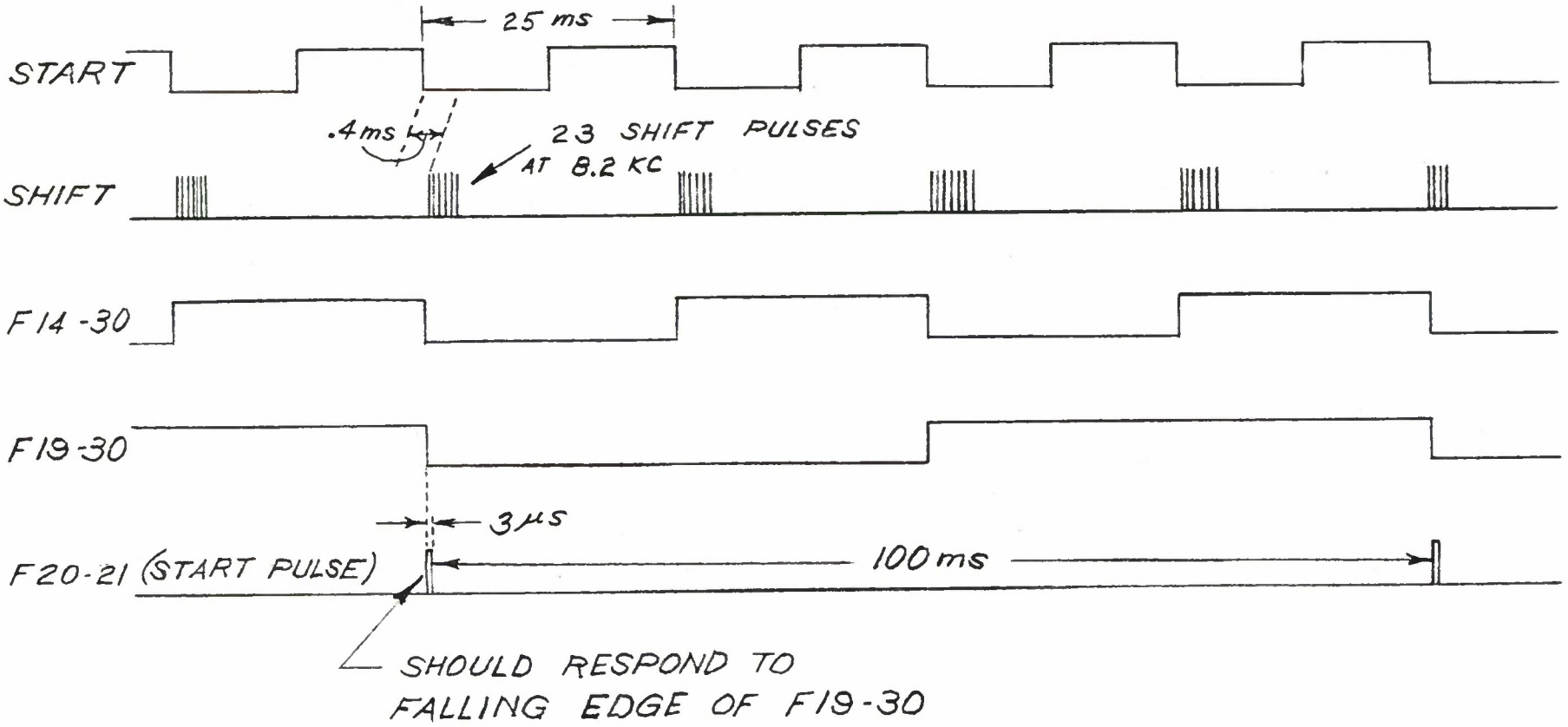


FIGURE 2A - START PULSE COUNTER TIMING DIAGRAM

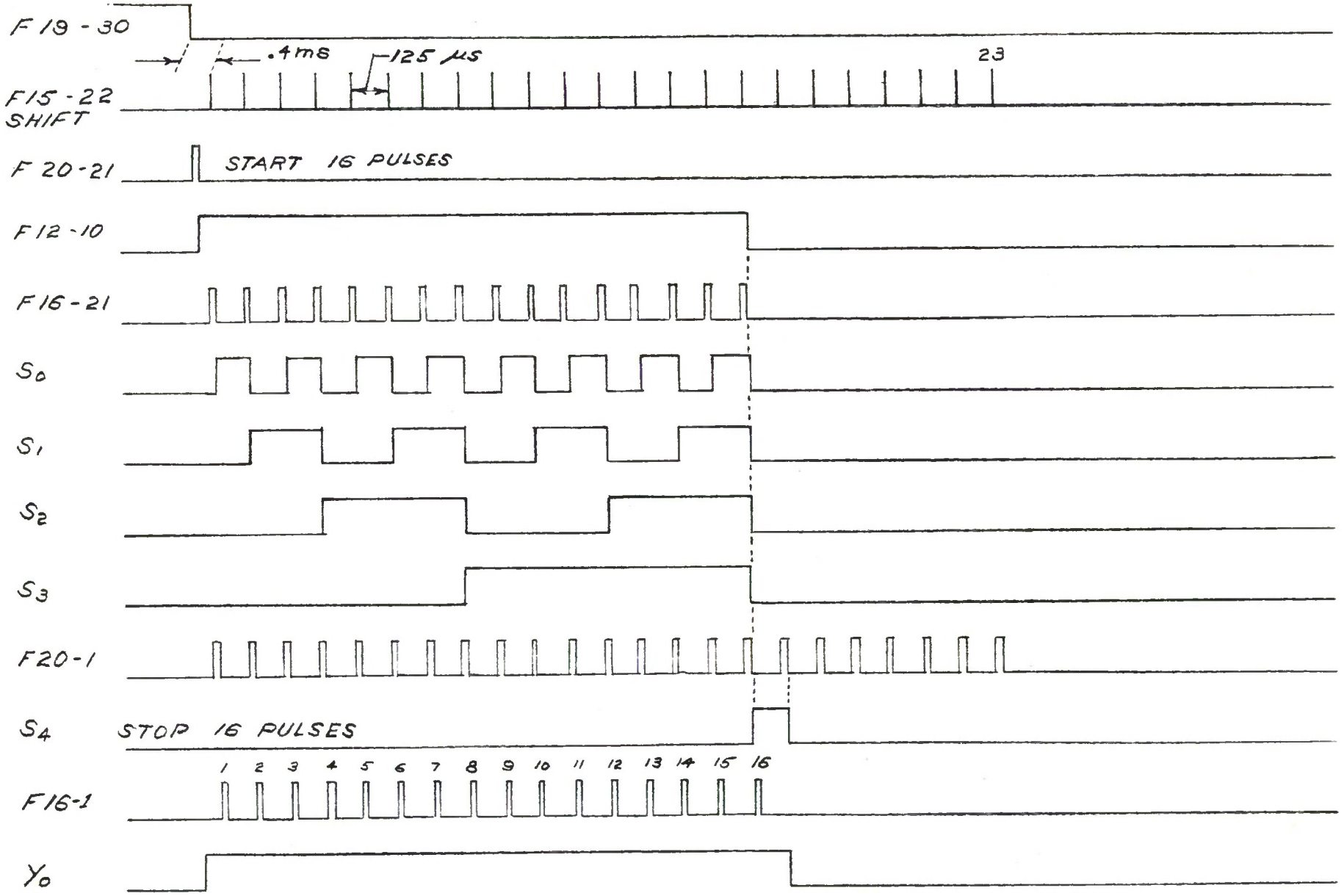


FIGURE 3A - INPUT SHIFT PULSE COUNTER TIMING DIAGRAM

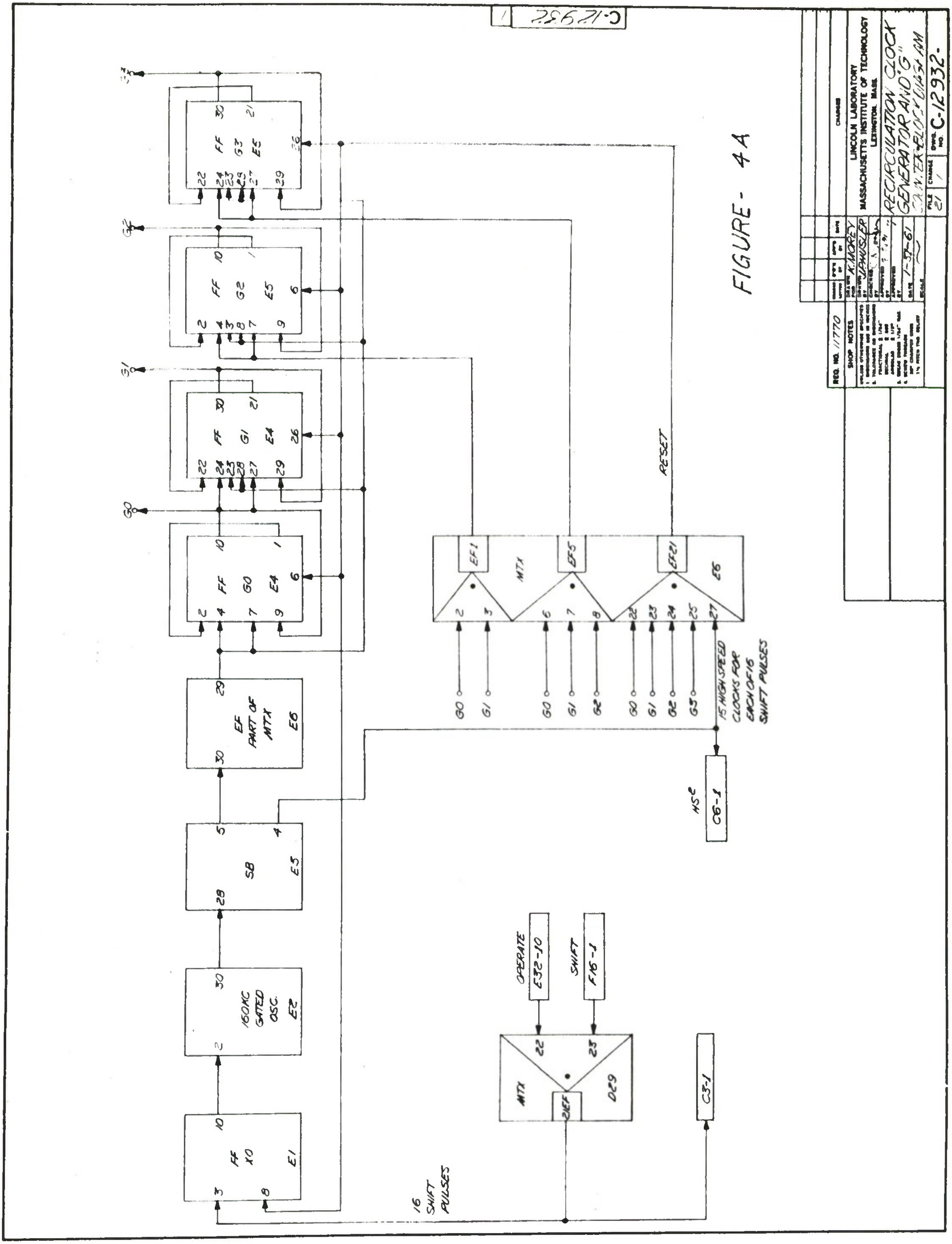
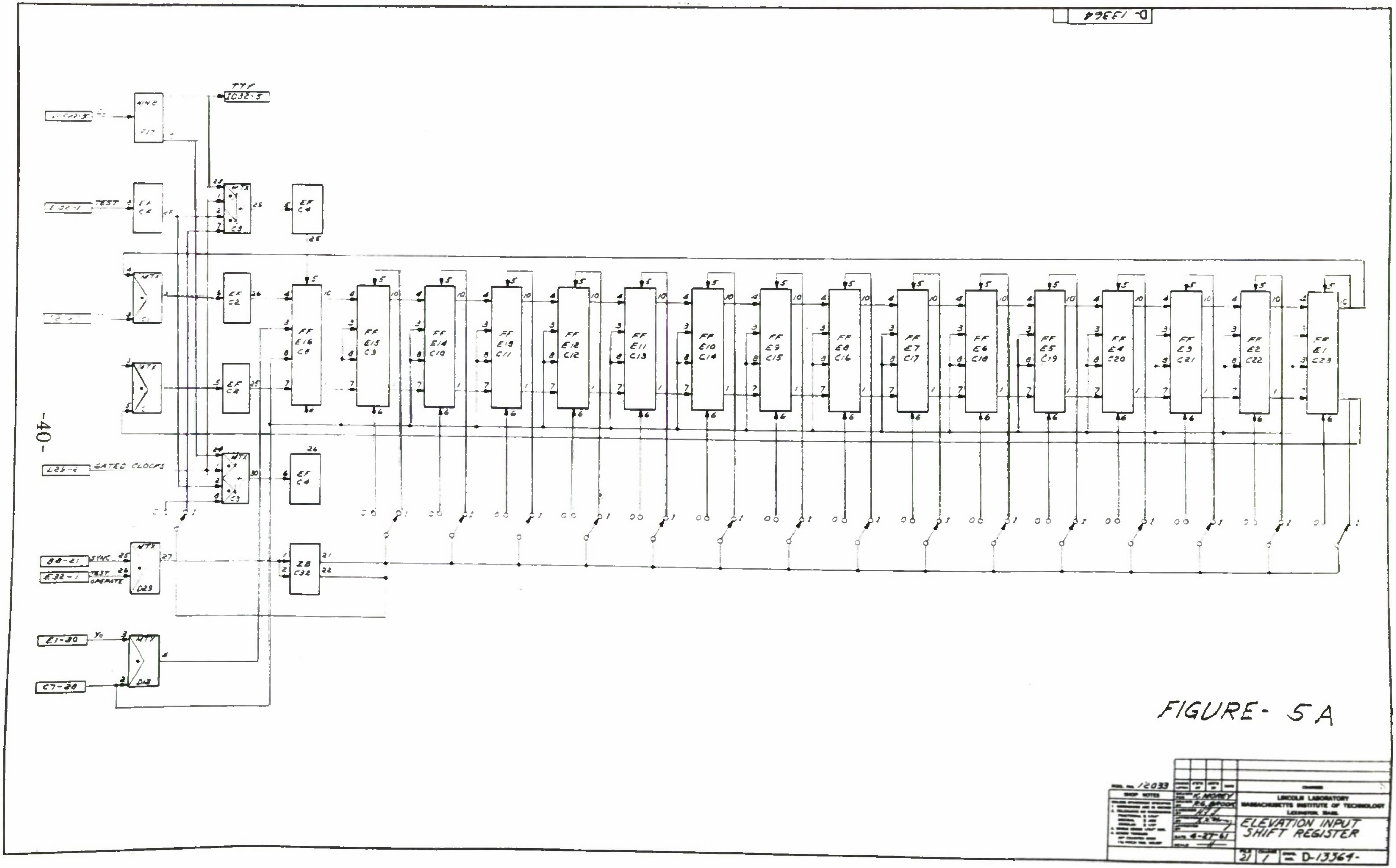

FF
X0
E1
160KC
GATED
OSC.
E2
SB
E3
EF
PART OF
MTX
E6
FF
G0
E4
FF
G1
E4
FF
G2
E5
FF
G3
E5
MTX
EF1
EF5
EF21
RESET
15 HIGH SPEED
CLOCKS FOR
EACH OF 16
SHIFT PULSES
C6-1
C3-1
OPERATE
E32-10
SHIFT
F16-1
D29
16
SHIFT
PULSES
C-12932
REQ. NO. 11770
SHOP NOTES
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
RECIRCULATION CLOCK
GENERATOR AND "G"
K. MOREY
1-31-61
C-12932-

FIGURE- 4A



D-13364
TTY
TEST
GATED CLOCKS
SYNC
TEST OPERATE
B8-21
E32-1
E1-30
C7-28
FIGURE- 5A
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
ELEVATION INPUT SHIFT REGISTER
4-27-61
D-13364-

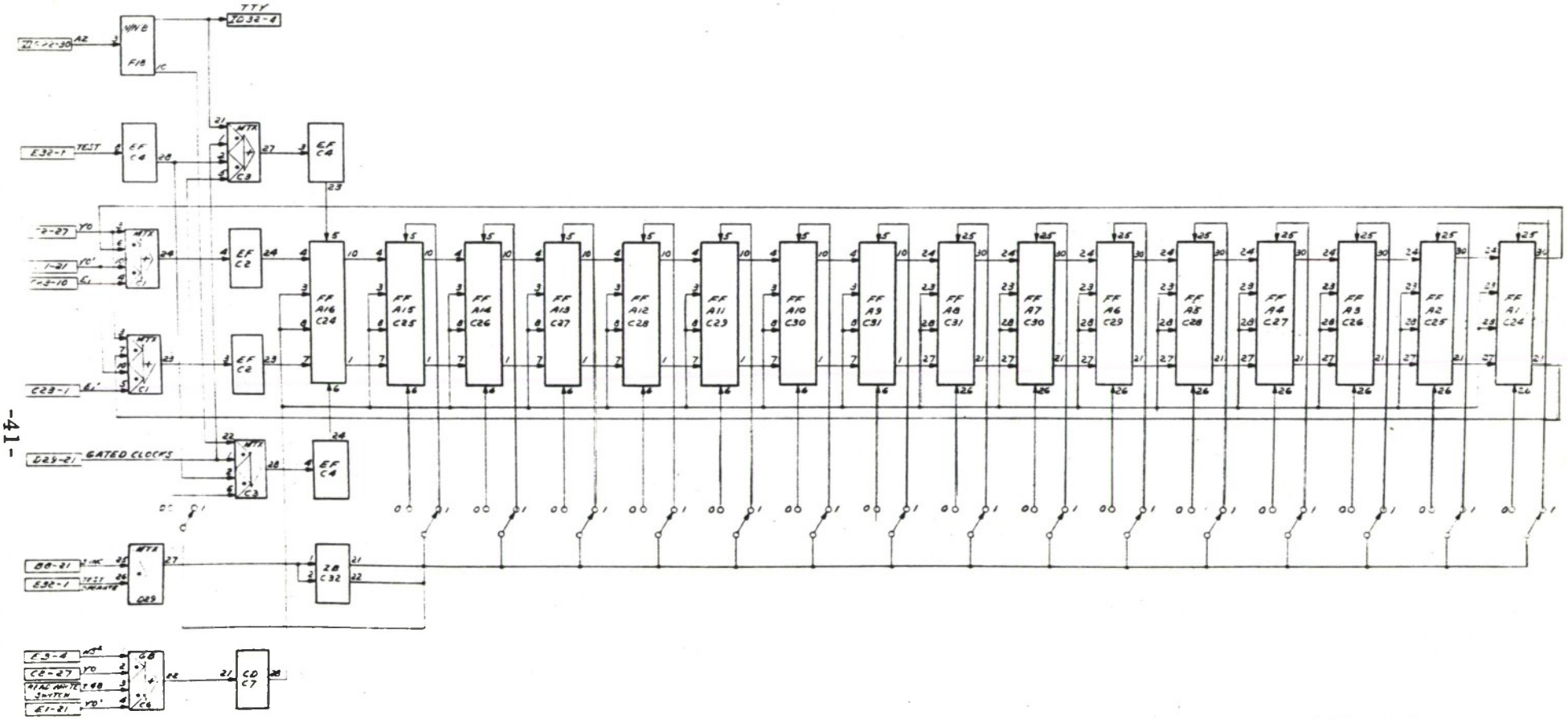


FIGURE - 6A

LINCOLN LABORATORY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, LEXINGTON, MASS.	
AZIMUTH INPUT SHIFT REGISTER	
SIZE 21 / SCALE	D-13363-

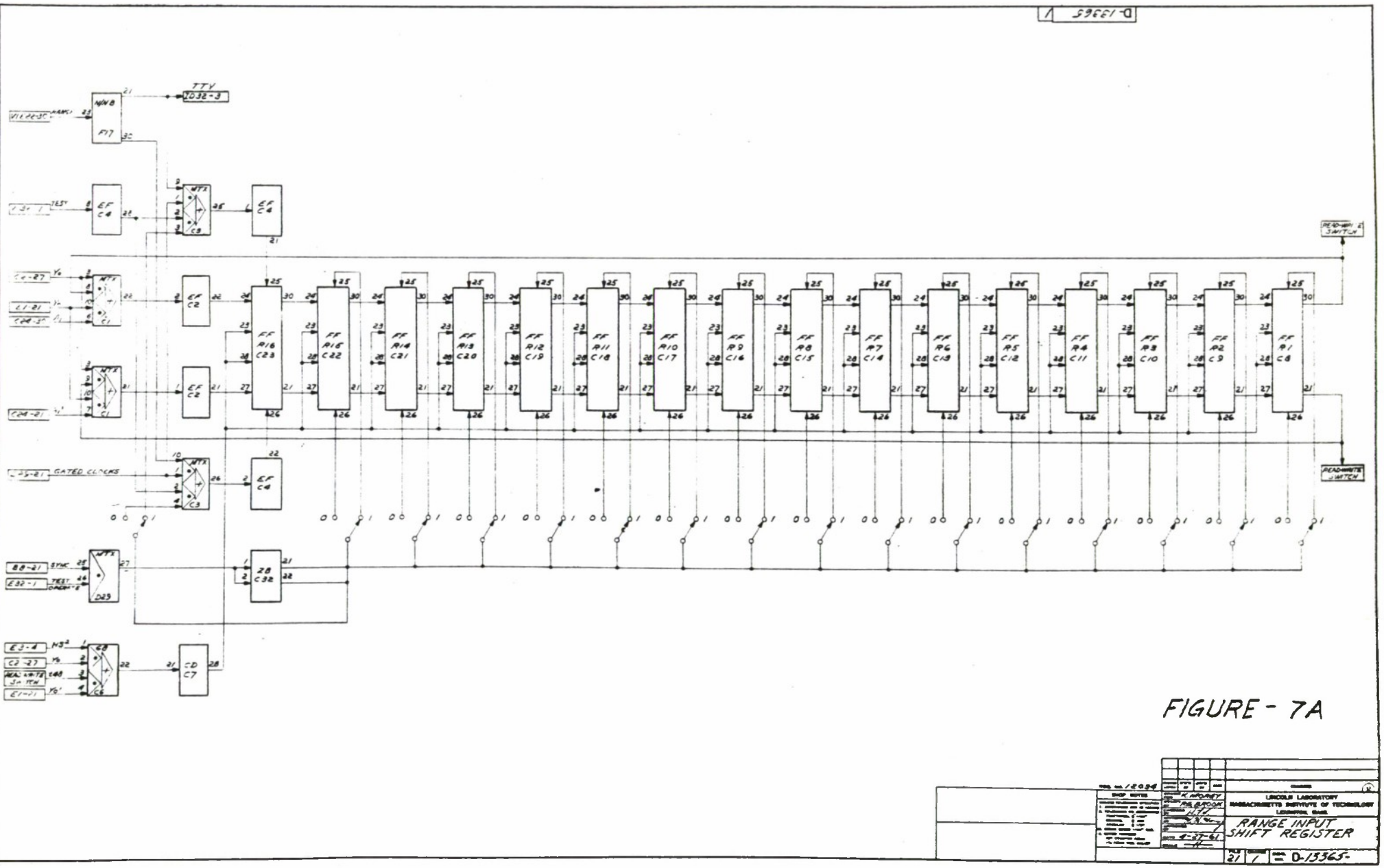

D-13365
TTY
2032-3
TEST
READ-WRITE SWITCH
GATED CLOCKS
SYNC
FF R16 C23
FF R15 C22
FF R14 C21
FF R13 C20
FF R12 C19
FF R11 C18
FF R10 C17
FF R9 C16
FF R8 C15
FF R7 C14
FF R6 C13
FF R5 C12
FF R4 C11
FF R3 C10
FF R2 C9
FF R1 C8
RANGE INPUT SHIFT REGISTER
D-13365-

FIGURE - 7A

A B C D E F G H I J K L M N P Q ← Start
(Input Data Sequence)

Typical 16 Bit Shift Register

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	Normal bit sequence (no bit reversal)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	At Start
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	First Data Bit Arrives
0	Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	First High Speed Shift
0	0	Q	0	0	0	0	0	0	0	0	0	0	0	0	0	Second High Speed Shift
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fourteenth High Speed Shift
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Q	Fifteenth High Speed Shift
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Q	Second Data Bit Arrives
Q	P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	First High Speed Shift
0	Q	P	0	0	0	0	0	0	0	0	0	0	0	0	0	Second High Speed Shift
0	0	Q	P	0	0	0	0	0	0	0	0	0	0	0	0	Third High Speed Shift
0	0	0	0	0	0	0	0	0	0	0	0	0	Q	P	0	Fourteenth High Speed Shift
0	0	0	0	0	0	0	0	0	0	0	0	0	0	Q	P	Fifteenth High Speed Shift
N	0	0	0	0	0	0	0	0	0	0	0	0	0	Q	P	Third Data Bit Arrives
P	N	0	0	0	0	0	0	0	0	0	0	0	0	0	Q	First High Speed Shift
Q	P	N	0	0	0	0	0	0	0	0	0	0	0	0	0	Second High Speed Shift
0	0	0	0	0	0	0	0	0	0	0	0	Q	P	N	0	Fourteenth High Speed Shift
0	0	0	0	0	0	0	0	0	0	0	0	0	Q	P	N	Fifteenth High Speed Shift
B	Ø	Q	P	N	M	L	K	J	I	H	G	F	E	D	C	Fifteenth Data Bit Arrives
C	B	Ø	Q	P	N	M	L	K	J	I	H	G	F	E	D	First High Speed Shift
D	C	B	Ø	Q	P	N	M	L	K	J	I	H	G	F	E	Second High Speed Shift
E	D	C	B	Ø	Q	P	N	M	L	K	J	I	H	G	F	Third High Speed Shift
Q	P	N	M	L	K	J	I	H	G	F	E	D	C	B	Ø	Fourteenth High Speed Shift
0	Q	P	N	M	L	K	J	I	H	G	F	E	D	C	B	Fifteenth High Speed Shift
A	Q	P	N	M	L	K	J	I	H	G	F	E	D	C	B	Sixteenth Data Bit Arrives
B	A	Q	P	N	M	L	K	J	I	H	G	F	E	D	C	First High Speed Shift
C	B	A	Q	P	N	M	L	K	J	I	H	G	F	E	D	Second High Speed Shift
D	C	B	A	Q	P	N	M	L	K	J	I	H	G	F	E	Third High Speed Shift
E	D	C	B	A	Q	P	N	M	L	K	J	I	H	G	F	Fourth High Speed Shift
F	E	D	C	B	A	Q	P	N	M	L	K	J	I	H	G	Fifth High Speed Shift
G	F	E	D	C	B	A	Q	P	N	M	L	K	J	I	H	Sixth High Speed Shift
H	G	F	E	D	C	B	A	Q	P	N	M	L	K	J	I	Seventh High Speed Shift
I	H	G	F	E	D	C	B	A	Q	P	N	M	L	K	J	Eighth High Speed Shift
J	I	H	G	F	E	D	C	B	A	Q	P	N	M	L	K	Ninth High Speed Shift
K	J	I	H	G	F	E	D	C	B	A	Q	P	N	M	L	Tenth High Speed Shift
L	K	J	I	H	G	F	E	D	C	B	A	Q	P	N	M	Eleventh High Speed Shift
M	L	K	J	I	H	G	F	E	D	C	B	A	Q	P	N	Twelfth High Speed Shift
N	M	L	K	J	I	H	G	F	E	D	C	B	A	Q	P	Thirteenth High Speed Shift
P	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Q	Fourteenth High Speed Shift
Q	P	N	M	L	K	J	I	H	G	F	E	D	C	B	A	Fifteenth High Speed Shift

← 125 μsec →

Figure 8A - Recirculation Bit Sequence

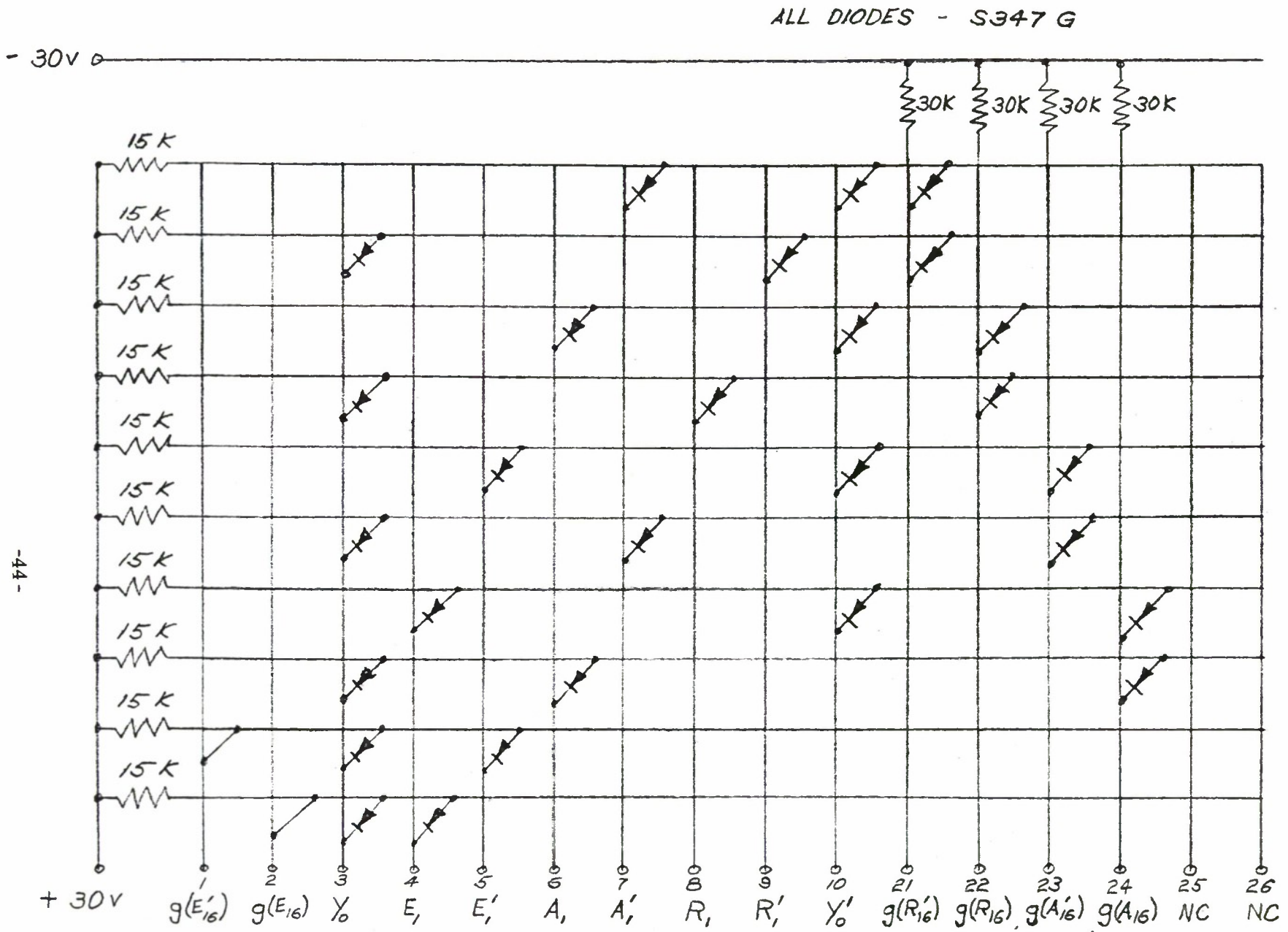


FIGURE 9A - INPUT REGISTER MATRIX C1

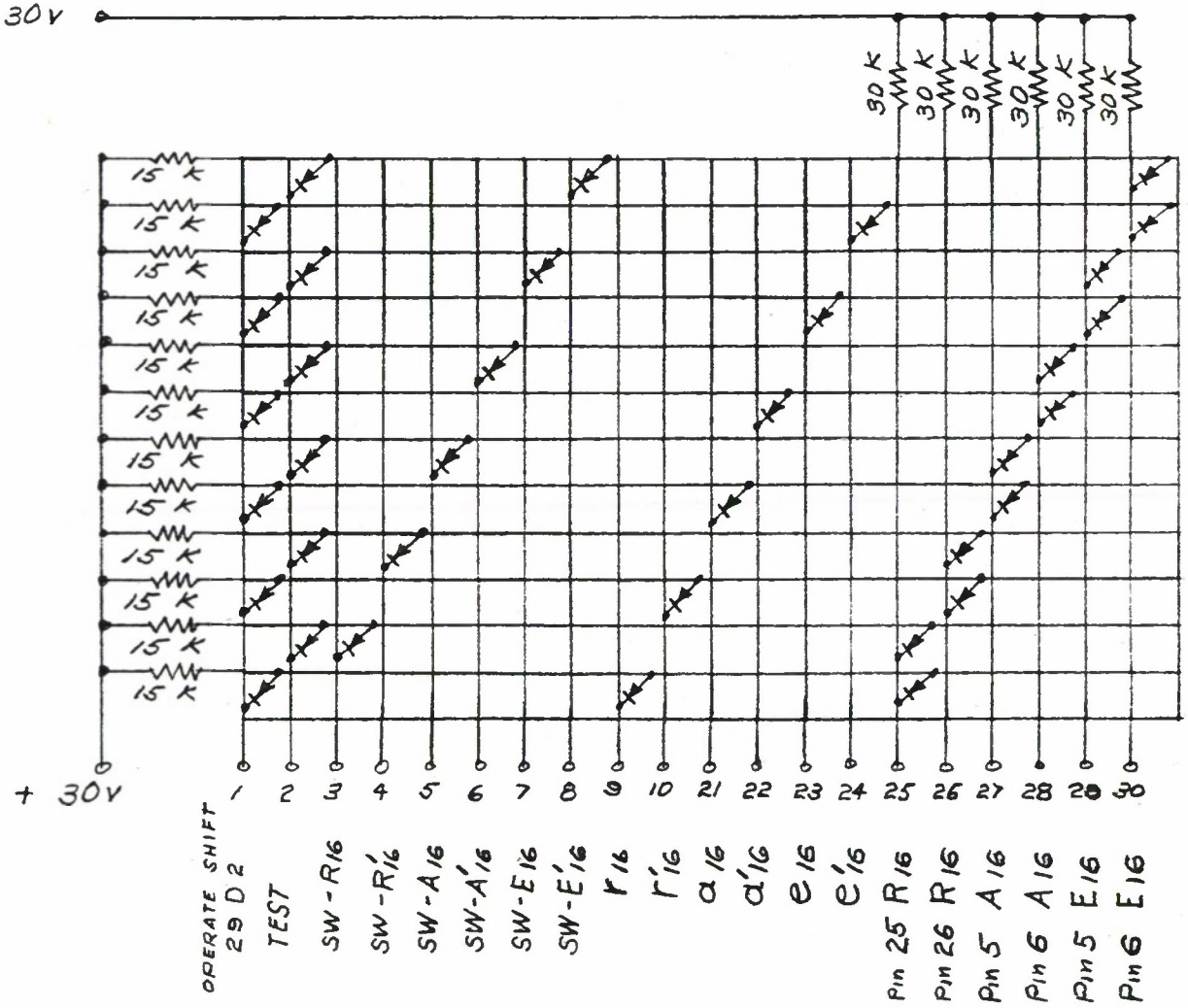


FIGURE 10A - INPUT REGISTER RESET MATRIX C3

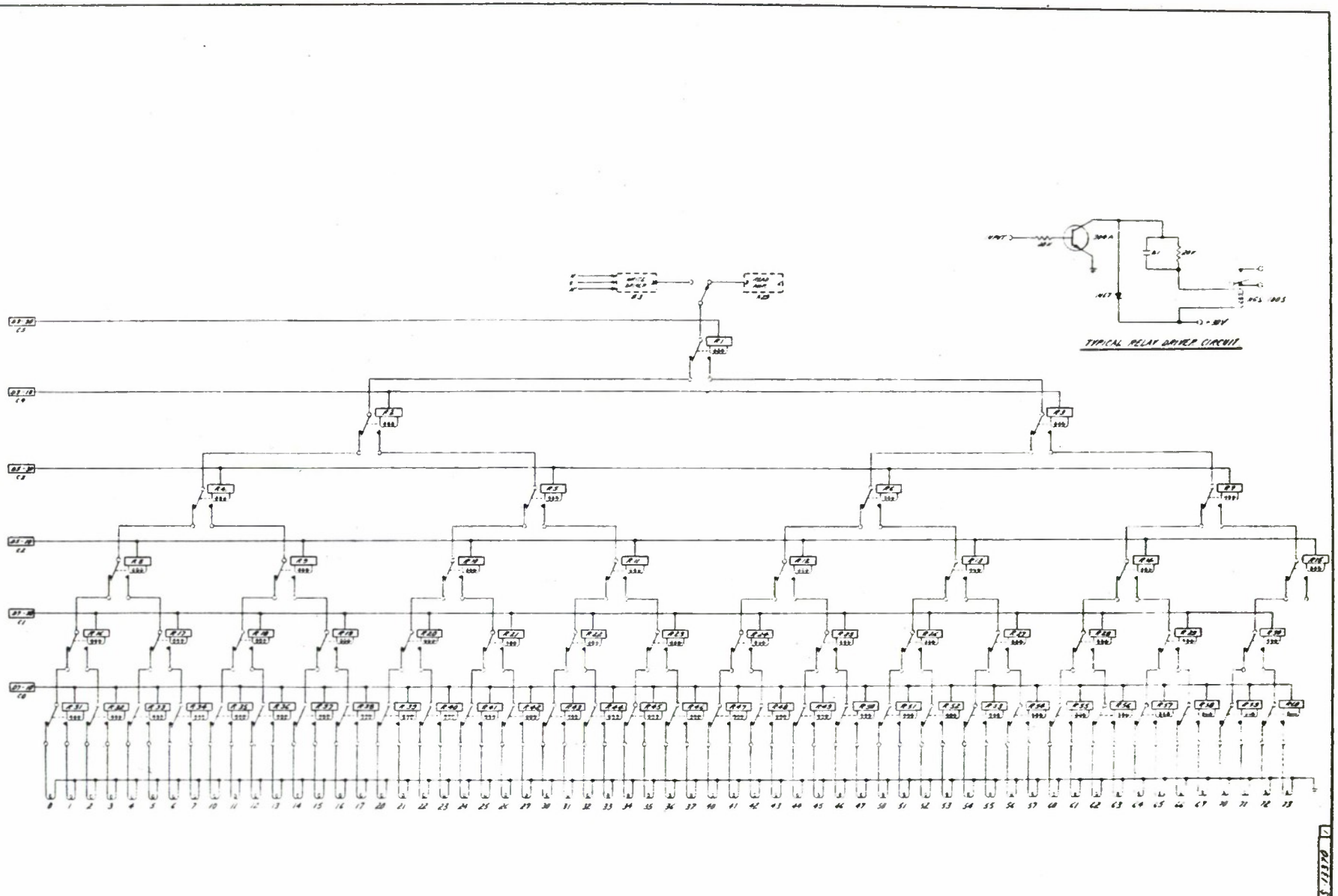
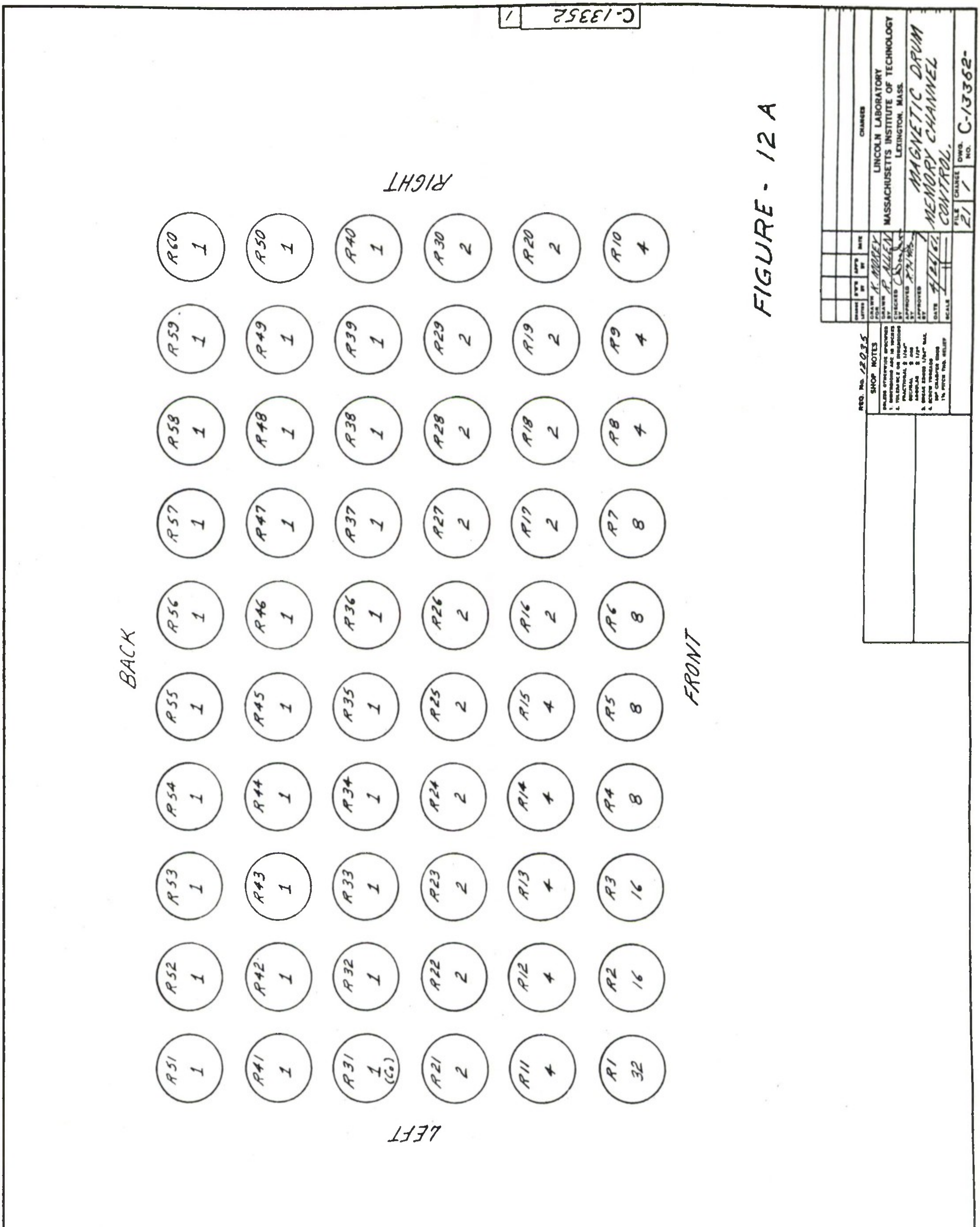
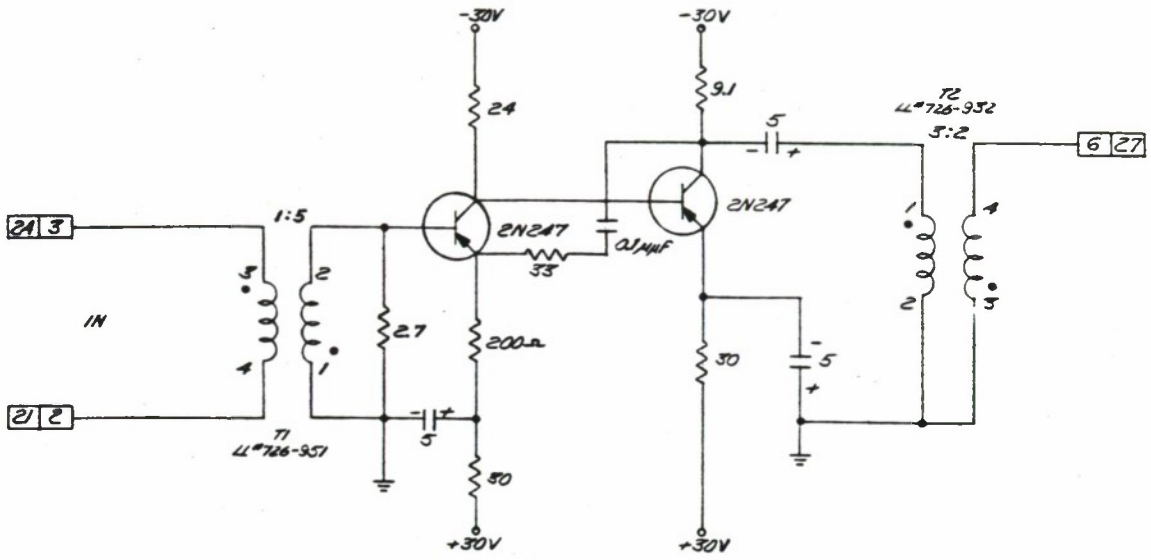


FIGURE- 11A

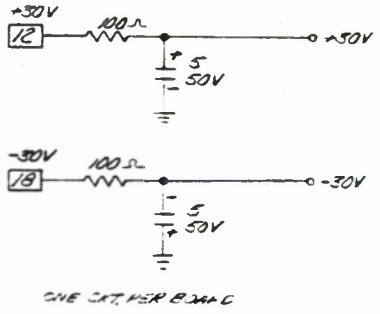


BACK
FRONT
LEFT
RIGHT
R1 32
R2 16
R3 16
R4 8
R5 8
R6 8
R7 8
R8 4
R9 4
R10 4
R11 4
R12 4
R13 4
R14 4
R15 4
R16 2
R17 2
R18 2
R19 2
R20 2
R21 2
R22 2
R23 2
R24 2
R25 2
R26 2
R27 2
R28 2
R29 2
R30 2
R31 1 (Co)
R32 1
R33 1
R34 1
R35 1
R36 1
R37 1
R38 1
R39 1
R40 1
R41 1
R42 1
R43 1
R44 1
R45 1
R46 1
R47 1
R48 1
R49 1
R50 1
R51 1
R52 1
R53 1
R54 1
R55 1
R56 1
R57 1
R58 1
R59 1
R60 1
REQ. No. 12035
SHOP NOTES
CHANGES
DRAWN K. MOREY
P. ALLEN
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
MAGNETIC DRUM MEMORY CHANNEL CONTROL.
FILE 21
CHANGE 1
DWG. NO. C-13362-

FIGURE - 12 A



2 CKT. PER BOARD



ONE CKT. PER BOARD

FIGURE 13A

REQ NO. 11764			CHANGES
SHOP NOTES	DRAWN BY K.MAGEY		LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON, MASS.
	TRACED BY J.RAISLER		READ AMPLIFER
	CHECKED BY		
	APPROVED BY		
	DATE 1-26-61		
	SCALE	FILE 21	CHANGE 1
			DWG. NO. C-12921-

C-12921 1

NOTE
ALL DIODES ARE S-347-B

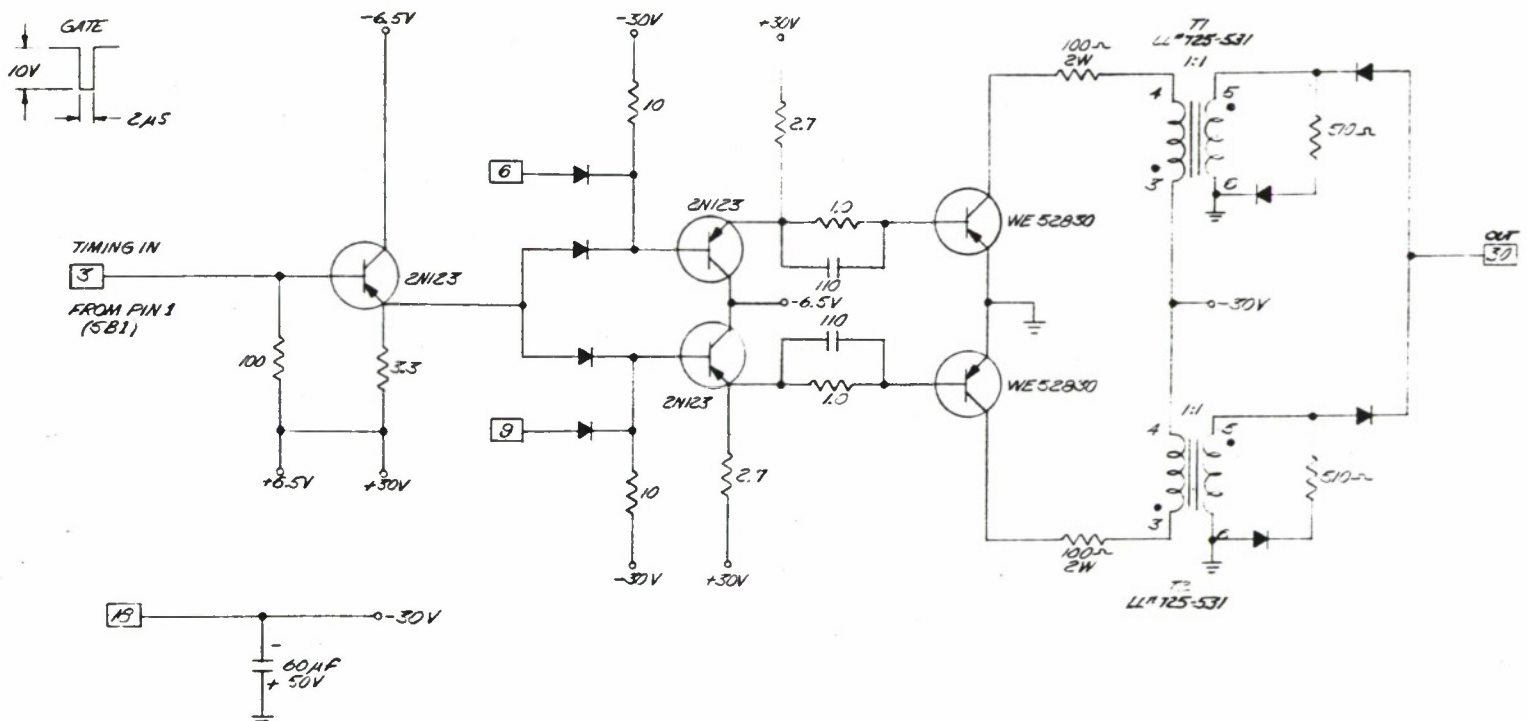


FIGURE 14 A

C-12922 1

REQ. NO. 11705	CHANGE LETTER	BY	APP'D BY	DATE	CHANGES
SHOP NOTES	DRAWN FOR	K.M.M.EY			LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON MASS
UNLESS OTHERWISE SPECIFIED: 1. DIMENSIONS ARE IN INCHES 2. TOLERANCE ON DIMENSIONS FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± 1/2° 3. BREAK EDGES 1/64" MAX 4. REMOVE THREADS 30° CHAMFER .010 5% PYRO TOO BRUSH	DRAWN BY	J.P.HUSLEY			
	CHECKED BY				
	APPROVED BY				
	APPROVED BY	J			DATA WRITE DRIVER
	DATE	1-26-61			
	SCALE				
	FILE	21	CHANGE	1	DWG. NO. C-12922-

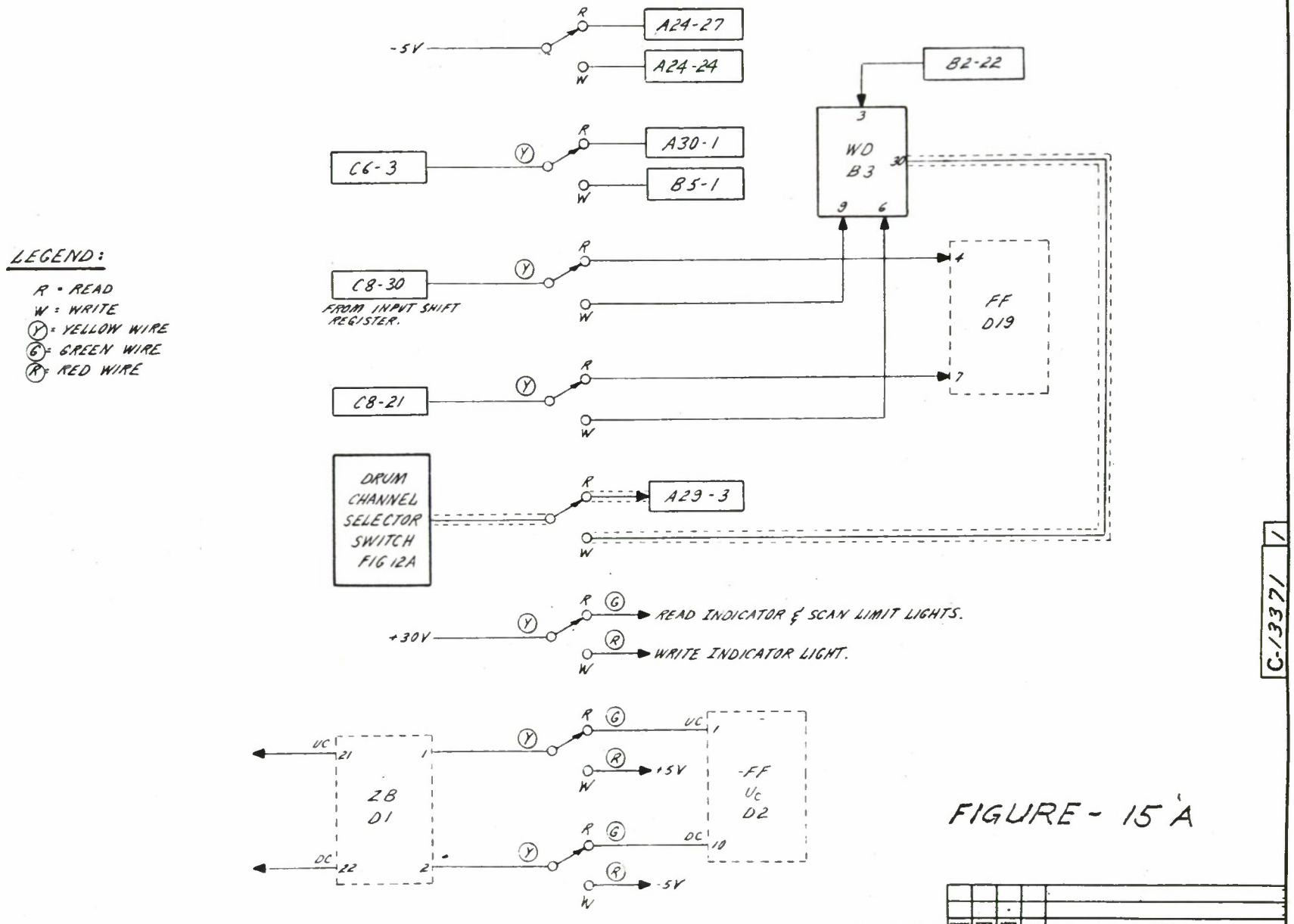


FIGURE - 15 A

C-13371

REQ. No. 12231	
SHOP NOTES	DRAWN K. MACY
1. DIMENSIONS ARE IN INCHES	DRAWN R. ALLEN
2. TOLERANCE ON DIMENSIONS: FRACTIONAL ± 1/64" DECIMAL ± .005 ANGULAR ± 1/2°	CHECKED H.T.J.
3. BREAK EDGES 1/64" MAX.	APPROVED
4. SCREW THREADS 60° CHAMFER EDGES 1½ PITCH THDS. RELIEF	APPROVED
	DATE 1/24/61
	SCALE —

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

MANUAL READ-WRITE SWITCH.

FILE — CHARGE — DWG. NO. C-13371-

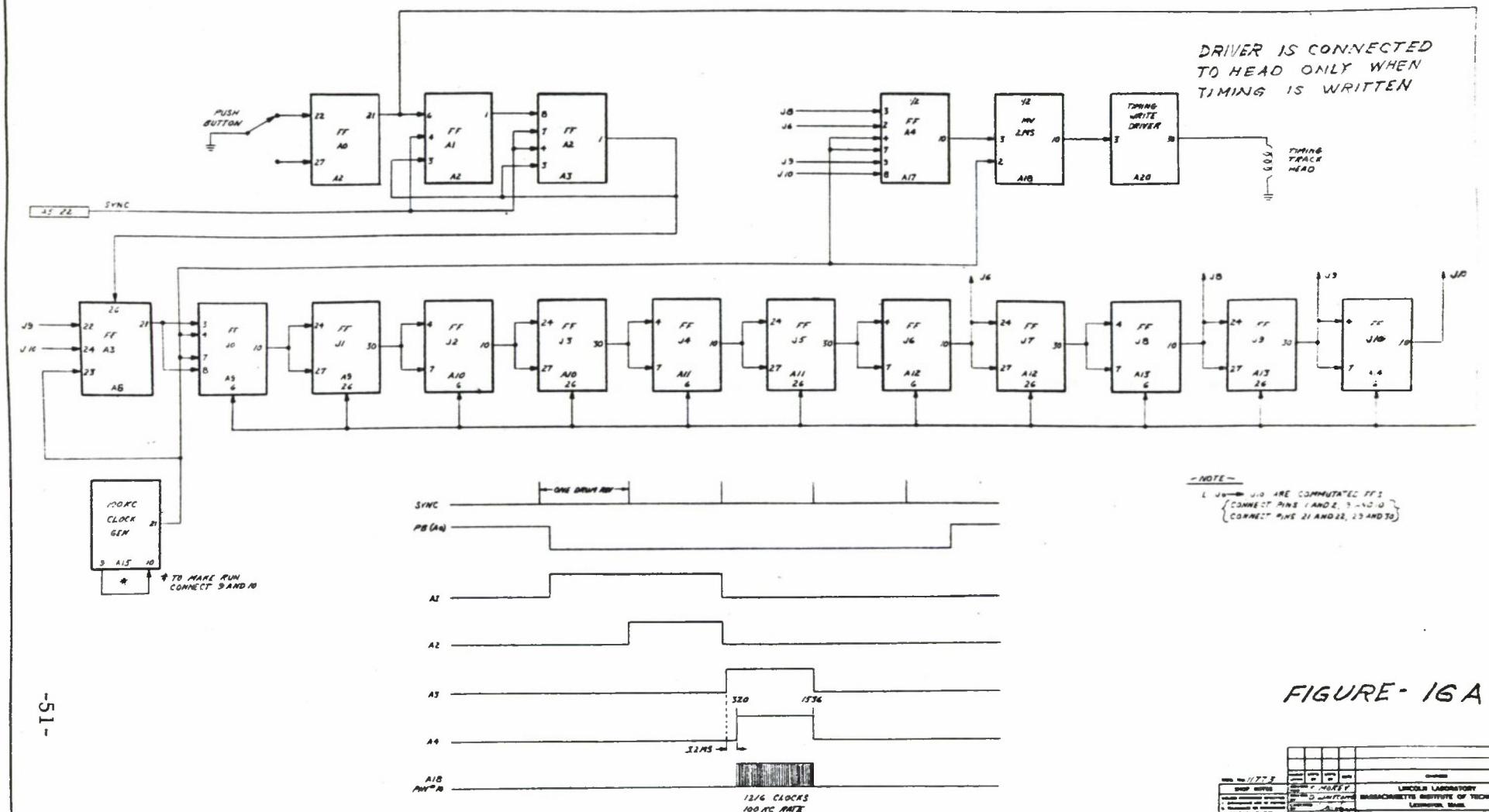


FIGURE - 16A

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

TIMING TRACK
LOGIC
BLOCK DIAGRAM

SIZE 21 | CODE / | D-12942-

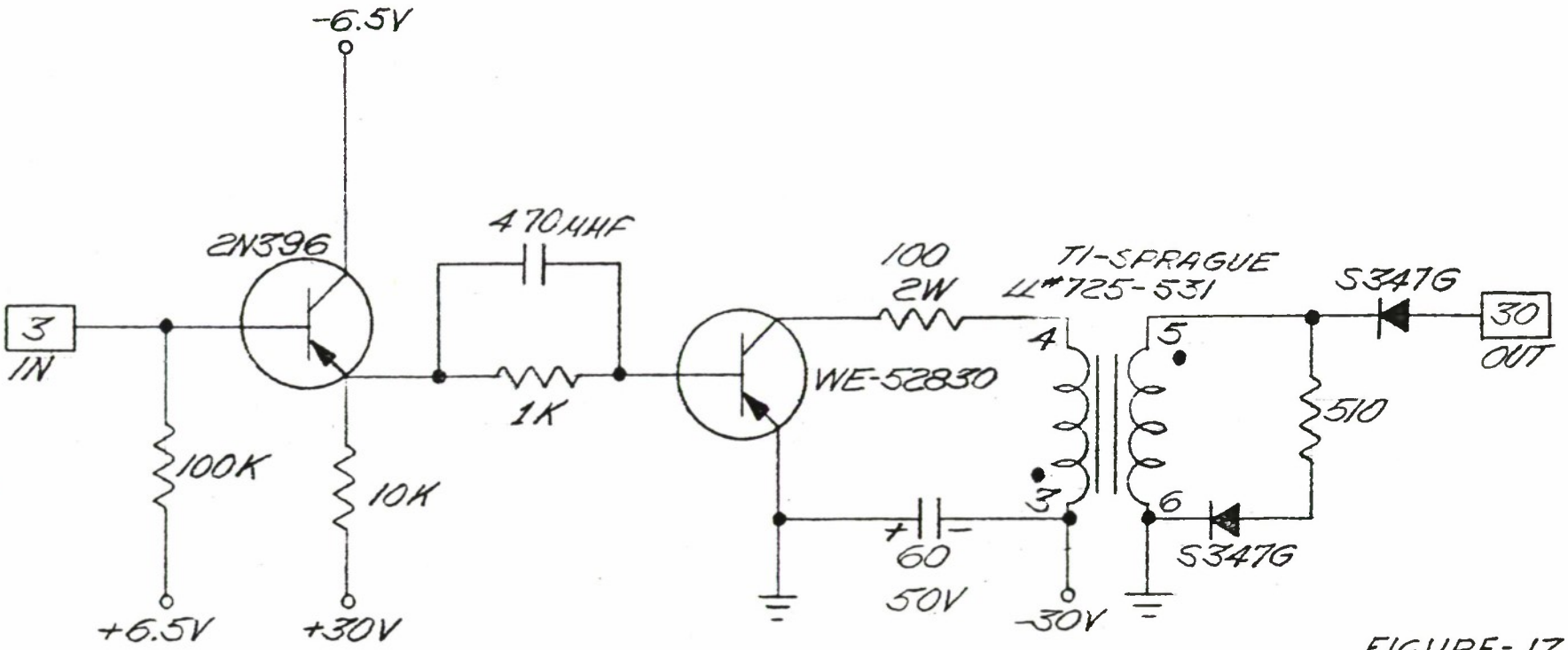


FIGURE-17A

TI-SPRAGUE #725-531

SCHEMATIC NOTES

UNLESS OTHERWISE SPECIFIED

REQ. No. 11766

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES

SHOP NOTES

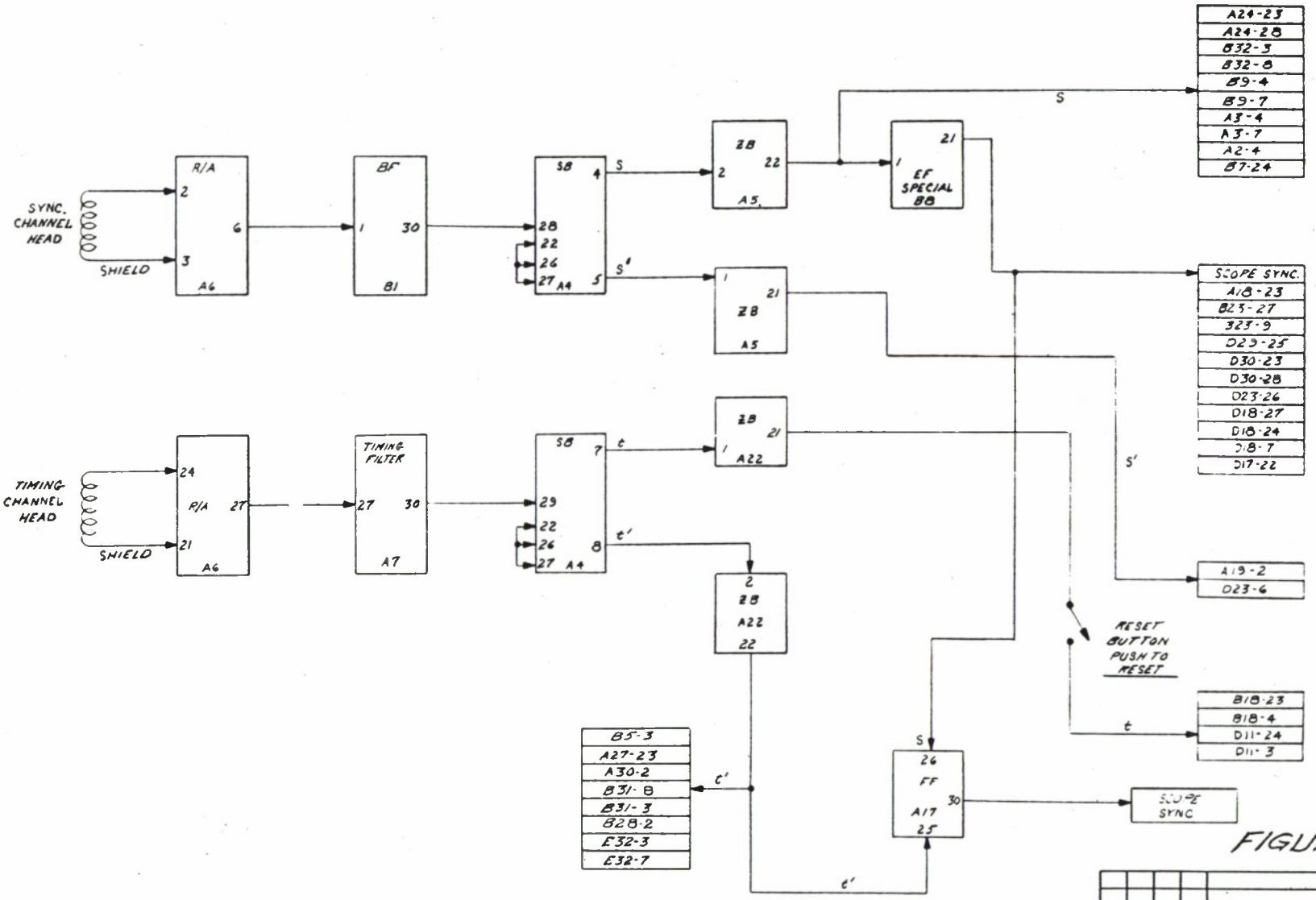
UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
   FRACTIONAL ± 1/64"
   DECIMAL ± .005
   ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
   30° CHAMFER ENDS
   1½ PITCH THD. RELIEF

DRAWN FOR	K. MOREY
DRAWN BY	J.P.HUSLER
CHECKED BY	
APPROVED BY	
APPROVED BY	
DATE	1-31-61
SCALE	~

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

TIMING DRIVER
21AW1527 SCHEMATIC

FILE	CHANGE	DWG. NO.
21	1	A-12934 -


SYNC. CHANNEL HEAD
SHIELD
R/A
A6
BF
B1
5B
A4
S
S'
2B
A5
EF SPECIAL B8
A24-23
A24-28
B32-3
B32-8
B9-4
B9-7
A3-4
A3-7
A2-4
B7-24
SCOPE SYNC.
A18-23
B23-27
323-9
D23-25
D30-23
D30-28
D23-26
D18-27
D18-24
D18-7
D17-22
TIMING CHANNEL HEAD
SHIELD
R/A
A6
TIMING FILTER
A7
t
t'
2B
A22
A19-2
D23-6
RESET BUTTON PUSH TO RESET
B18-23
B18-4
D11-24
D11-3
B5-3
A27-23
A30-2
B31-8
B31-3
B28-2
E32-3
E32-7
FF
A17
SCOPE SYNC
FIGURE- 18A
C-12929
REQ. No. 11767
SHOP NOTES
DRAWN FOR R. MORET
DRAWN BY D. WHITCOMB
CHECKED BY A.J. RODELL
APPROVED BY
APPROVED BY
DATE 1-27-61
SCALE
CHANGES
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
SYNC. + TIMING DERIVATION BLOCK DIAGRAM
FILE 21
CHANGE /
DWG. NO. C-12929-

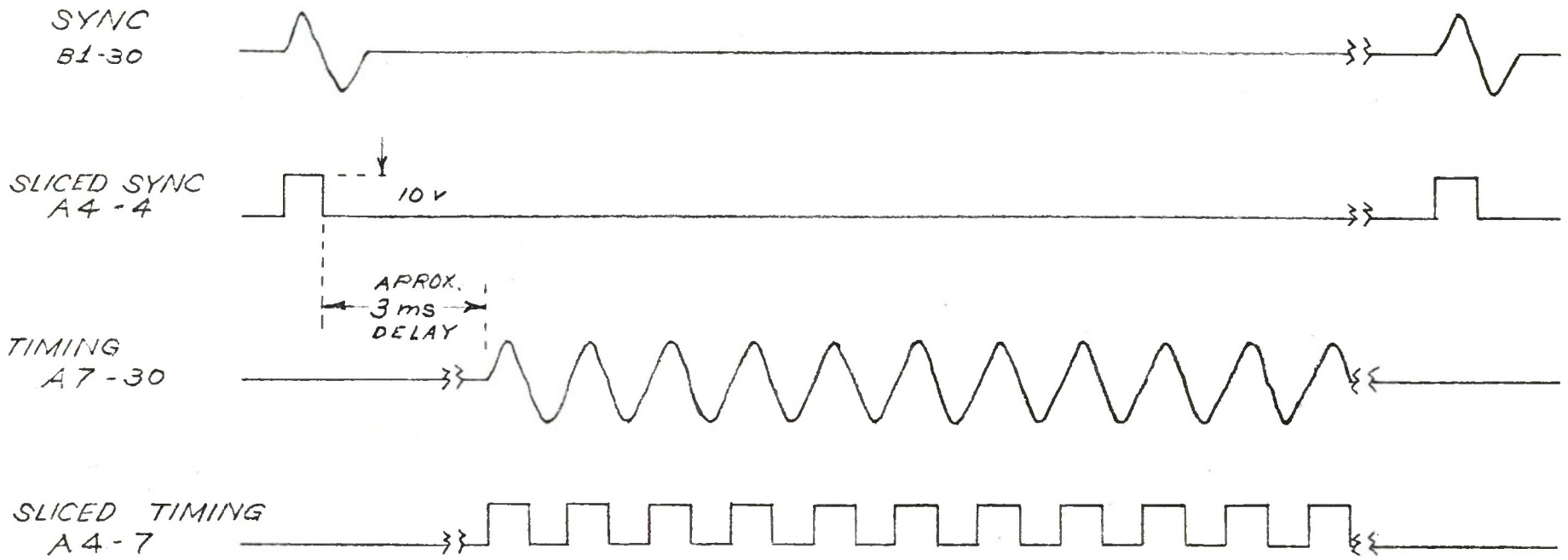
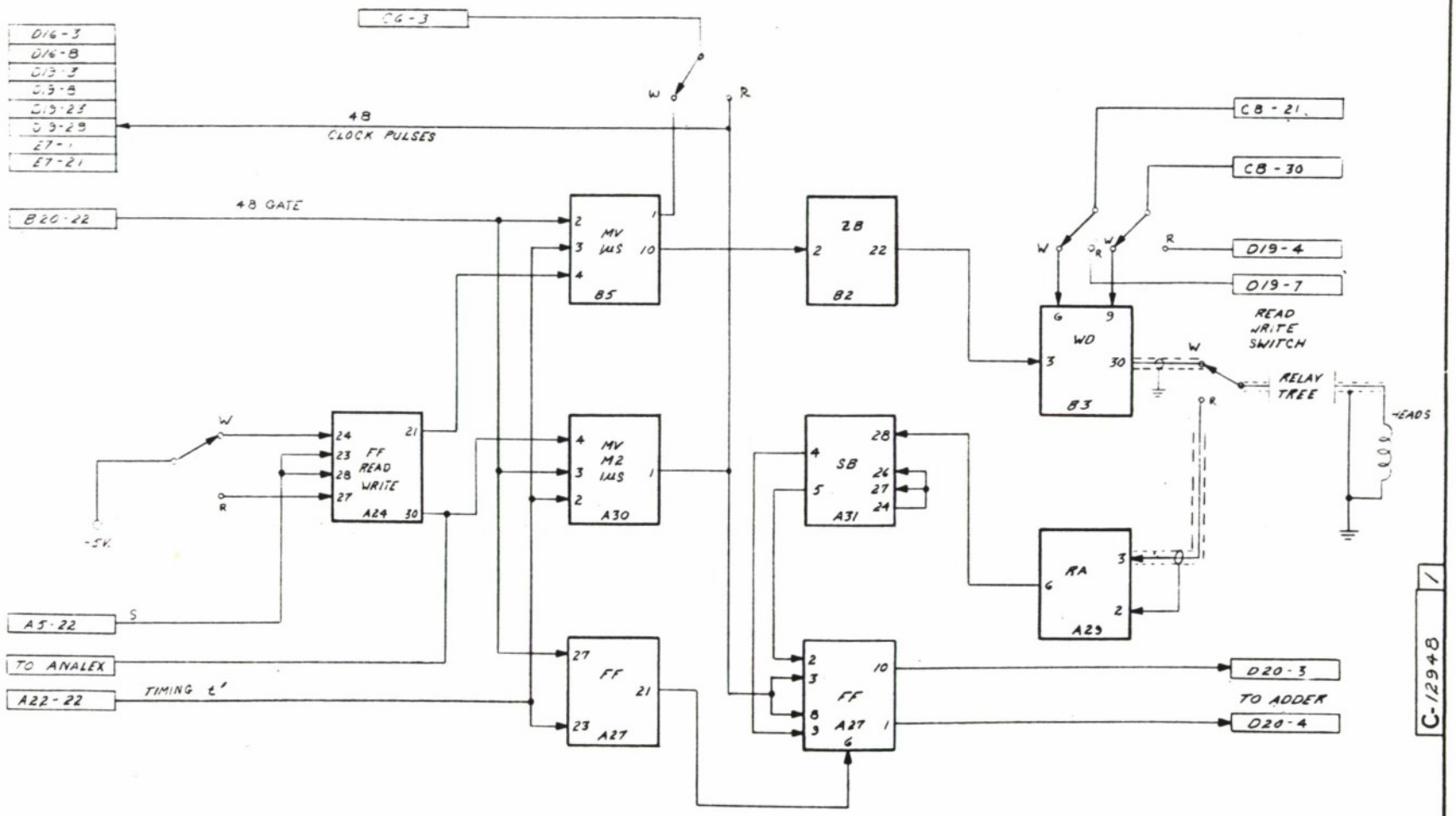


FIGURE-19A TIMING DIAGRAM FOR DRUM TIMING & SYNC



C-12948 /

FIGURE - 20A

REQ. NO. 11775	CHANGES	LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON, MASS.
SHOP NOTES	DRAWN BY R.MOREY	READ WRITE SWITCH LOGIC BLOCK DIAGRAM
UNLESS OTHERWISE SPECIFIED 1. DIMENSIONS ARE IN INCHES 2. TOLERANCE ON DIMENSIONS FRACTIONAL ± 1/64" DECIMAL ± .005 ANGULAR ± 1/2° 3. BREAK EDGES 1/32" MAX. 4. SCREW THREADS 90° CHAMFER EDGE 1½ PITCH THD. RELIEF	CHECKED BY APPROVED BY APPROVED BY DATE 8-3-61 SCALE	FILE 21 · CHARGE / · DWG. NO. C-12948 -

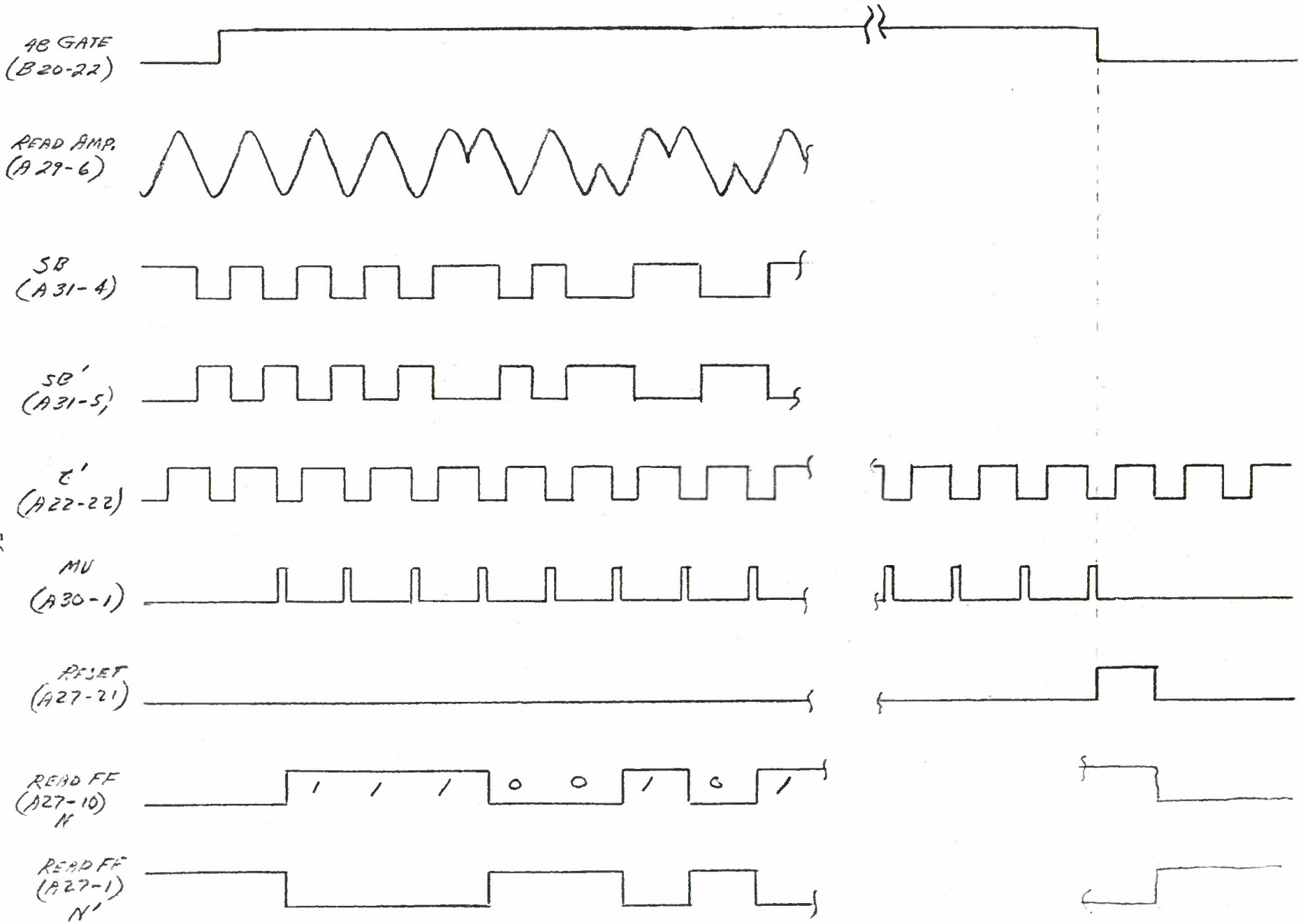


FIGURE - 21A TIMING DIAGRAM DATA READ FUNCTION K. Morey

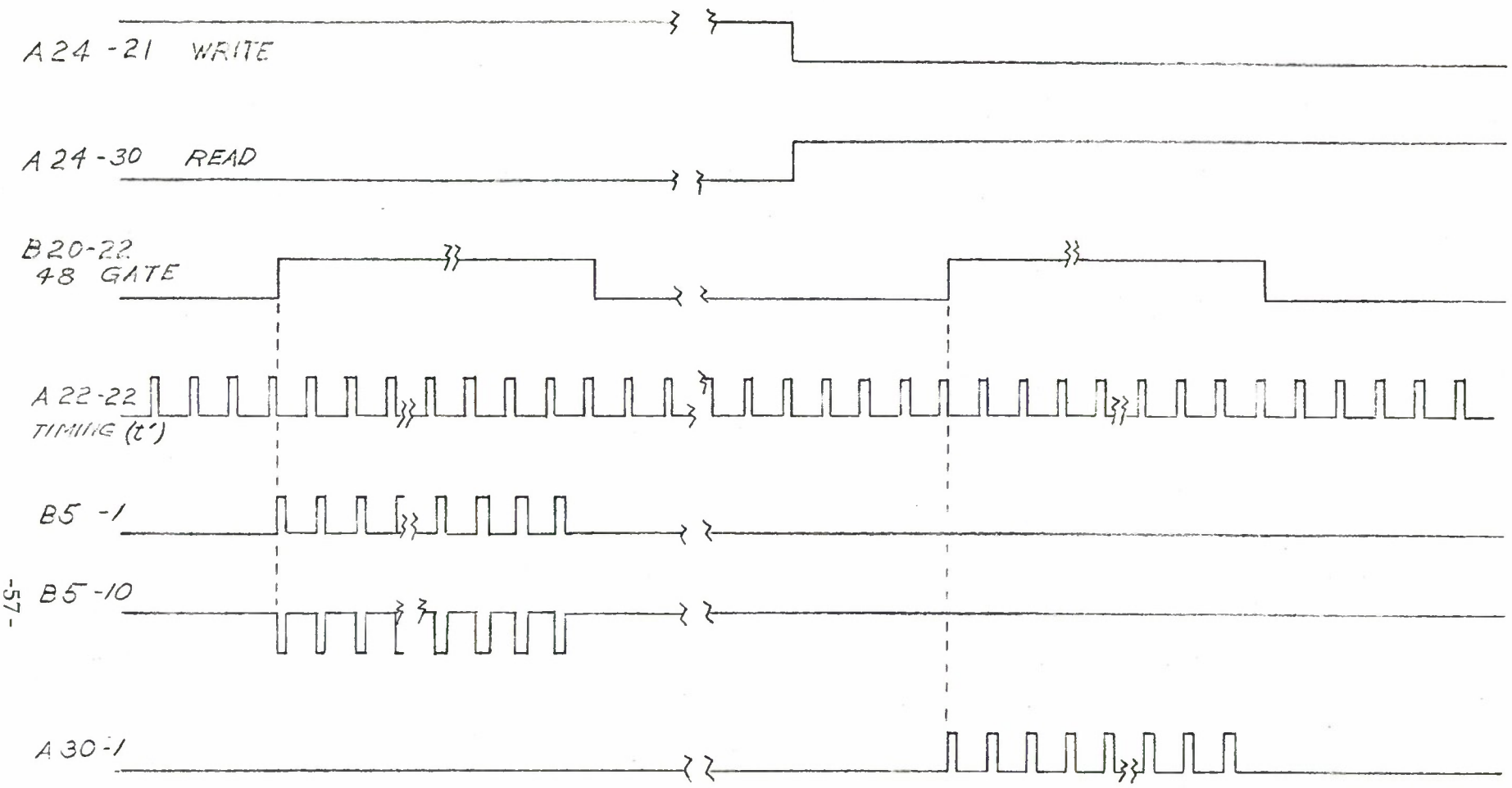


FIGURE 22A - TIMING DIAGRAM READ - WRITE CONTROL

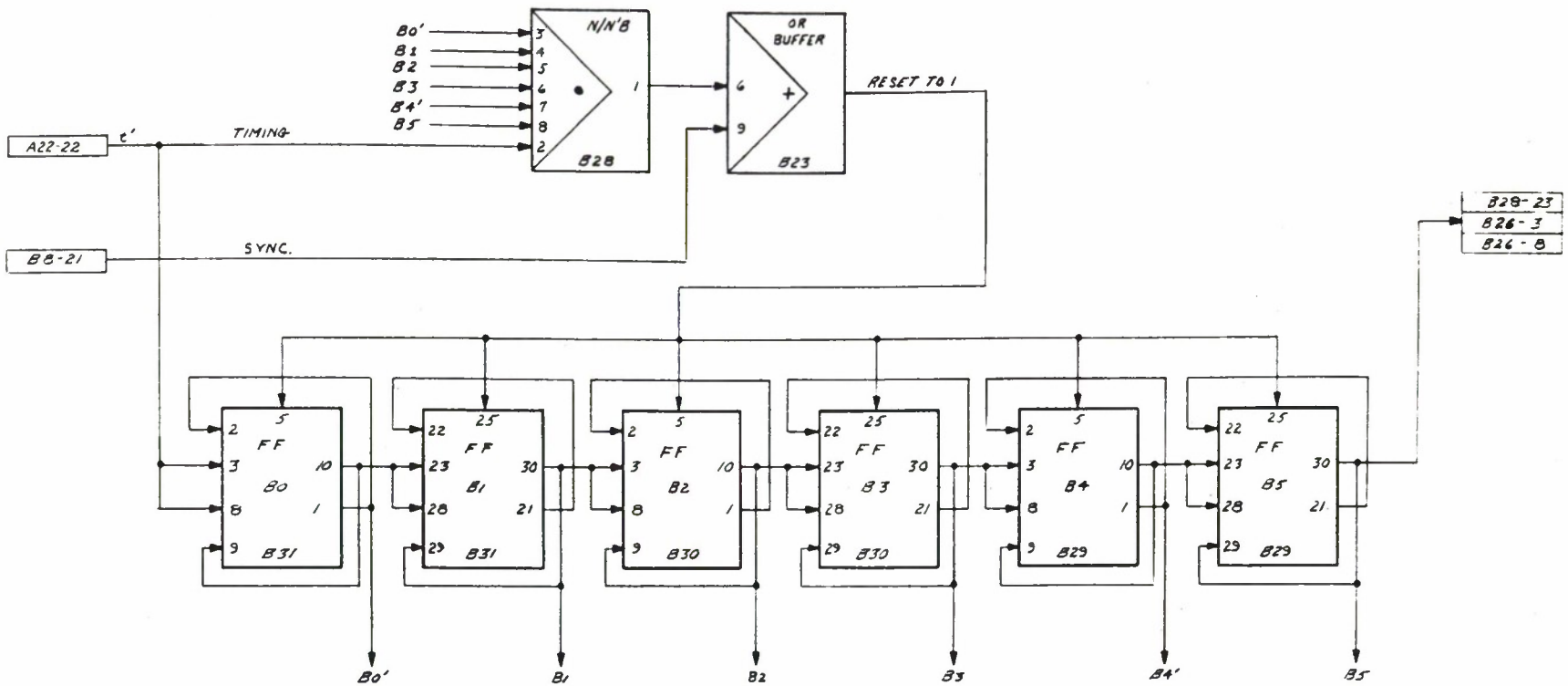


FIGURE- 23 A

C-12933

DRAWN BY	K. MOREY		
TRACED BY	D. WHITCOMB		
CHECKED BY			
APPROVED BY			
APPROVED BY			
DATE	1-31-61		
SCALE			

REQ. No. 11771

SHOP NOTES

CHANGES

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

BIT COUNTER
BLOCK DIAGRAM

FILE 21 | CHARGE 7 | DWG. NO. C-12933-

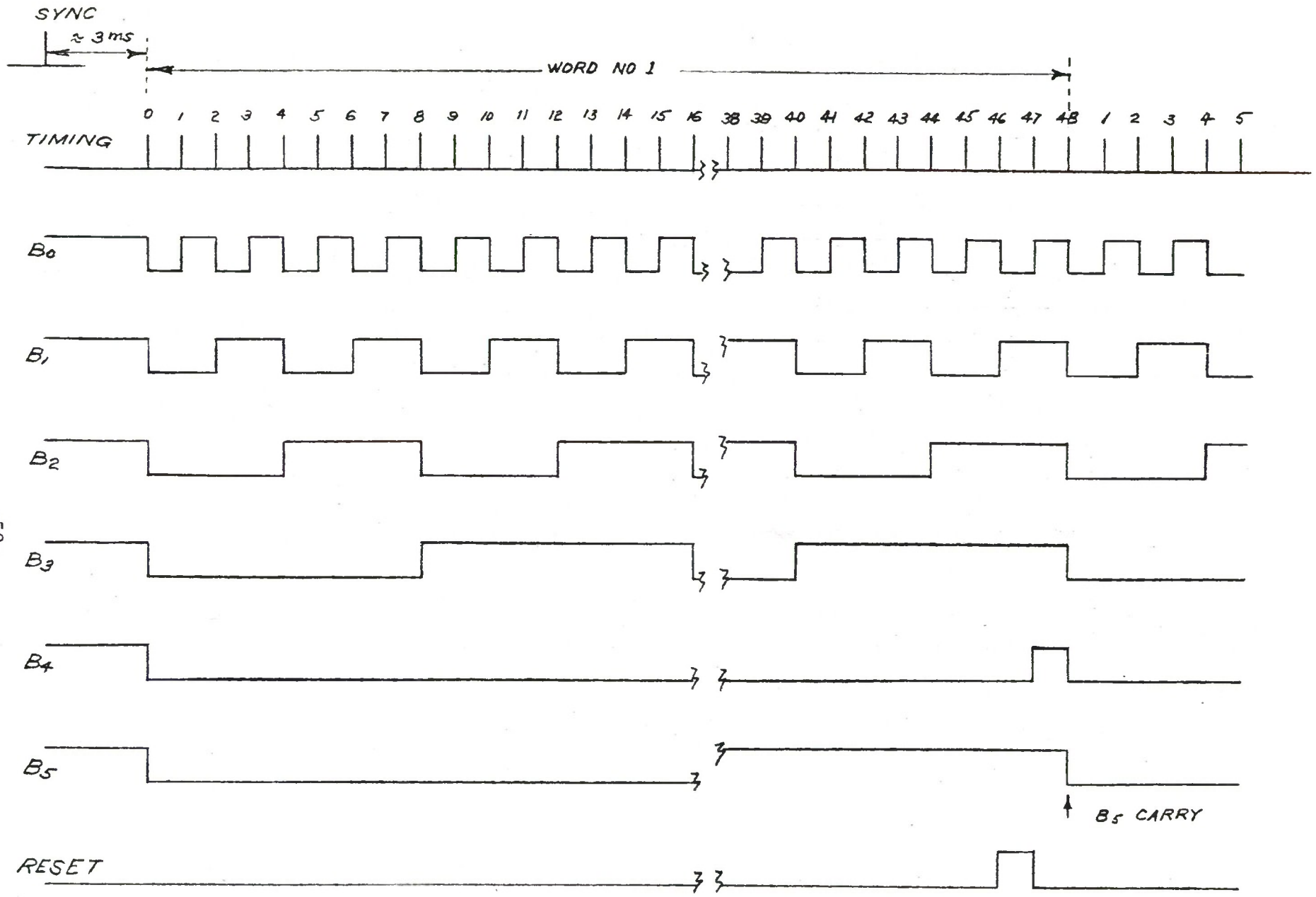
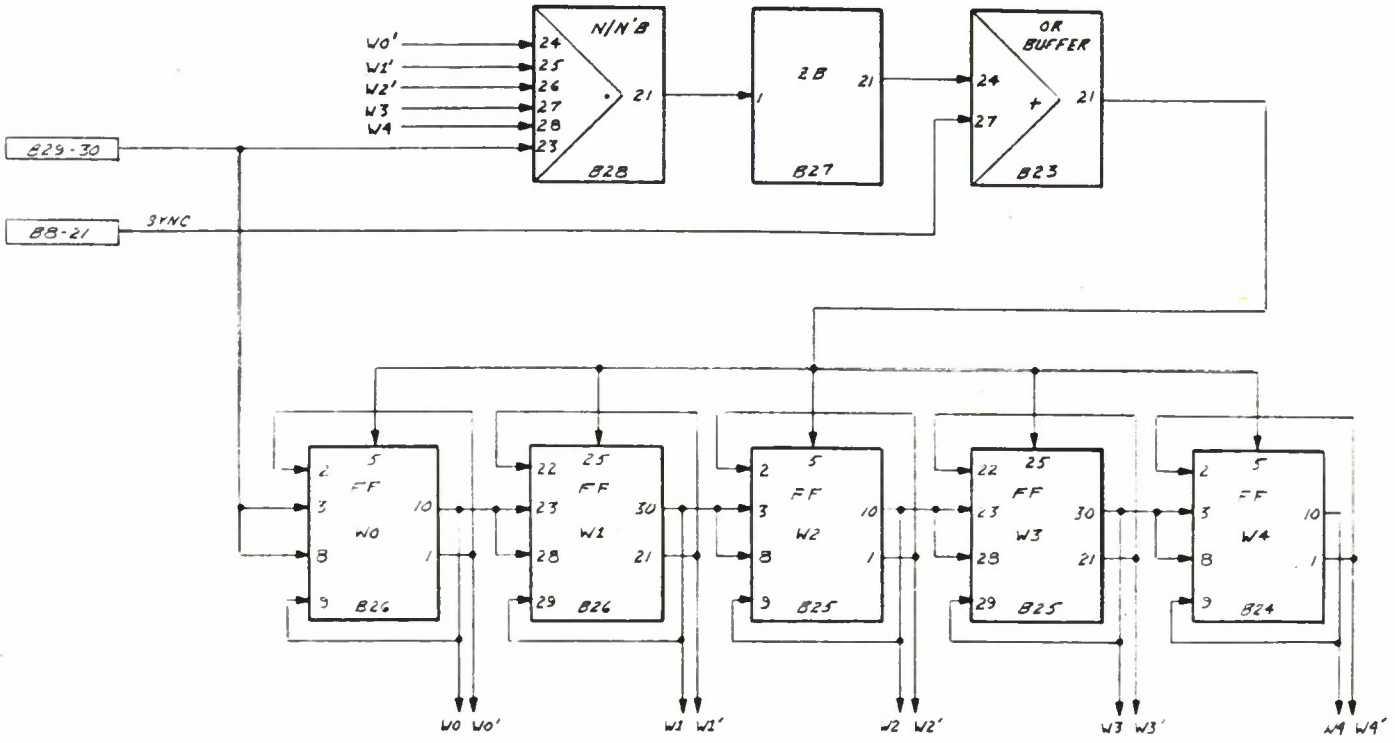


FIGURE 24A- TIMING DIAGRAM OF BIT COUNTER "B"



TO COMPARATOR

FIGURE- 25 A

C-12937

REQ NO. 11772	CHANGES
SHOP NOTES	DRAWN FOR Y. MORET
	DRAWN BY D. WHITCOMB
	CHECKED BY
	APPROVED BY
	APPROVED BY
	DATE 2-1-61
	SCALE

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS

WORD COUNTER
BLOCK DIAGRAM

FILE 21 | CHANGE 1 | DWG NO. C-12937-

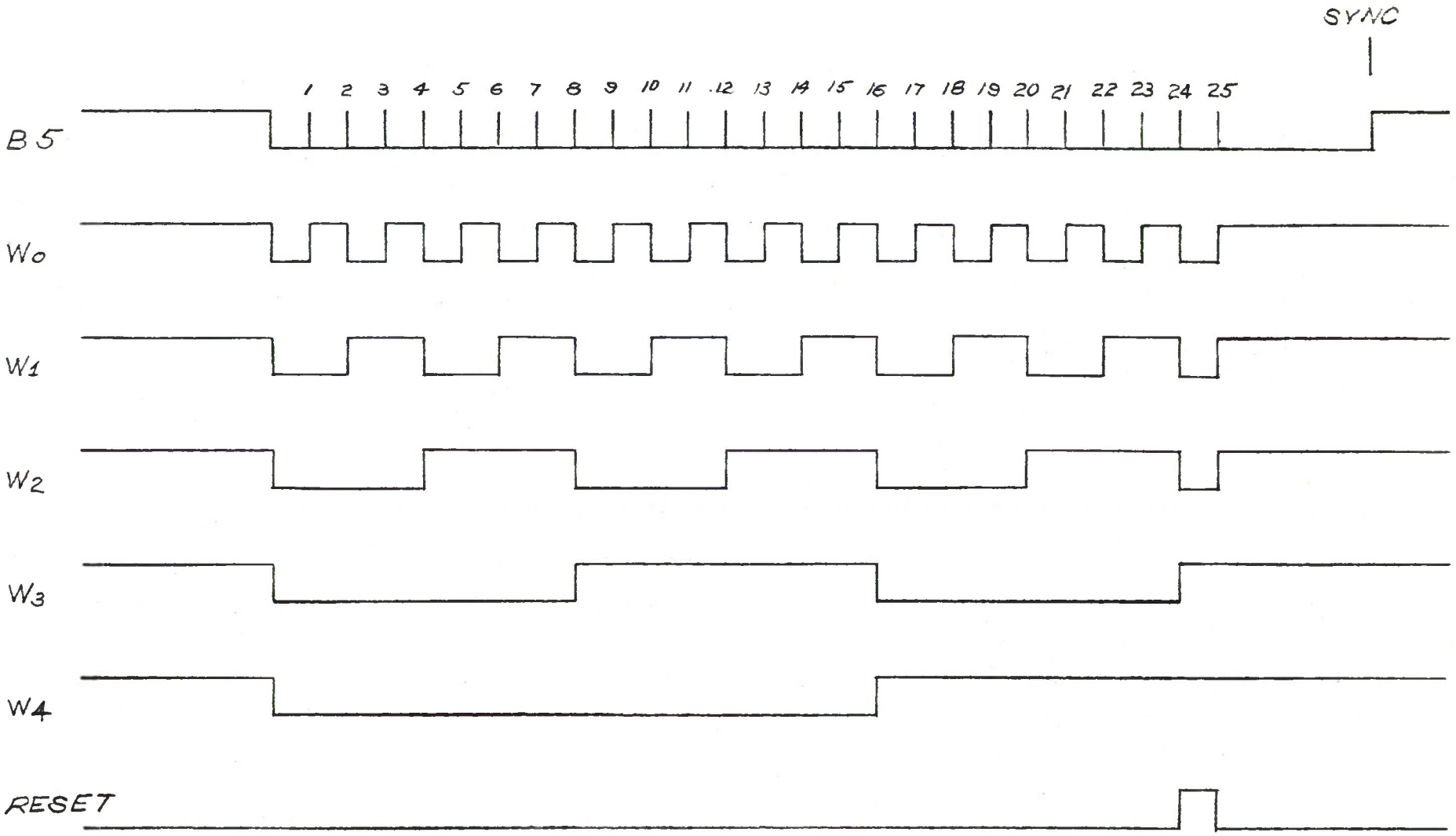
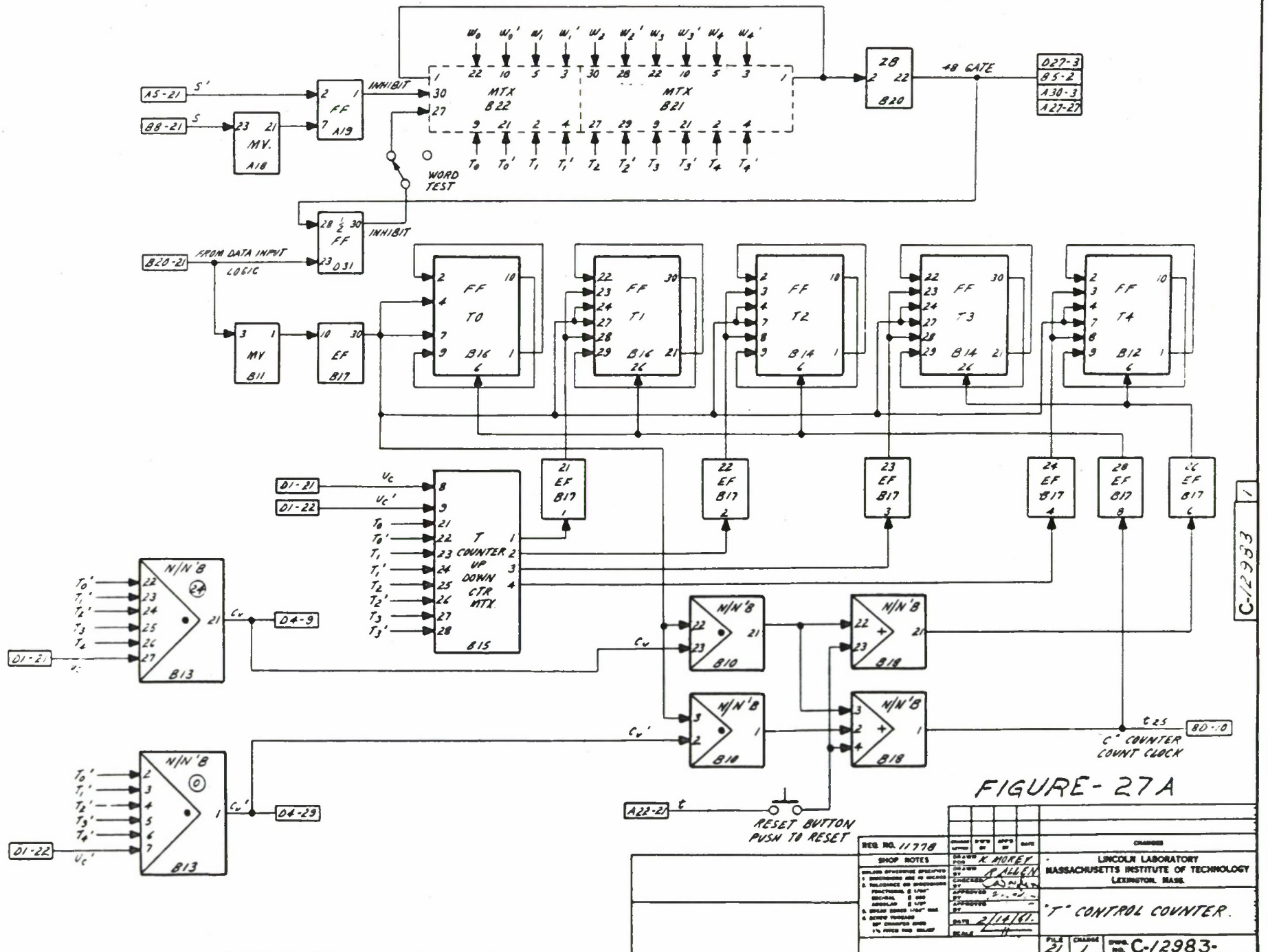
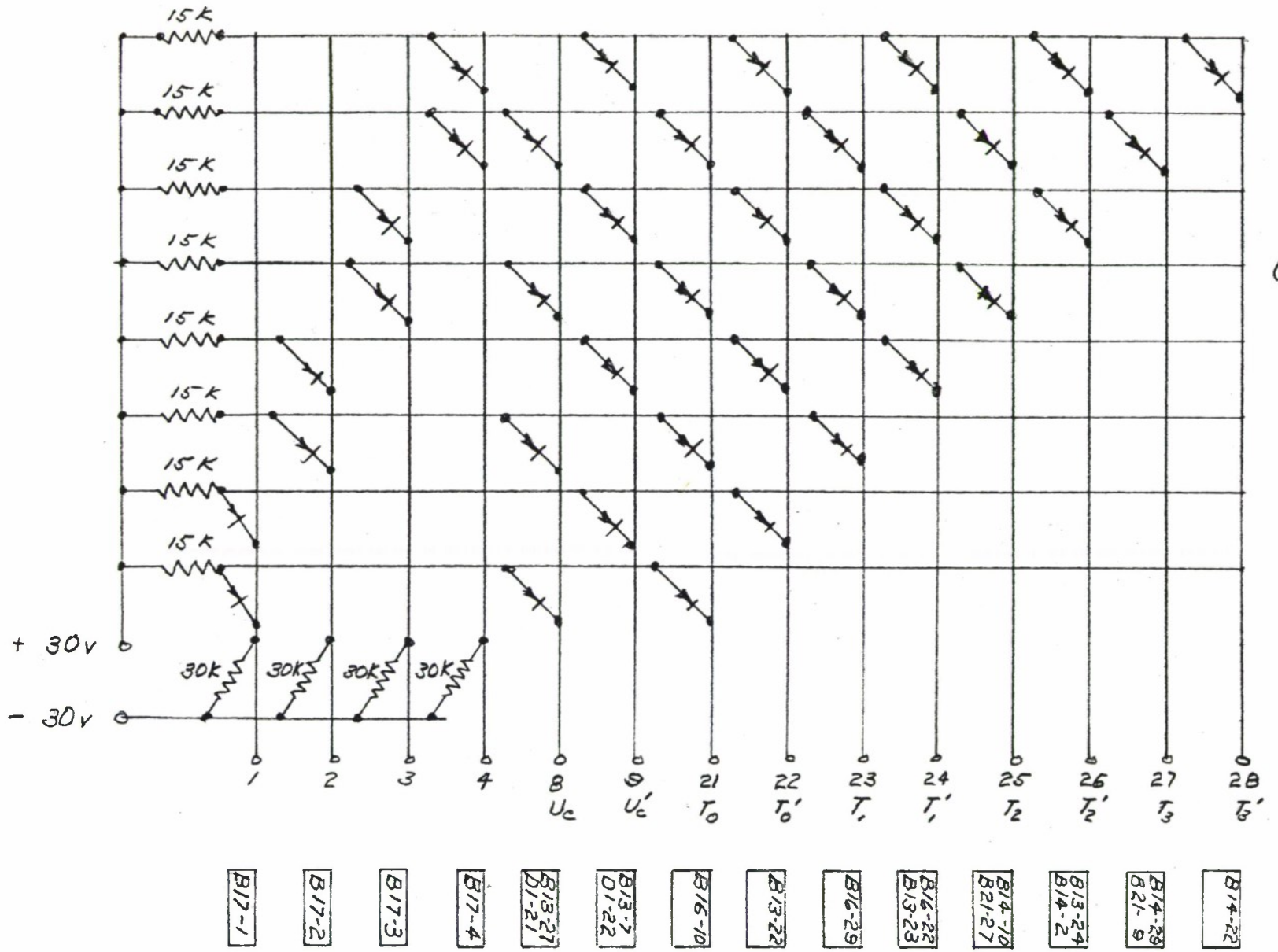


FIGURE 26A- TIMING DIAGRAM OF WORD COUNTER "W"


A5-21
S'
B8-21
S
MV. A18
FF A19
INHIBIT
MTX B22
MTX B21
WORD TEST
28 B20
48 GATE
D27-3
B5-2
A30-3
A27-27
28 1/2 30 FF 031
INHIBIT
B20-21
FROM DATA INPUT LOGIC
MV B11
EF B17
FF T0 B16
FF T1 B16
FF T2 B14
FF T3 B14
FF T4 B12
21 EF B17 1
22 EF B17 2
23 EF B17 3
24 EF B17 4
28 EF B17 8
CC EF B17 C
D1-21
D1-22
T COUNTER UP DOWN CTR MTX B15
N/N'8 B13
D4-9
N/N'8 B10
N/N'8 B18
C" COUNTER COUNT CLOCK
80-10
A22-21
RESET BUTTON PUSH TO RESET
C-12983 1
FIGURE-27A
REQ. NO. 11778
SHOP NOTES
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
"T" CONTROL COUNTER.
FILE 21
CHANGE 1
DWG. NO. C-12983-



DIODES:
S347G
(TRANSITRON)

FIGURE 28A-"T" COUNTER UP-DOWN PARALLEL CONTROL MATRIX (B15)

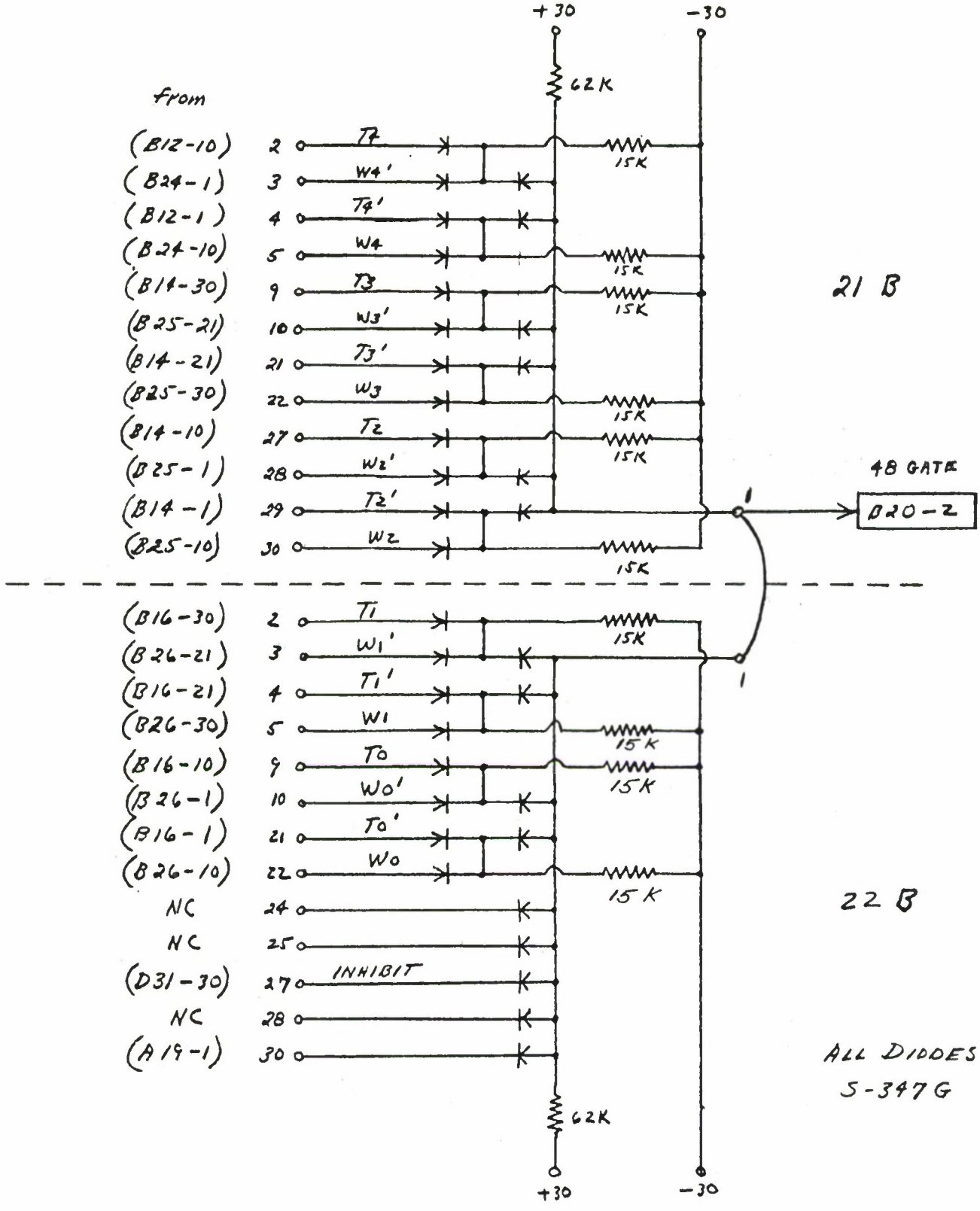


FIGURE 29A-COMPARATOR MTX
(2 CARDS)

K. H. MOREY

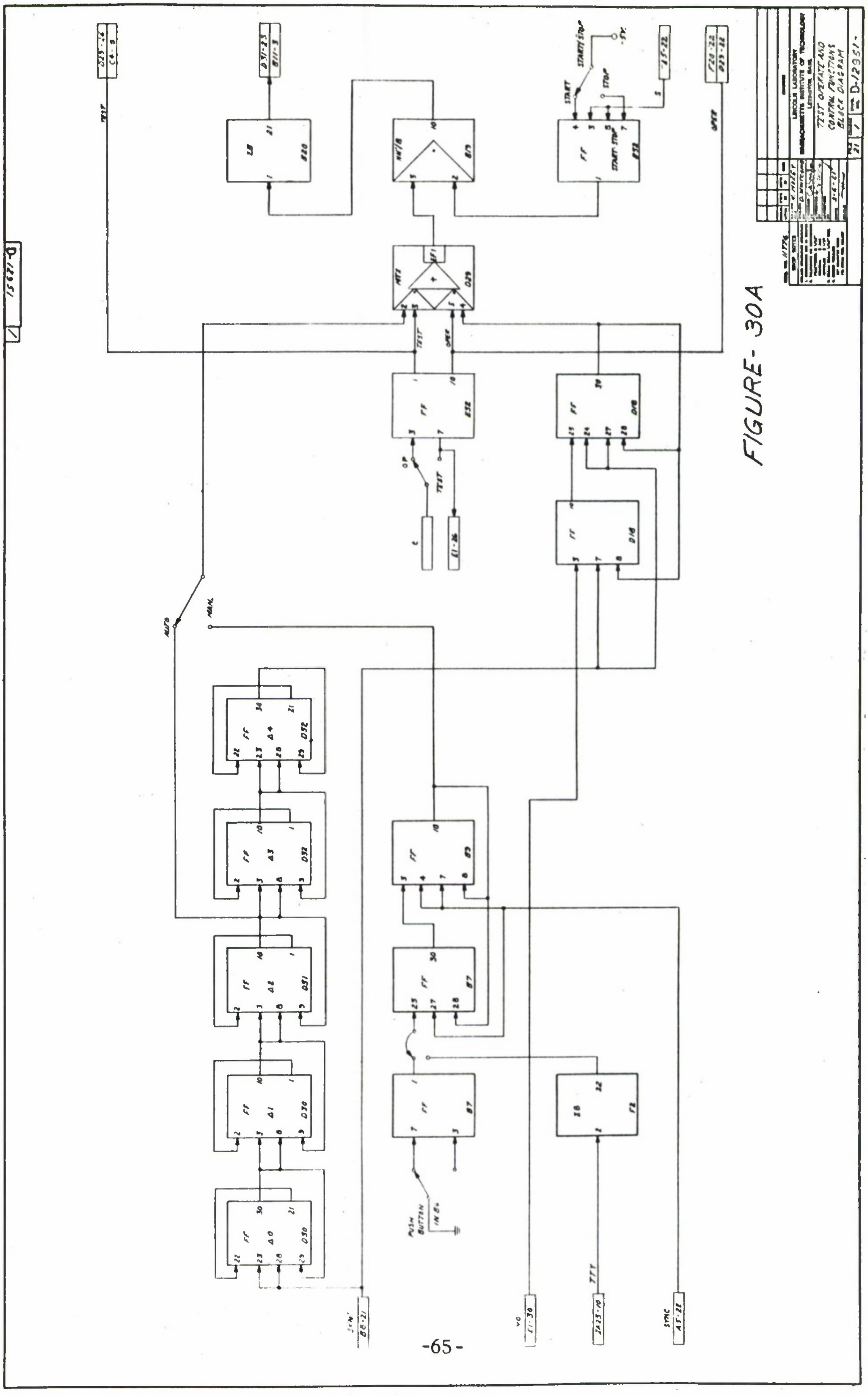

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
TEST OPERATE AND CONTROL FUNCTIONS BLOCK DIAGRAM
D-12951

FIGURE- 30A

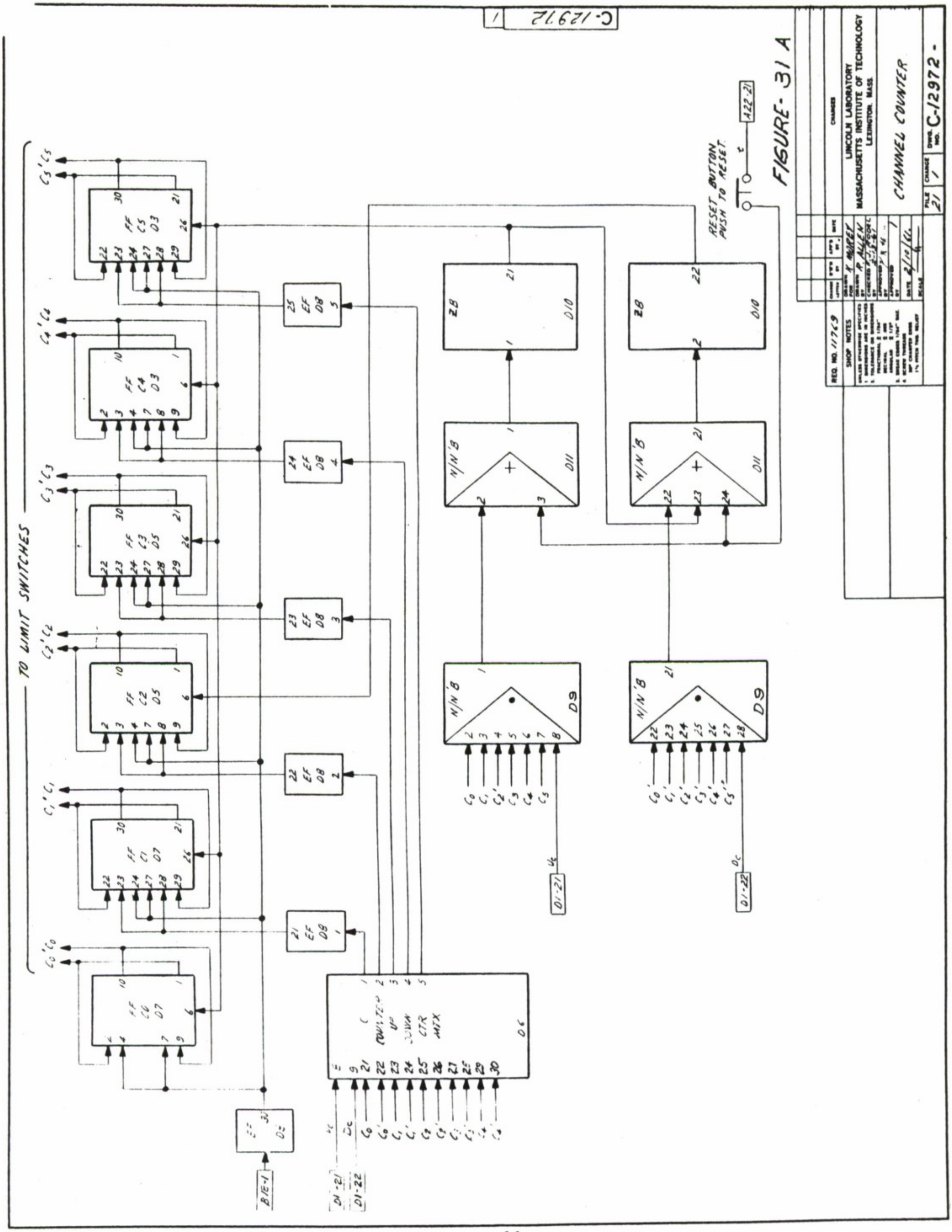

TO LIMIT SWITCHES
RESET BUTTON PUSH TO RESET.
CHANNEL COUNTER
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
C-12972

FIGURE- 31 A

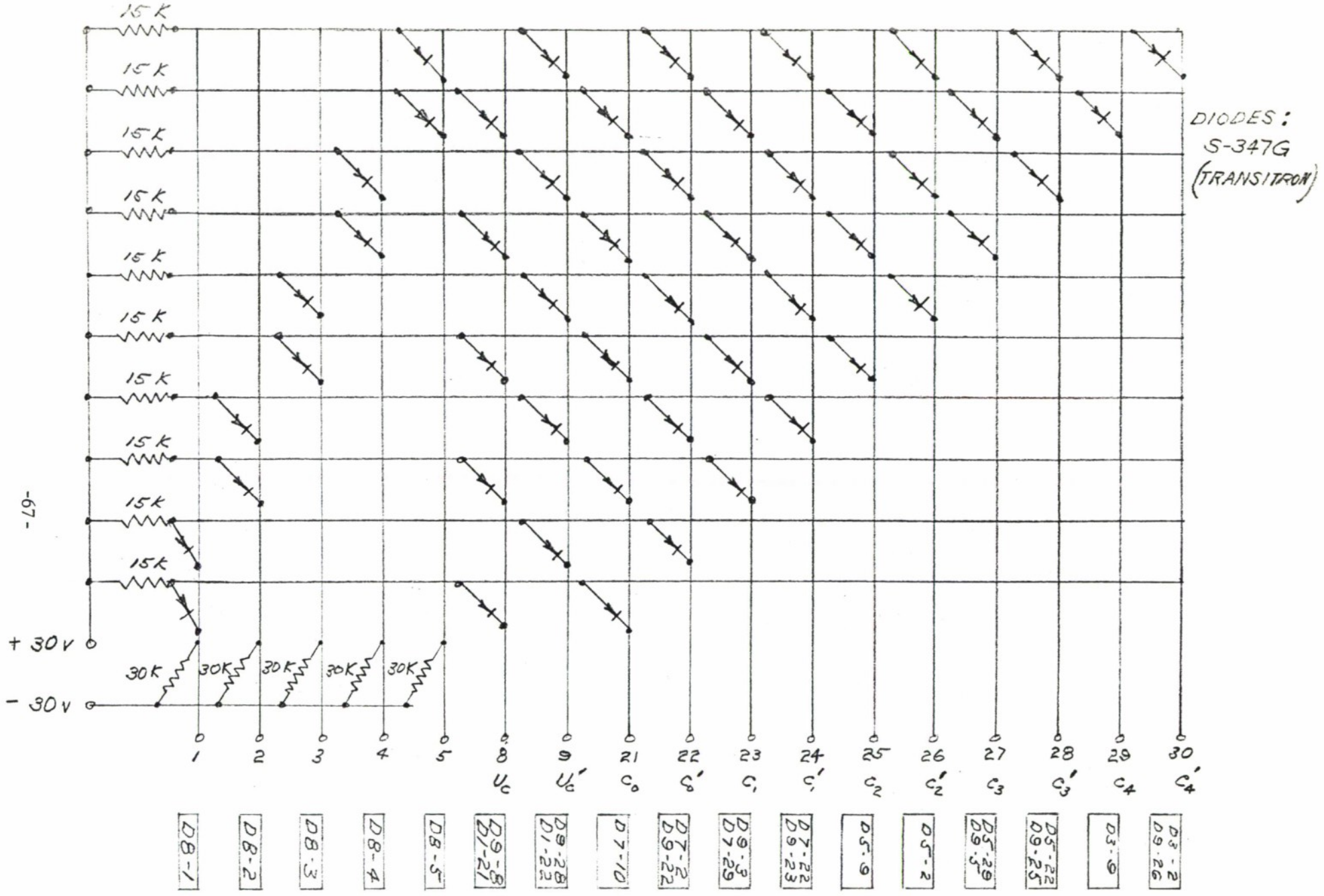


FIGURE 32A - CHANNEL COUNTER UP-DOWN PARALLEL CONTROL MTX.

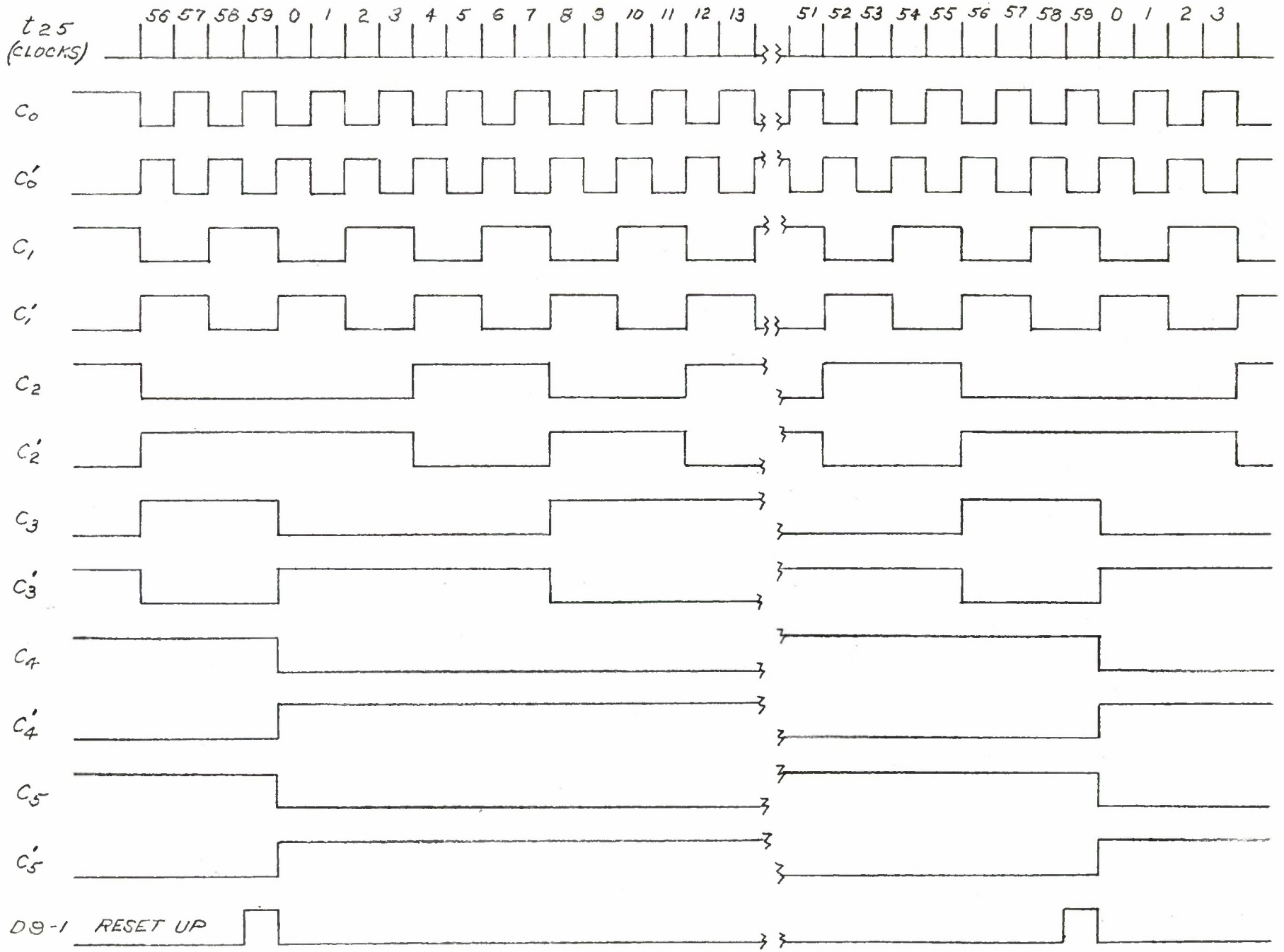


FIGURE 33A - TIMING DIAGRAM OF CHANNEL COUNTER "C"

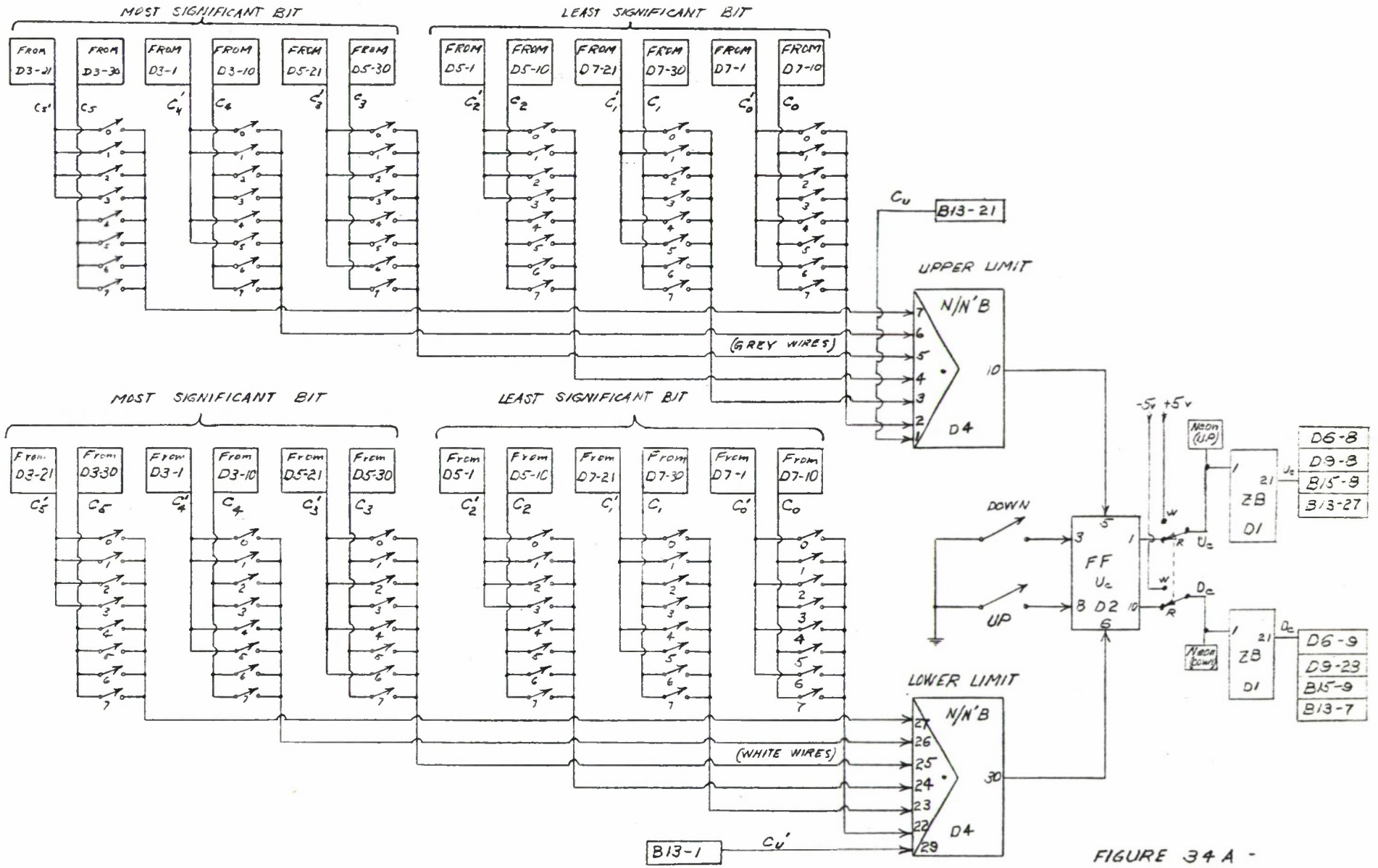


FIGURE 34 A -

SCAN LIMIT SWITCH

K H MURRAY

B- 13376 /

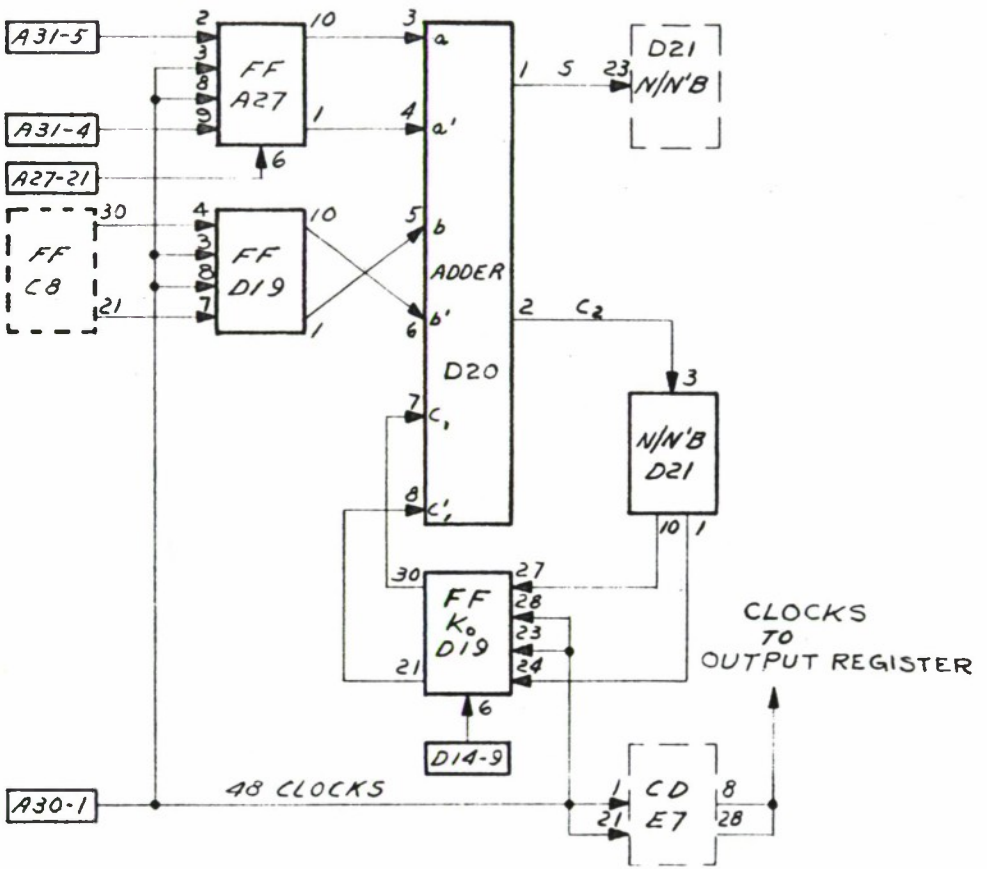


FIGURE - 35 A

-70-

CHANGE LETTER	BY	APP'D BY	DATE	CHANGES

REQ. NO. 12037

SHOP NOTES

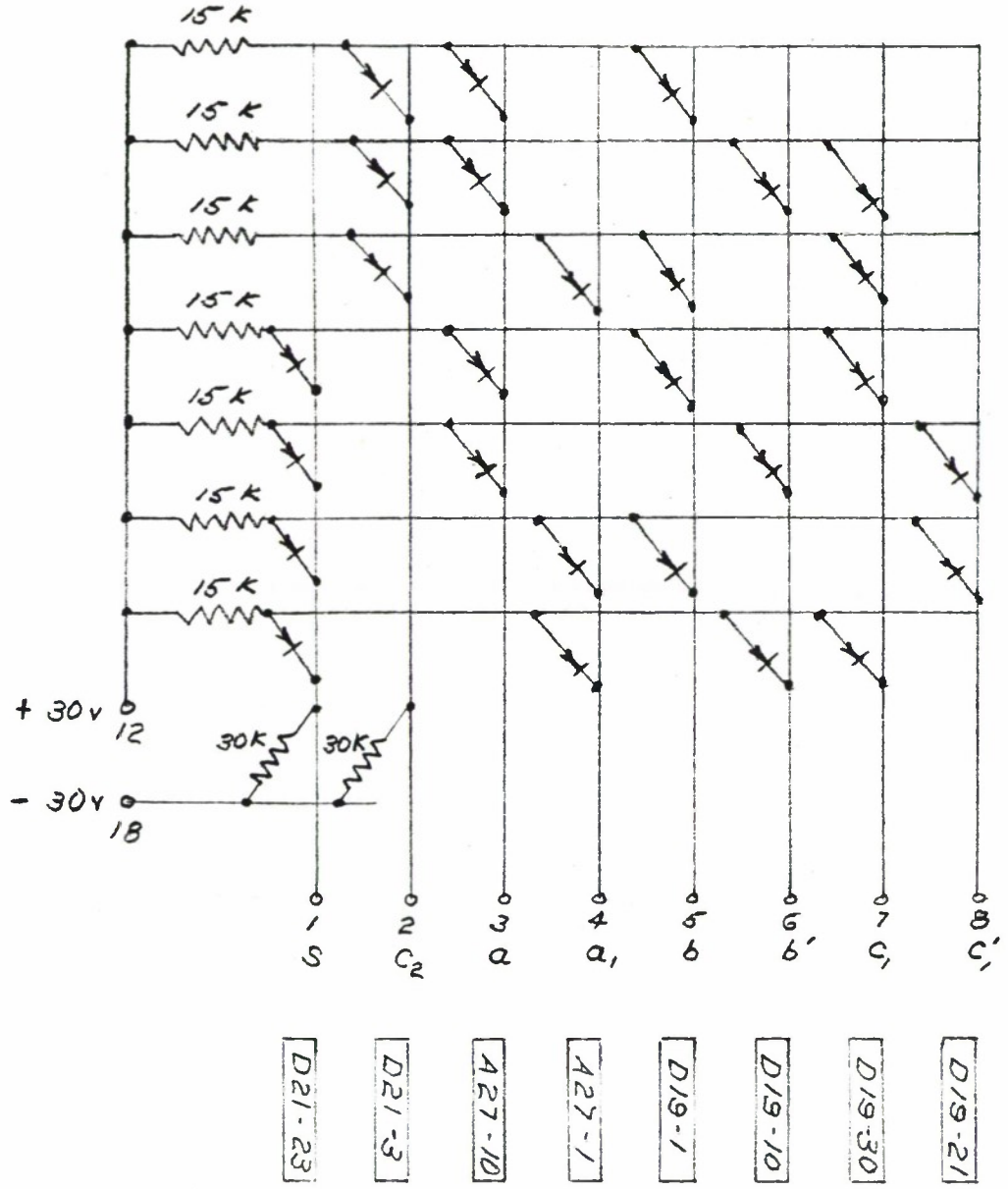
UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
30° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR	K. MOREY
DRAWN BY	R.G. BROOK
CHECKED BY	
APPROVED BY	
APPROVED BY	
DATE	5-1-61
SCALE	

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

ARITHMETIC UNIT

FILE	CHANGE	DWG. NO.
21	1	B-13376 -



$S = \acute{a}\acute{b}c_1 + \acute{a}bc_1' + a\acute{b}c_1' + abc_1$

$C_2 = \acute{a}bc_1 + a\acute{b}c_1 + ab$

DIODES : S-347 G
(TRANSITRON)

FIGURE 36A - ARITHMETIC UNIT MATRIX (D 20)

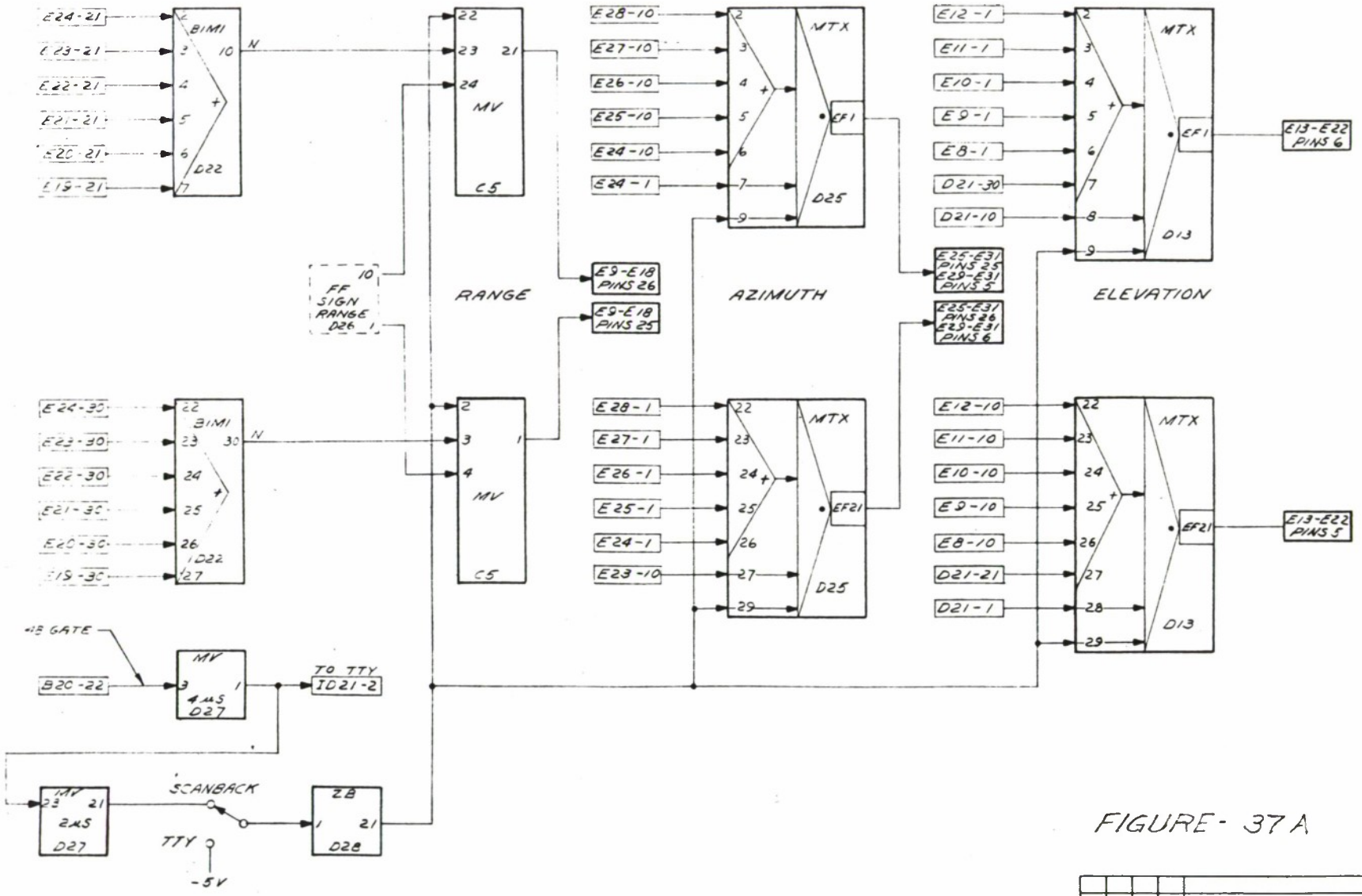


FIGURE - 37A

REQ. NO. 11779			
SHOP NOTES	DRAWN FOR	R.H. MOREY	LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON, MASS.
	DRAWN BY	R.G. BROOK	
	CHECKED	F.J. RODAL 2-10-61	
	APPROVED	R.H. MOREY	OUTPUT REGISTER RESET MAX. ERROR FUNCTION
	APPROVED BY		
	DATE	2-10-61	
	SCALE		FILE 21 / CHANGE 1 / DWG. NO. C-12970-

C-12970 1

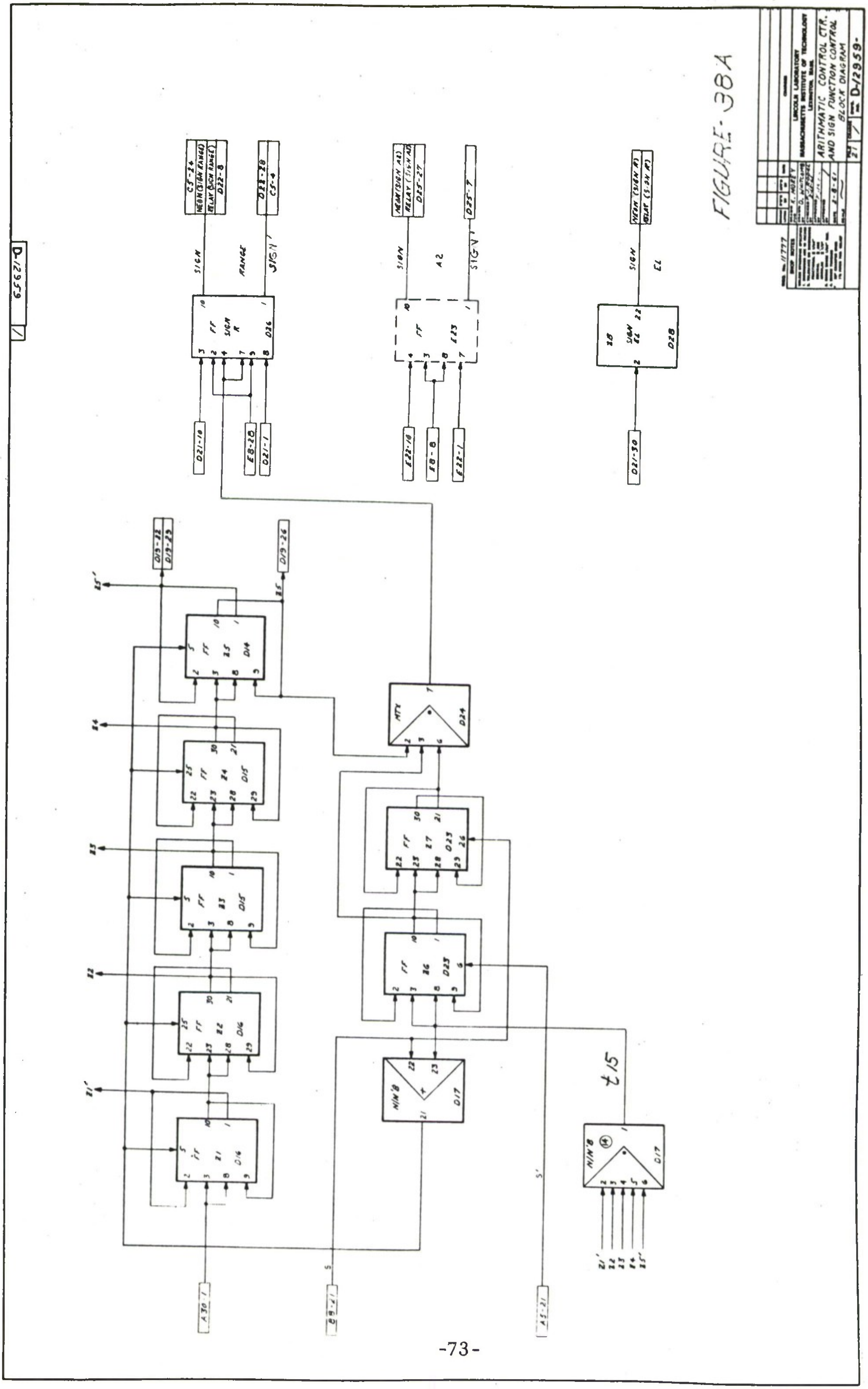
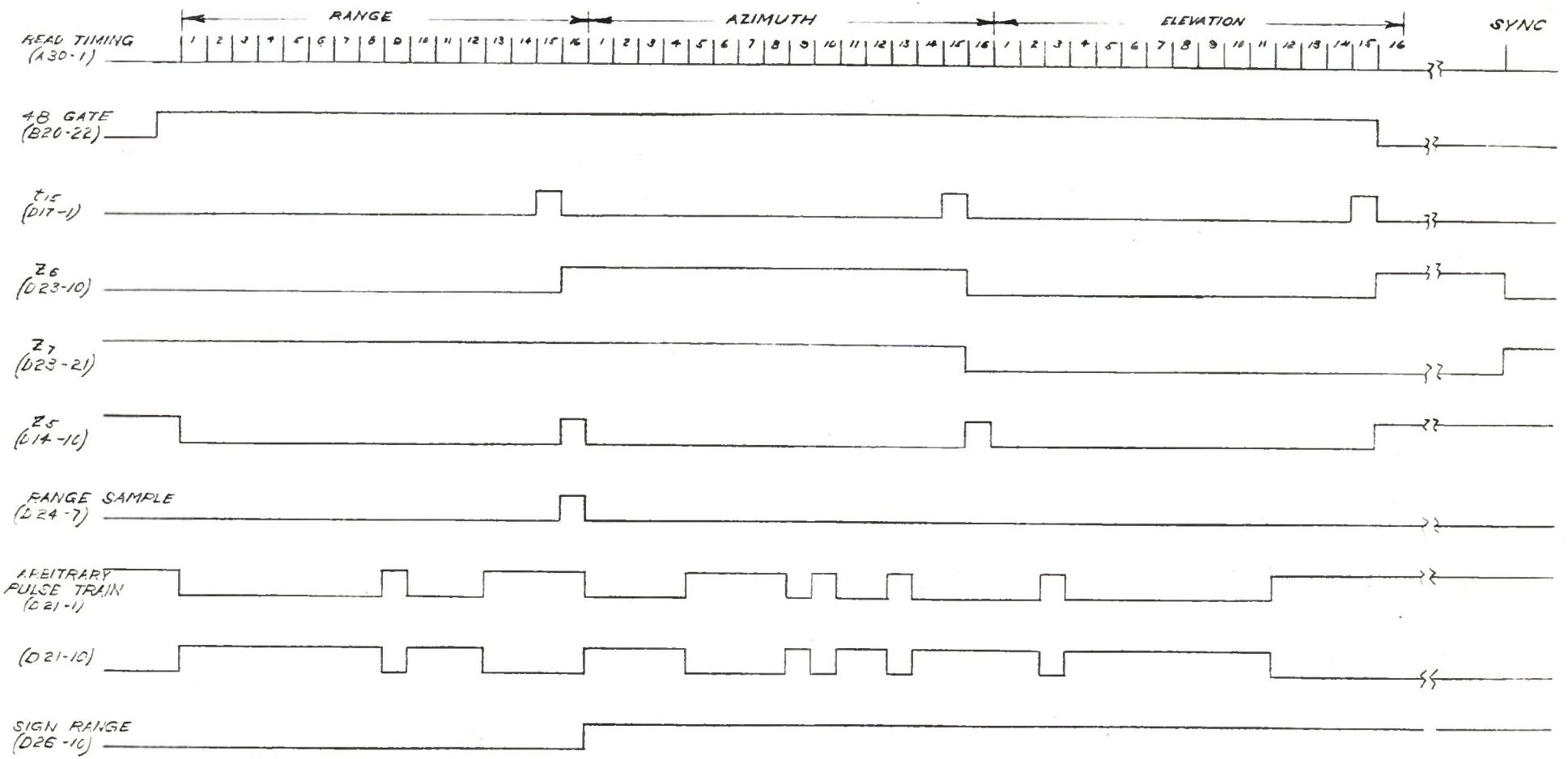


FIGURE 38A
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
ARITHMATIC CONTROL CTR.
AND SIGN FUNCTION CONTROL
BLOCK DIAGRAM
D-12959



1 - THE SIGN OF ELEVATION IS (D21-10)

2 - THE SIGN OF AZIMUTH IS GENERATED BY SAMPLING THE 16th AZ BIT WHICH IS EQUAL TO 180°

FIGURE 39 A - SIGN FUNCTION TIMING DIAGRAM

D-13348 1

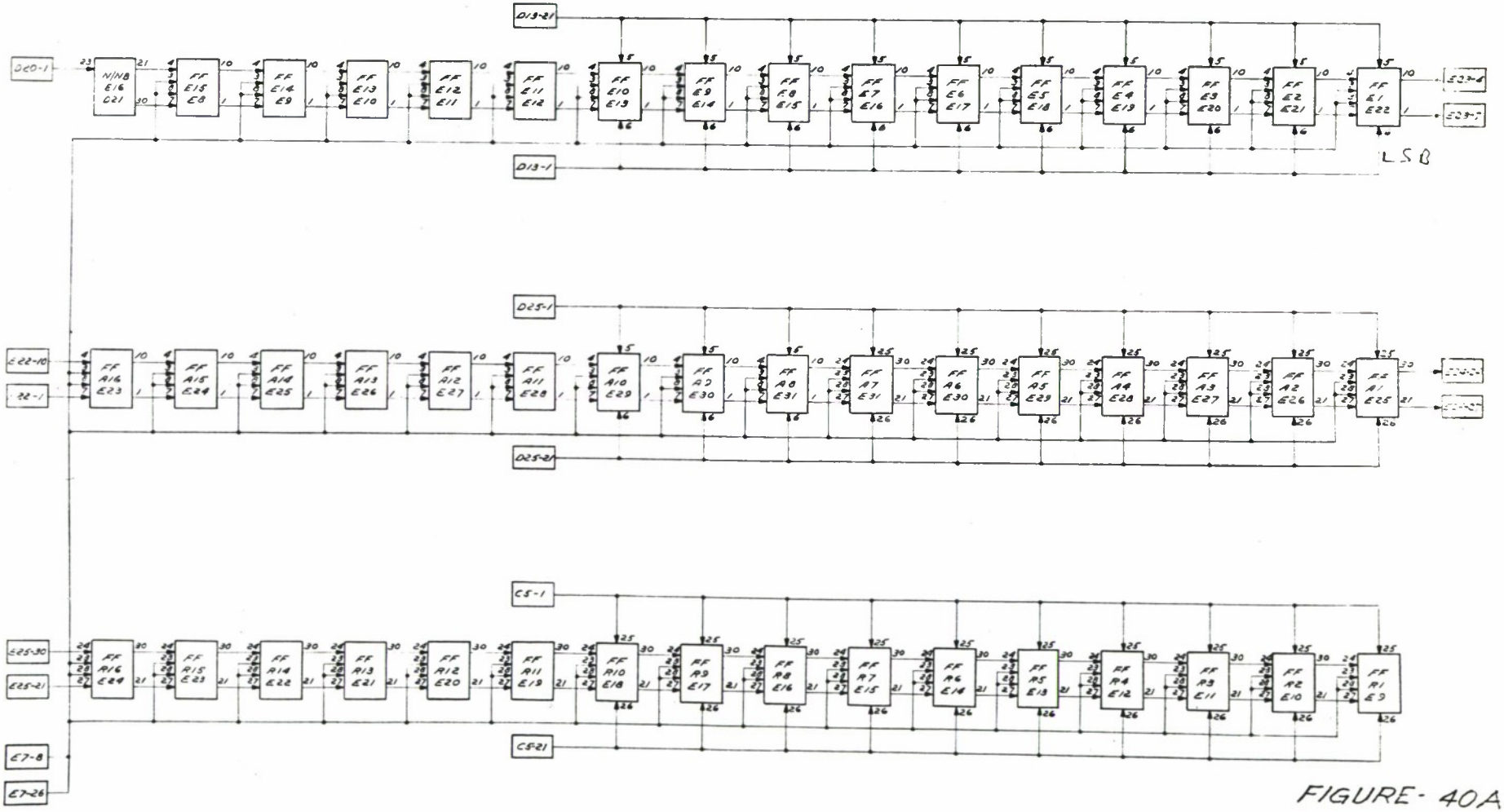
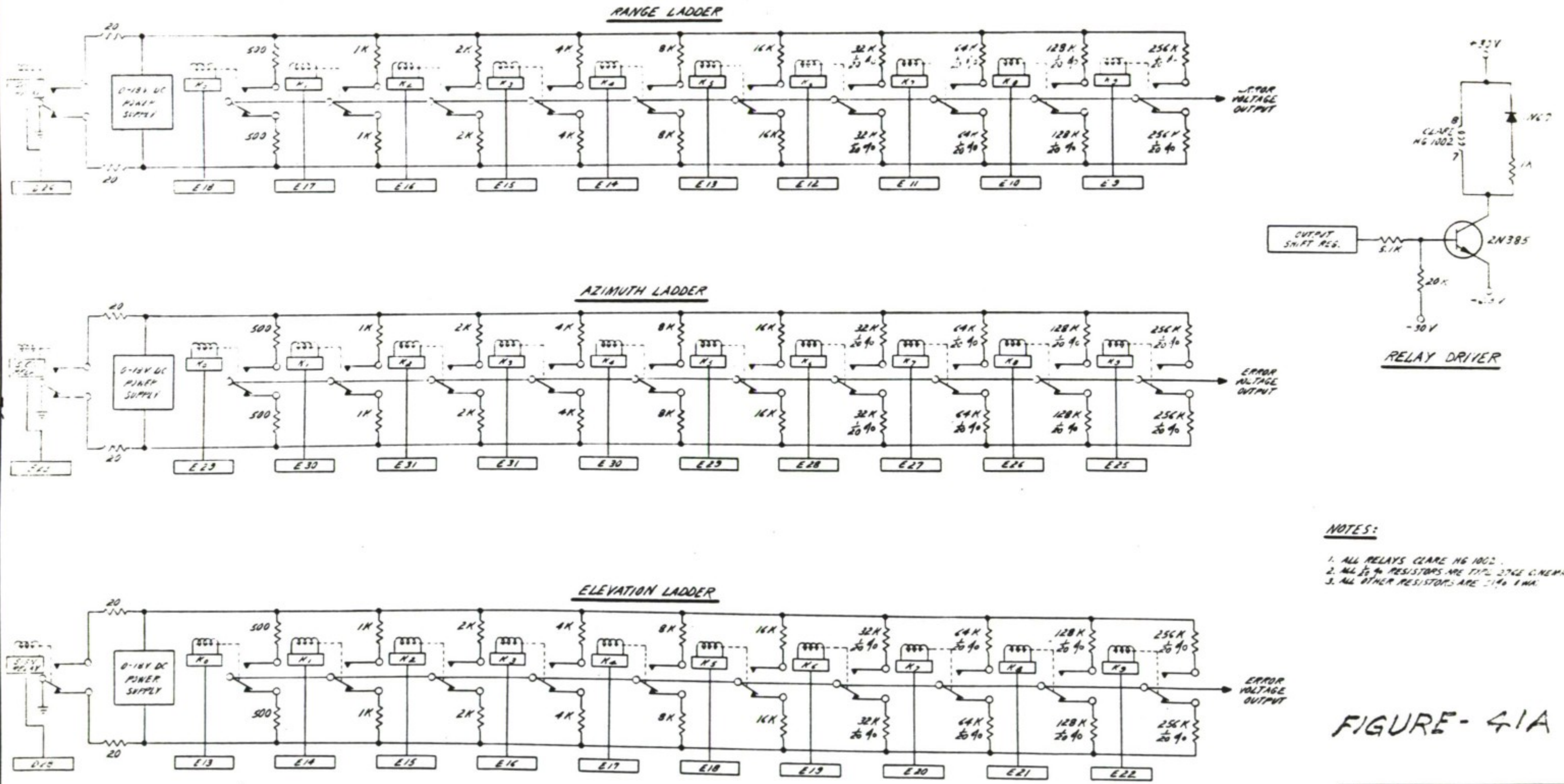


FIGURE - 40A

SHOP NOTES	DRAWN K. MOREY	LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON, MASS.	
	ENG. SUPPORT	OUTPUT SHIFT REGISTER	
	DATE 4-24-61	SIZE 21	D-13348-



NOTES:

1. ALL RELAYS CLARE HG 1002.
2. ALL 1/20 % RESISTORS ARE TYPE 276E C.NEMA
3. ALL OTHER RESISTORS ARE ±1% 1 WA.

FIGURE- 41A

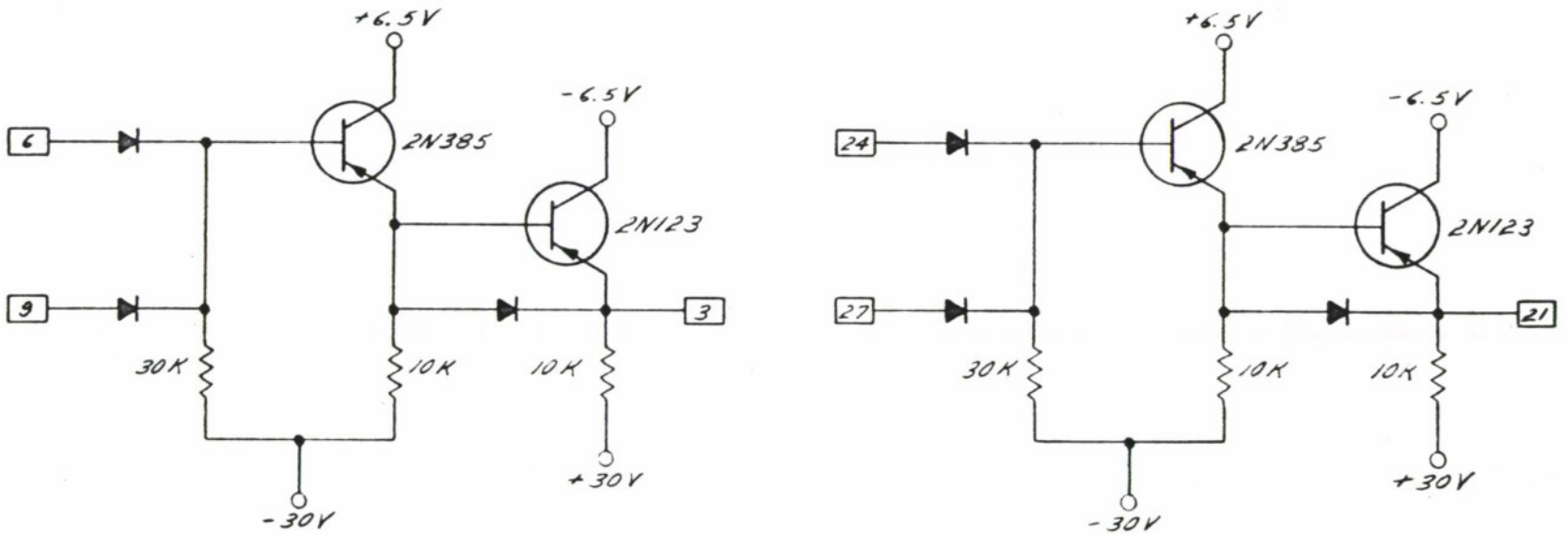
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

SCANBACK DIGITAL ANALOG CONVERTER (SCHEMATIC)

D-13372

SCHEMATIC NOTES

B-13484 /



NOTE:

ALL DIODES S 347 G

FIGURE 42.A

SCHEMATIC NOTES UNLESS OTHERWISE SPECIFIED RESISTANCE CAPACITANCE INDUCTANCE RESISTORS ½ W ± 5%						
CHANGE LETTER	D.W.G. BY	APP'D BY	DATE	CHANGES		

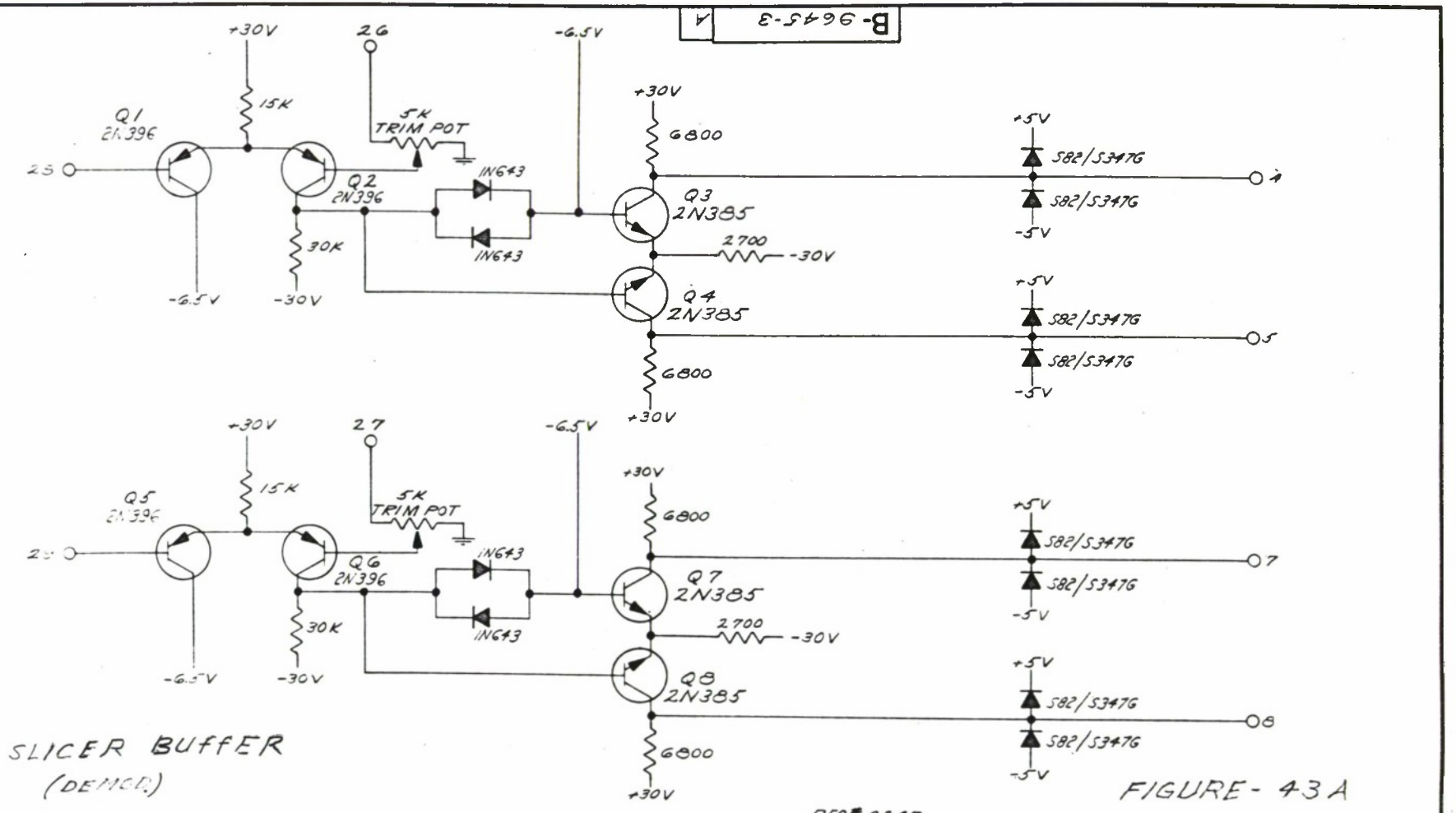
REQ. NO. 12149	
SHOP NOTES UNLESS OTHERWISE SPECIFIED 1. DIMENSIONS ARE IN INCHES 2. TOLERANCE ON DIMENSIONS FRACTIONAL ± 1/64" DECIMAL ± .000 ANGULAR ± 1/2° 3. BREAK EDGES 1/64" MAX. 4. SCREW THREADS 30° CHAMFER EDGE 1½ PITCH THD RELIEF	DRAWN FOR A.M. COLES DRAWN BY R. ALLEN CHECKED BY I.M.F. APPROVED BY I.M. Ches APPROVED BY DATE 6/5/61 SCALE

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

OR BUFFER
SLOT B-23
SCHEMATIC.

FILE	CHANGE	DWG. NO.
21	1	B-13484-

-11-



SLICER BUFFER
(DEMOD.)

FIGURE - 43A

REQ.# 9347

SHOP NOTES	DRAWN FOR	K. MOREY
UNLESS OTHERWISE SPECIFIED	DRAWN BY	G.A.S. PARFILO
1. TOLERANCE ON DIMENSIONS FRACTIONAL ± 1/64" DECIMAL ± .005 ANGULAR ± 1/2°	CHECKED BY	
2. BREAK EDGES 1/64" MAX.	APPROVED BY	
3. SCREW THREADS 30° CHAMFER ENDS 1½ PITCH THD. RELIEF	APPROVED BY	
	DATE	2-17-59
	SCALE	

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES
A	A.G.	C.L.J.	10/1/59	SEE CHANGE REQ. NO. 4875

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE — CAPACITANCE — INDUCTANCE
Ω f h
RESISTORS ½ W. ± 5%

LINCOLN LABORATORY (M)
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

ARPA
DEMODULATOR
CARD - 3 - 21PW 1255

FILE	CHANGE	DWG. NO.
21	A	B-9645-3

A-13479

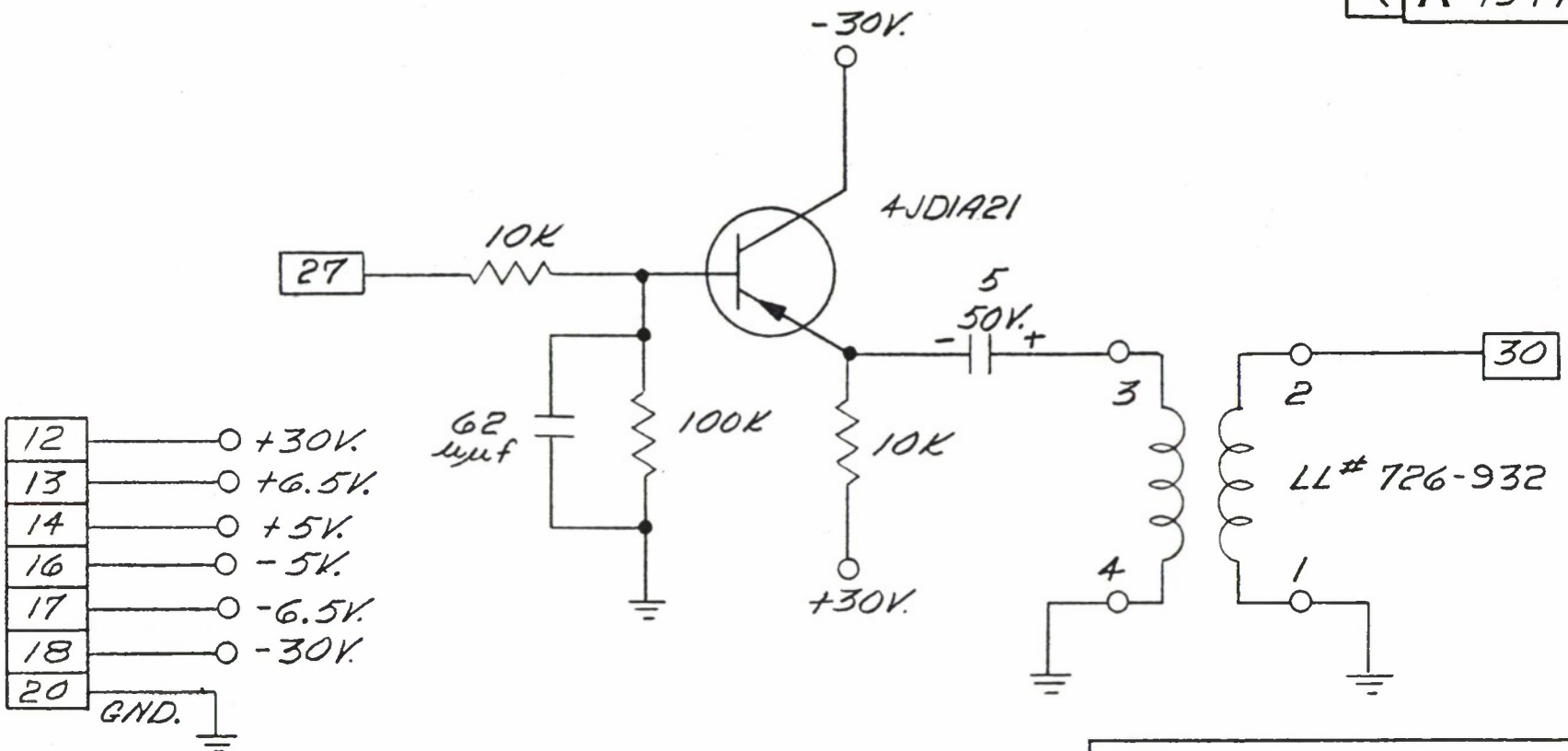


FIGURE - 44A

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
Ω μf h
RESISTORS ½ W. ± 5%

REQ. NO. 12152

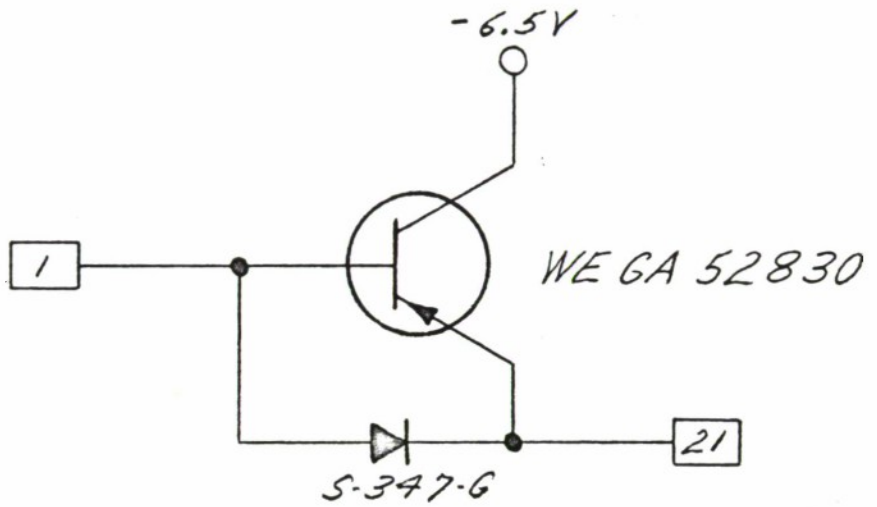
SHOP NOTES	
UNLESS OTHERWISE SPECIFIED	DRAWN FOR R.M. COLES
1. TOLERANCE ON DIMENSIONS	DRAWN BY D. WHITCOMB
FRACTIONAL ± 1/64"	CHECKED BY
DECIMAL ± .005	APPROVED BY R.M. Coles
ANGULAR ± 1/2°	APPROVED BY
2. BREAK EDGES 1/64" MAX.	DATE JUNE 2, 1961
3. SCREW THREADS	SCALE H
30° CHAMFER ENDS	
1¼ PITCH THD. RELIEF	

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

TIMING FILTER
SLOT A7
SCHEMATIC

FILE	CHANGE	DWG. NO.
21	1	A-13479-



-80-

FIGURE - 45A

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
A f h
RESISTORS ½W ±5%

REQ. No. 12150

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES

SHOP NOTES

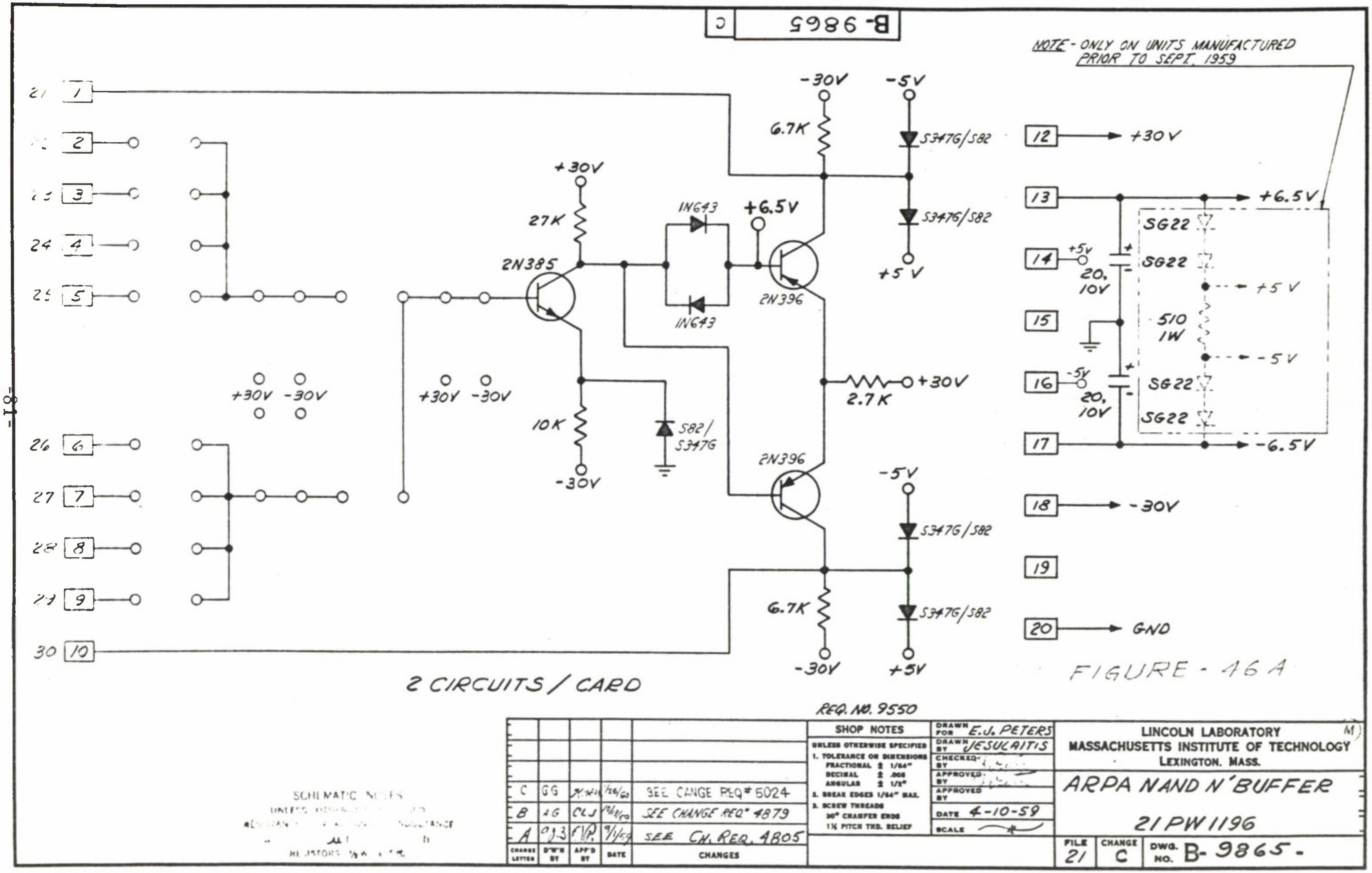
UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64'
DECIMAL ± .005
ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
30° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR R.M. COLES
DRAWN BY R. ALLEN
CHECKED BY
APPROVED BY RM Coles
APPROVED BY
DATE 6/2/61.
SCALE —H—

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

EF SPECIAL
SLOT B3
SCHEMATIC.

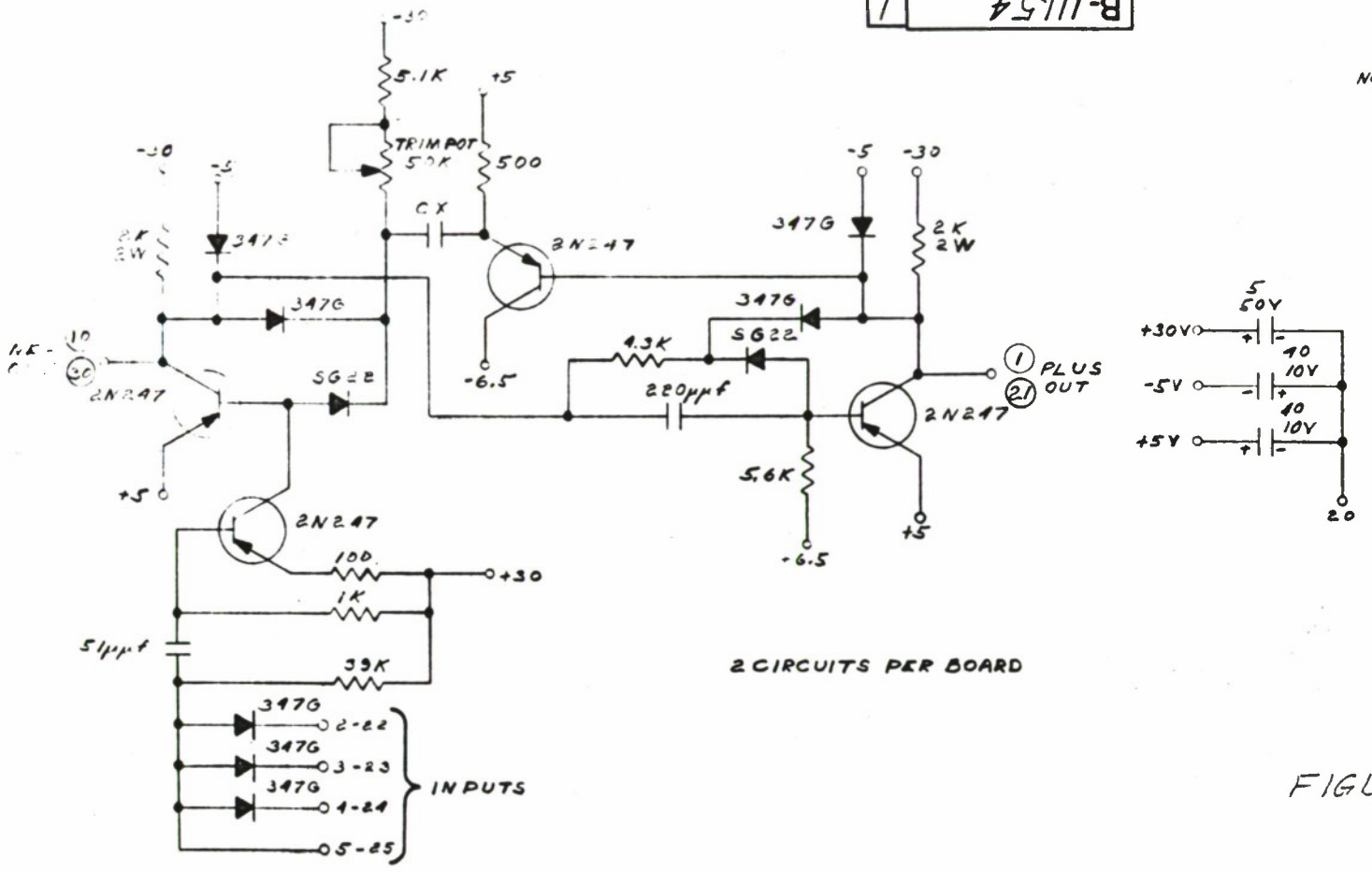
FILE	CHANGE	DWG. NO.
21	1	A-13480 -



B-9865 C
NOTE - ONLY ON UNITS MANUFACTURED PRIOR TO SEPT. 1959
2N385
2N396
IN643
6.7K
27K
10K
2.7K
S347G/S82
S82/S347G
+6.5V
+30V
-30V
-5V
+5V
SG22
510 1W
20, 10V
-6.5V
GND
2 CIRCUITS / CARD
REQ. NO. 9550
SHOP NOTES
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.
ARPA NAND N' BUFFER
21PW1196
DRAWN FOR E.J. PETERS
DRAWN BY JESULAITIS
DATE 4-10-59
C SEE CANGE REQ# 5024
B SEE CHANGE REQ* 4879
A SEE CH. REQ. 4805
FILE 21
CHANGE C
DWG. NO. B-9865-

FIGURE - 46 A

B-11154 | 1



NOTE
CX IS VARIABLE CAPACITOR TO DETERMINE PULSE WIDTH

FIGURE - 47A

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
Ω μf h
RESISTORS ½W ± 5%

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES

REQ. NO. 10282

SHOP NOTES
UNLESS OTHERWISE SPECIFIED
1. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
2. BREAK EDGES 1/64" MAX.
3. SCREW THREADS
90° CHAMFER END
1X PITCH THD. RELIEF

DRAWN FOR L. WILBER
DRAWN BY L. SOUSA
CHECKED BY
APPROVED BY C L Jeber
APPROVED BY
DATE 10-19-59
SCALE

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

ONE SHOT MULTIVIBRATOR

FILE 21 | CHANGE 1 | DWG. NO. B-11154 -

B-9790 A

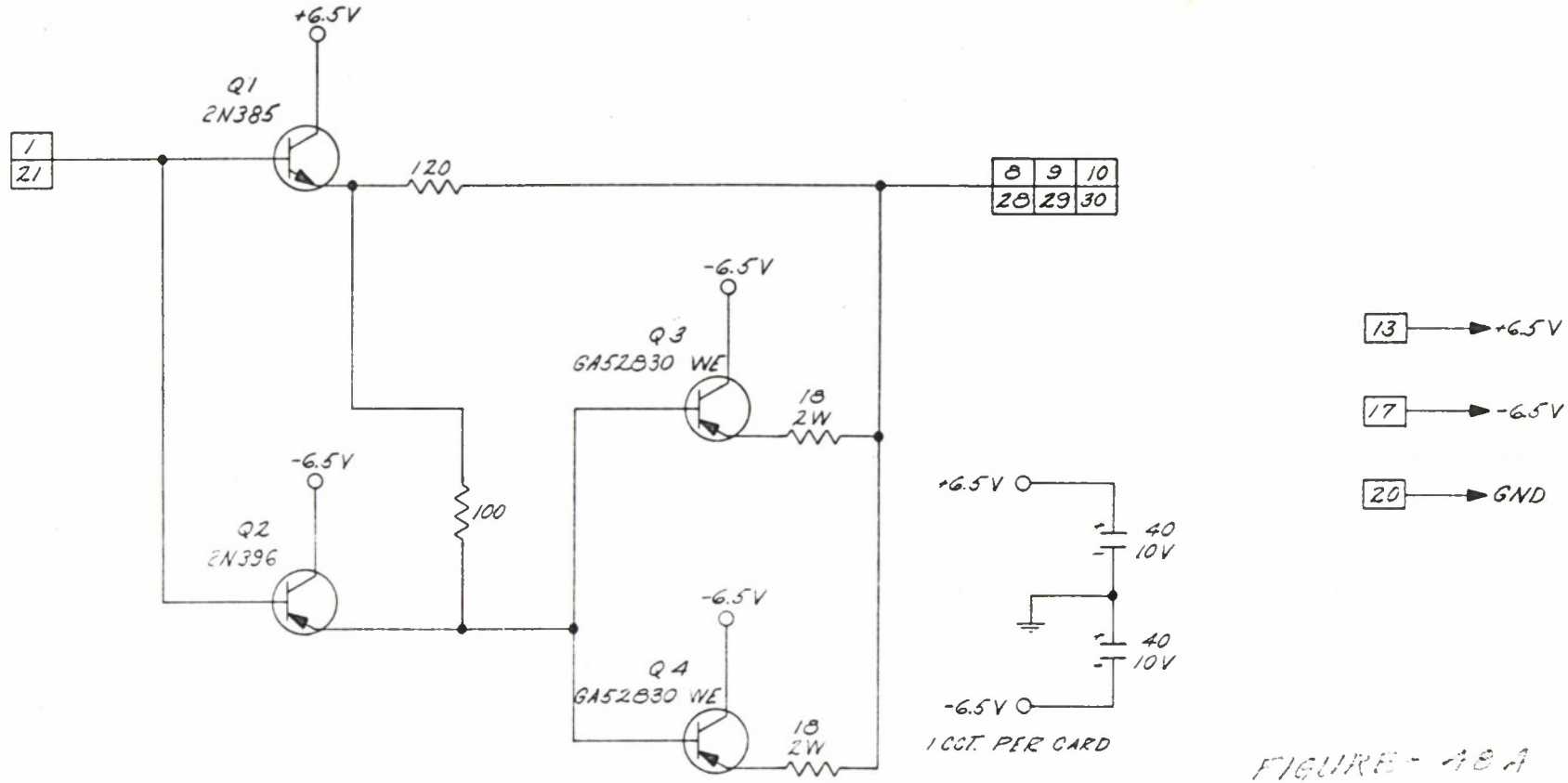


FIGURE - 19 A

REQ.° 9404

CHANGE LETTER	DRAWN BY	APP'D BY	DATE	CHANGES
A	AG	CLJ	3/19/63	SEE CHANGE REQ.° 4876

SHOP NOTES

UNLESS OTHERWISE SPECIFIED
1. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
2. BREAK EDGES 1/64" MAX.
3. SCREW THREADS
90° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR K. MOREY
DRAWN BY J. ASPARELLO
CHECKED BY
APPROVED BY
APPROVED BY
DATE 3-18-63
SCALE

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

ARPA CLOCK DRIVER
21PW1268

FILE 21 | CHANGE A | DWG. NO. B-9790-

SCHEMATIC NOTES

B-10965 B

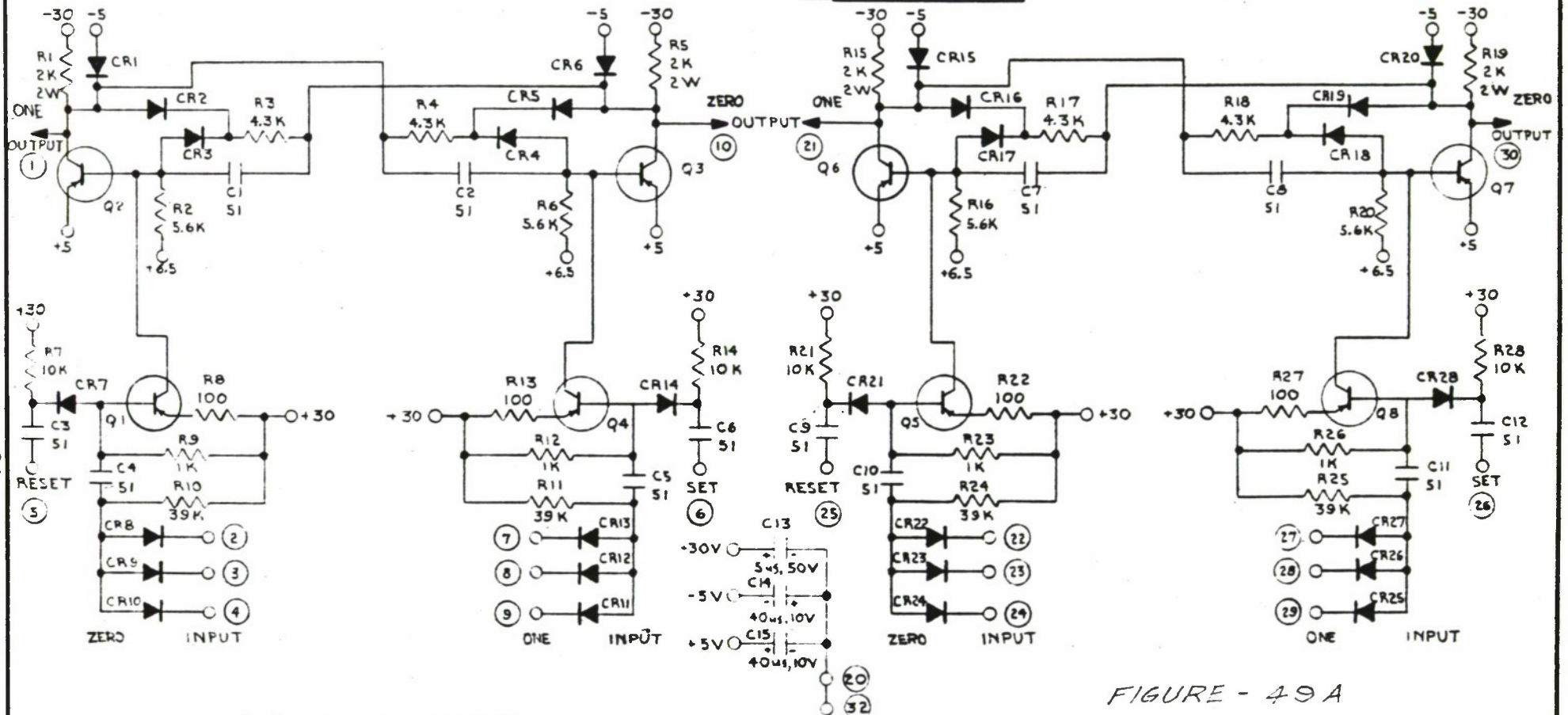


FIGURE - 49A

PINS: 1-10 1ST FLIP-FLOP
21-30 2ND FLIP-FLOP

B	SEG	CJS	9/11/59	SEE CHG REQ# 5060	
A	P.P.	JSB	8/6/59	SEE CHG REQ# 4960	
CHANGE LETTER	CHK'D BY	APP'D BY	DATE	CHANGES	

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
Ω μf h
RESISTORS ½ W. ± 5%

REQ. NO. 10178

SHOP NOTES
UNLESS OTHERWISE SPECIFIED
1. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
2. BREAK EDGES 1/64" MAX.
3. SCREW THREADS
90° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR F. McBRIDE
DRAWN BY D. PATTERSHALL
CHECKED BY
APPROVED BY
APPROVED BY
DATE 9-24-59
SCALE

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

JAMTRAC
FLIP-FLOP
SCHEMATIC 21PW1024

FILE 73 | CHANGE B | DWG. NO. B-10965-

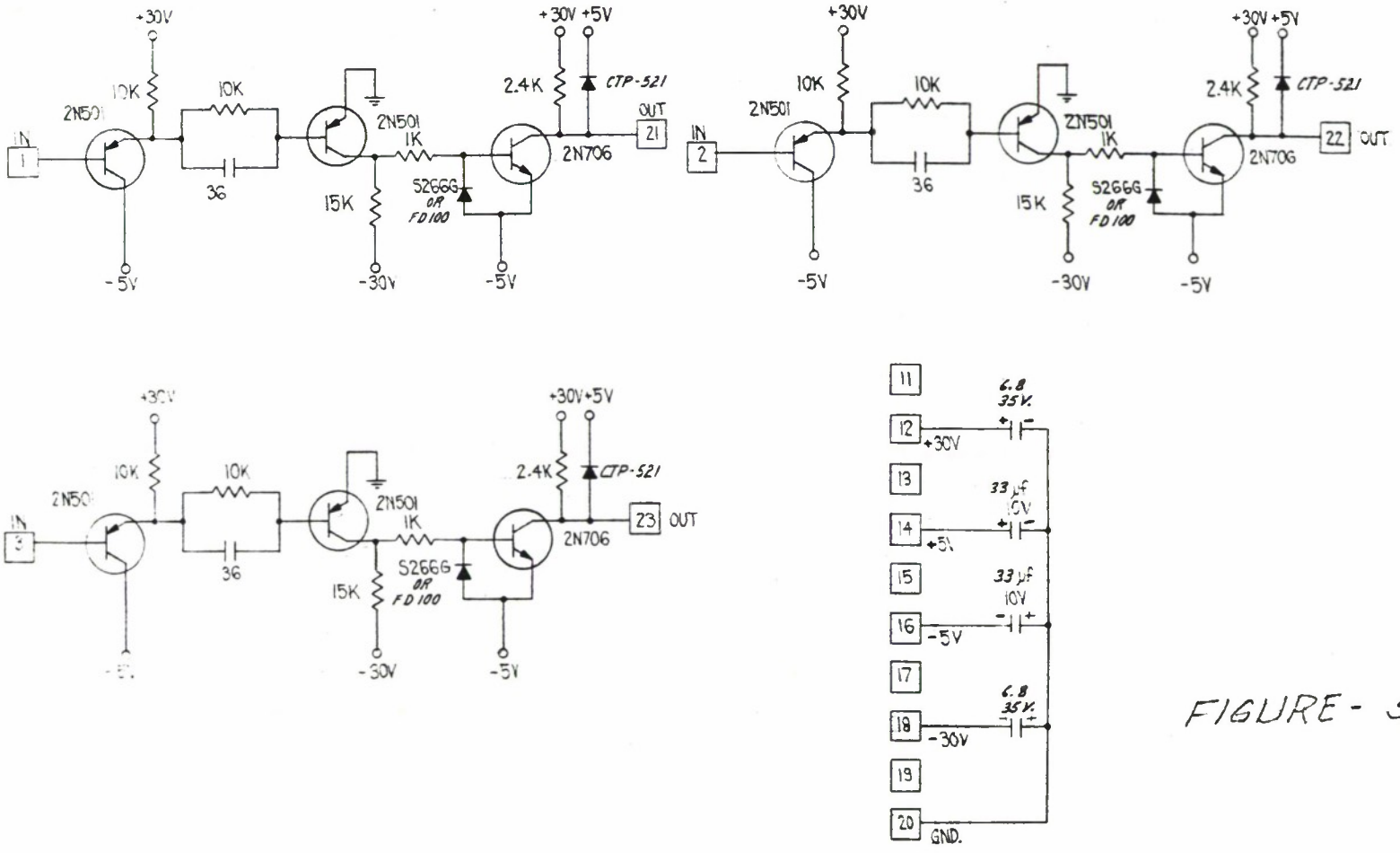


FIGURE - 50 A

C-12241 A

				A	SEE CHANGE REQ. # 5216
				CHANGE LETTER	CHANGES

REQ. No. 10890

SHOP NOTES

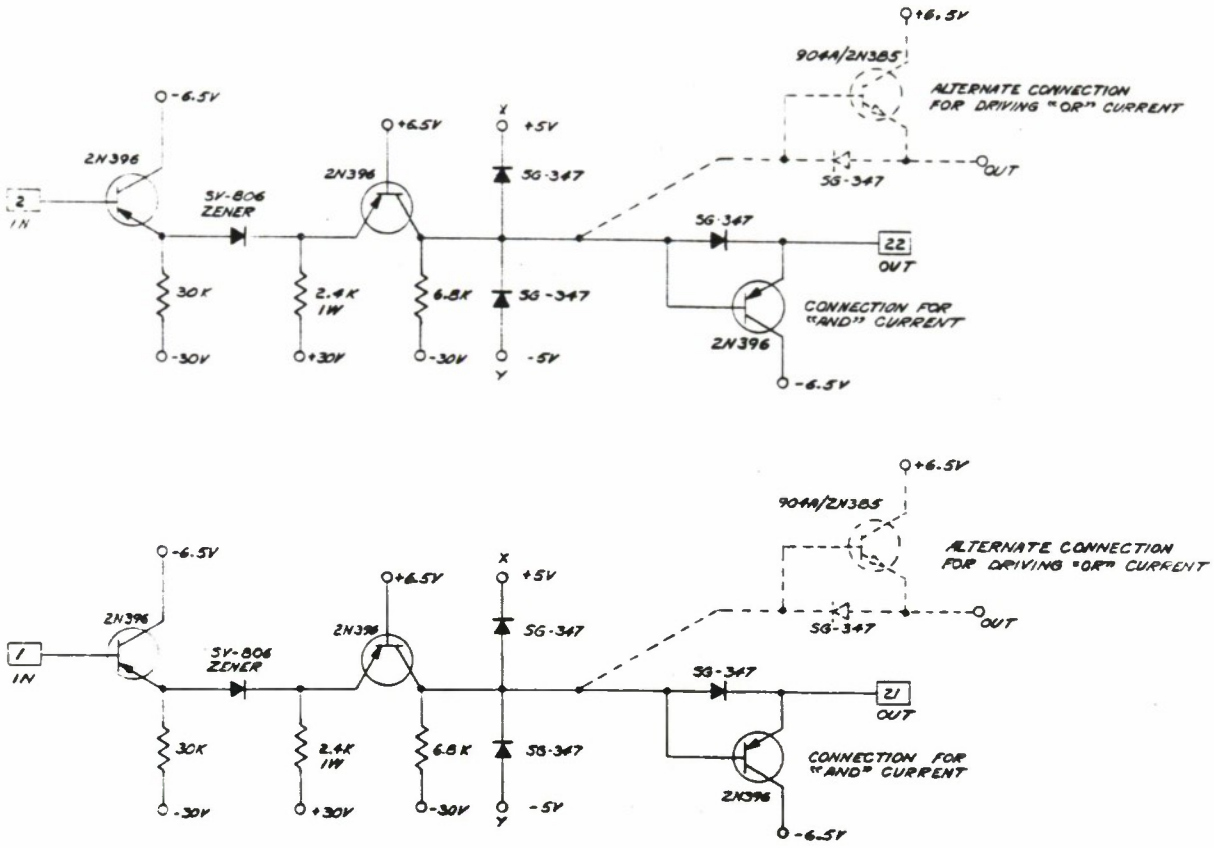
SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
Ω µµf h
RESISTORS ½W. ± 5%

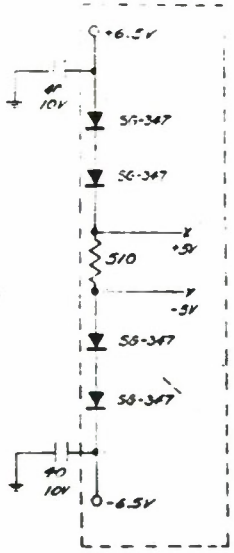
DRAWN BY K. NOREY
DRAWN BY G. GARLAND
CHECKED BY
APPROVED BY
APPROVED BY
DATE 4-15-60
SCALE

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

PULSE SHAPER
21 PW 1504
SCHEMATIC

FILE 21 | CHANGE A | DWG. NO. C-12241-





OMITTED ON ALL UNITS MANUFACTURED AFTER SEPT. 1959

FIGURE - 51A

C-11236

REQ. NO. 10284	
SHOP NOTES	
SCHEMATIC NOTES UNLESS OTHERWISE SPECIFIED RESISTANCE CAPACITANCE INDUCTANCE RESISTORS ½ W ± 5%	C. JOBES; J. GALPERN; R. L. Jobes; 11-10-59
LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON, MASS.	
ZENER BUFFER JAMTRACK SCHEMATIC 21 PM1125	
FILE 21 / CHARGE / DWG. NO. C-11236-	

B-13485

NOTE
1. COILS SPECIAL WOUND

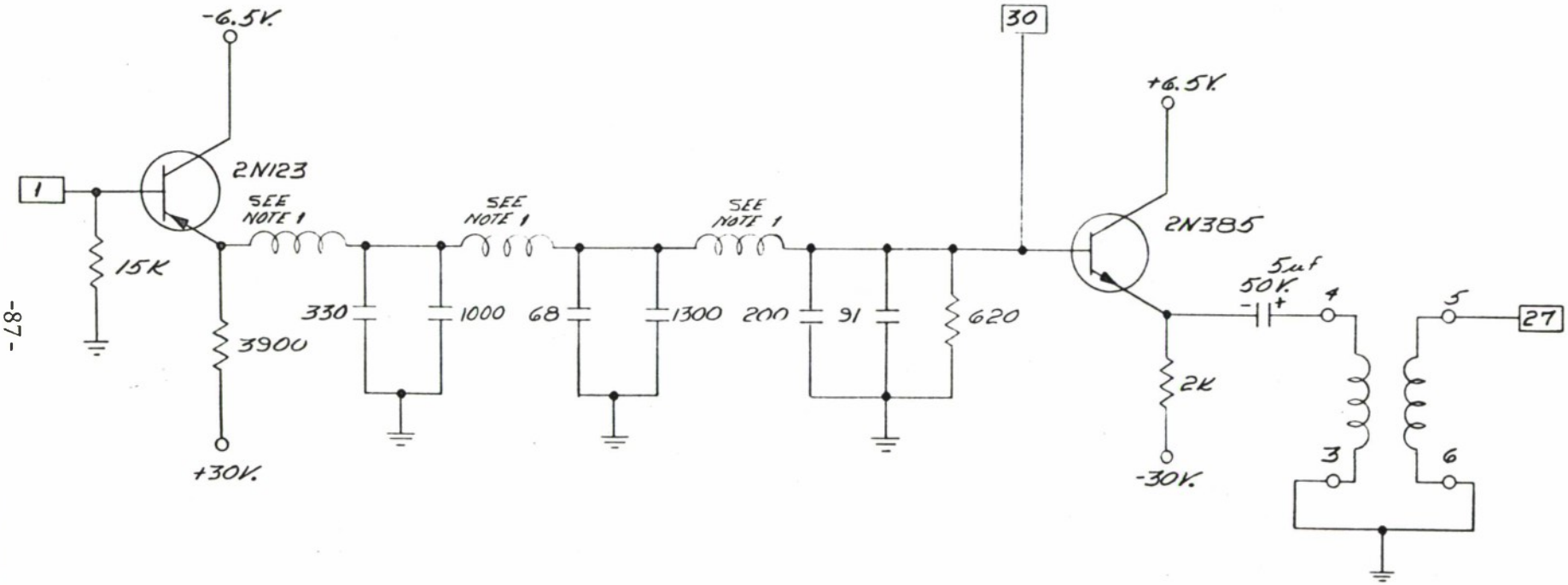


FIGURE- 52 A

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
Ω μμf h
RESISTORS ½W ± 5%

CHANGE LETTER	D'WN BY	APP'D BY	DATE	CHANGES

REQ. NO. 12151

SHOP NOTES
UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
3. BREAK EDGES 1/64" MAX.
4. SCREW THREADS
30° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR R.M. COLES
DRAWN BY D. WHITCOMB
CHECKED BY
APPROVED BY R.M. Coles
APPROVED BY
DATE JUNE 2, 1961
SCALE —H—

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

BESSEL FILTER

SCHEMATIC

FILE 21 | CHANGE 1 | DWG. NO. B-13485-

1 | A-13486

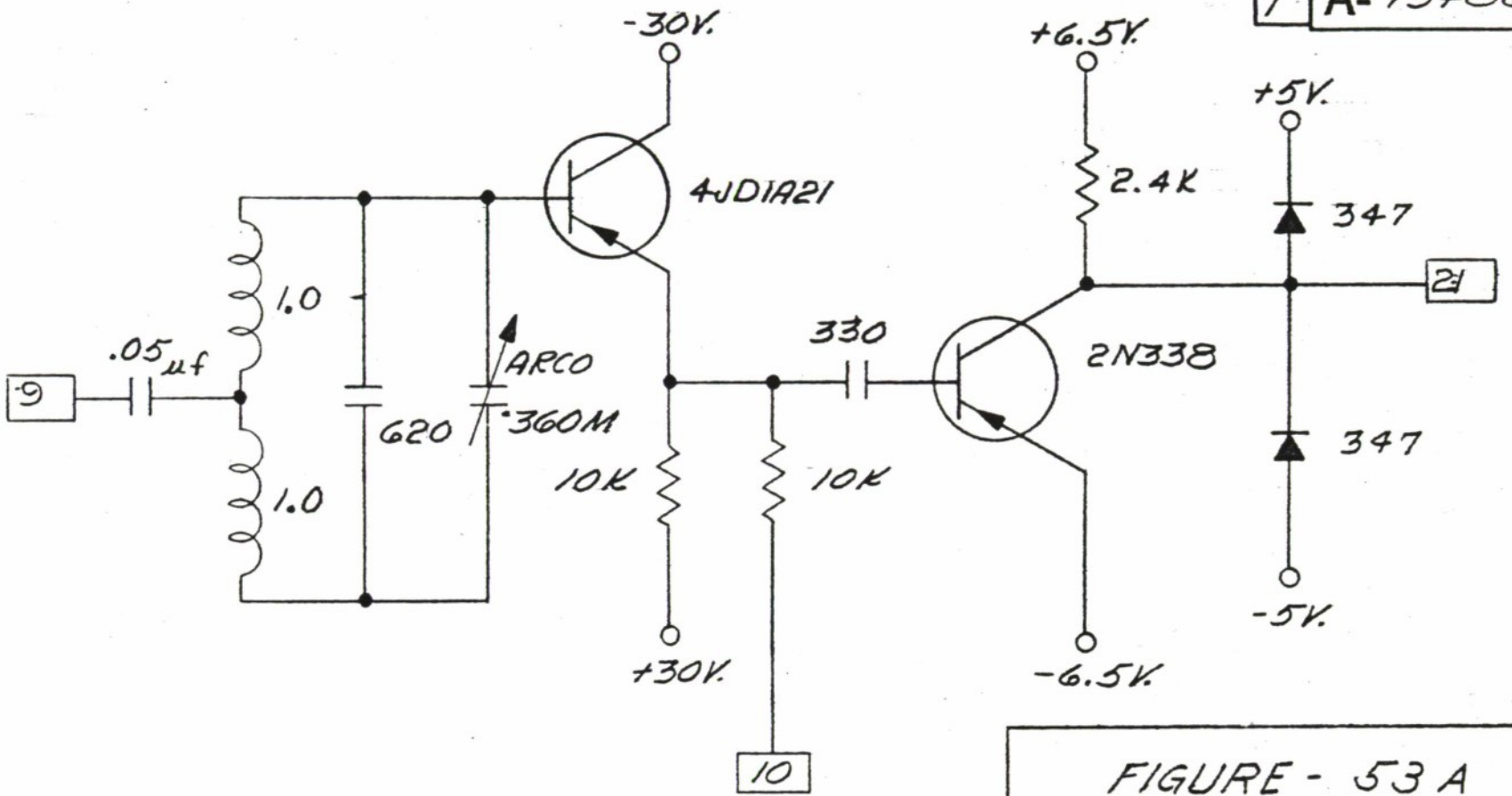


FIGURE - 53 A

SCHEMATIC NOTES
UNLESS OTHERWISE SPECIFIED
RESISTANCE CAPACITANCE INDUCTANCE
Ω μμf mh
RESISTORS ½ W. ± 5%

REQ. NO. 12148

CHANGE LETTER	D'W'N BY	APP'D BY	DATE	CHANGES

SHOP NOTES
UNLESS OTHERWISE SPECIFIED
1. TOLERANCE ON DIMENSIONS
FRACTIONAL ± 1/64"
DECIMAL ± .005
ANGULAR ± 1/2°
2. BREAK EDGES 1/64" MAX.
3. SCREW THREADS
30° CHAMFER ENDS
1½ PITCH THD. RELIEF

DRAWN FOR R.M. COLES
DRAWN BY O. WHITCOMB
CHECKED BY
APPROVED BY RM Coles
APPROVED BY
DATE JUNE 5, 1961
SCALE —

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LEXINGTON, MASS.

100KC
OSCILLATOR
SCHEMATIC

FILE 21 | CHANGE 1 | DWG. NO. A-13486

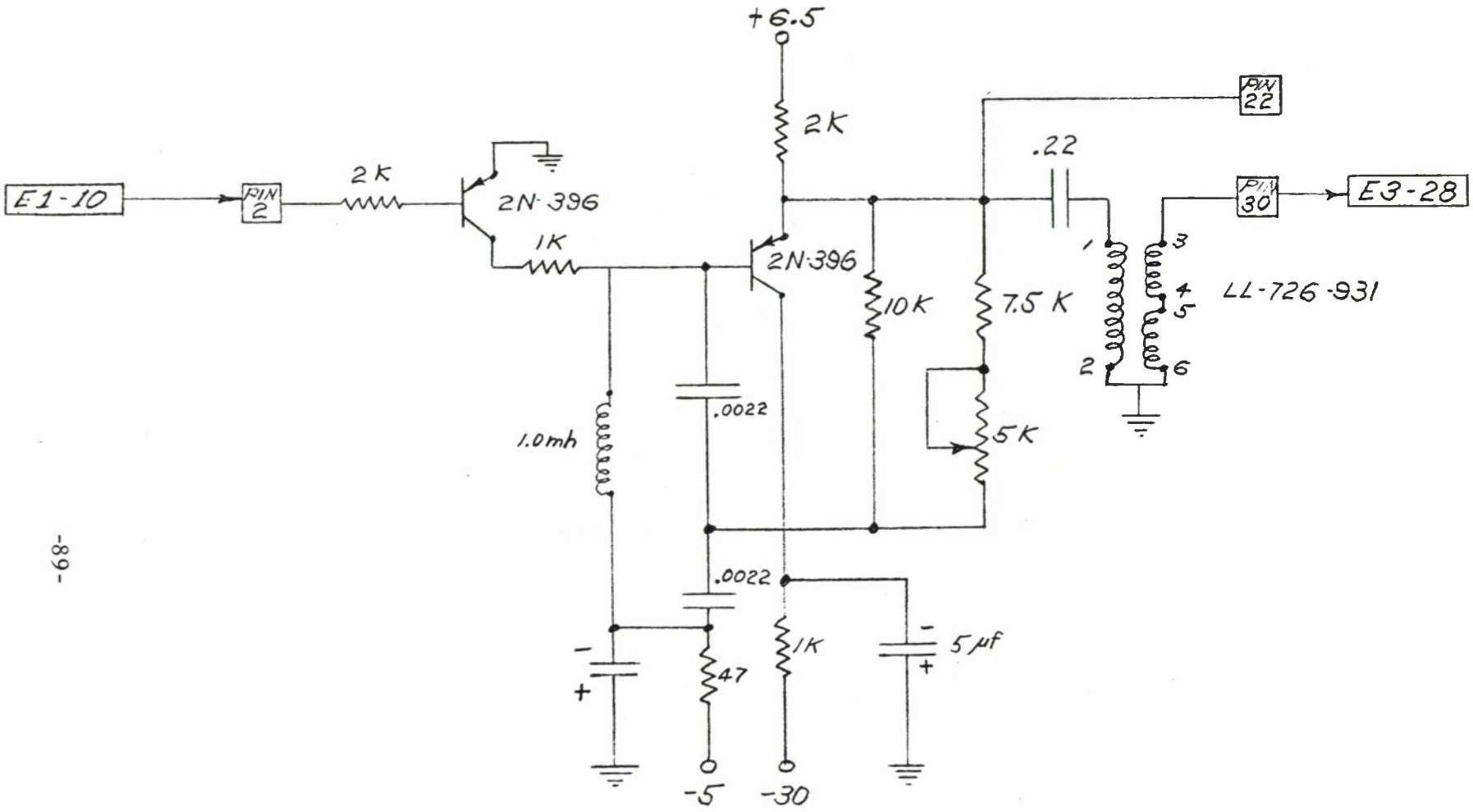


FIGURE 54A - 160 KC GATED OSCILLATOR (E2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
E	X0 FF Y0	160KC G OSC	SB	G0 FF G1	G2 FF G3	GCTR MTX AND EF	CD	E15 FF	E14 FF R1	E13 FF R2	E12 FF R3	E11 FF R4	E10 FF R5	E9 FF R6	E8 FF R7	E7 FF R8
D	UC ZB UC'	U-D FF	C4 FF C5	UPPER LIMIT N/N'B LOWER LIMIT	C2 FF C3	U-D MTX "C" CTR.	C0 FF C1	"C" CTR EF	N/N'B "C" CTR	ZB "C" CTR RESET	N/N'B "C" CTR	MTX	MAX. ERROR LOGIC MTX EL	Z5 FF	Z3 FF Z4	Z1 FF Z2
C	MTX	EF	MTX	EF	RANGE MAX MV ERROR RESET	GB	CD	E1 FF R1	E2 FF R2	E3 FF R3	E4 FF R4	E5 FF R5	E6 FF R6	E7 FF INPUT SHIFT R7	E8 FF ICM R8	E9 FF REG R9
B	SYNC BF	ZB	DATA WD ↔		MV	PB	FF	SYNC EF SPECIAL CARD	FF	N/N'B	MV	T4 FF	CU' N/N'B CU	T2 FF T3	U-D MTX T	T0 FF T1
A	PB	A1 FF A0	A2 FF	SYNC SB TIMING	S' ZB S	SYNC R/A TIMING	TIMING T FILTER	FF A3	J0 FF J1	J2 FF J3	J4 FF J5	J6 FF J7	J8 FF J9	J10 FF	100KC G OSC ↔	
F		ZB									S4 FF	FF S3	S1 FF S2	S0 FF B0	ZB	MV

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
E	E6 FF R9	E5 FF R10	E4 FF OUTPUT R11	E3 FF R12	E2 FF SHIFT R13	E1 FF REG R14	A16 FF R15	A15 FF R16	A14 FF A1	A13 FF A2	A12 FF A3	A11 FF A4	A10 F A5	A9 FF A6	A8 FF A7	OP TEST FF
D	N/N'B "Z" CTR.	FF	FF K0	ADDER MTX	ARITH LOGIC N/N'B E16	MAX ERROR LOGIC BIMI RANGE	Z6 FF Z7	"Z" CTR. MTX	MAX. ERROR LOGIC MTX AZ	SIGN RANGE FF	MV	RESET SAMPLE PULSE ZB SIGN EL	1,2,3 4,5 MTX 21,22 23	Δ1 FF Δ0	Δ2 FF	Δ3 FF Δ4
C	E10 FF R10	E11 FF R11	E12 FF R12	E13 FF R13	E14 FF R14	E15 FF R15	E16 FF R16	A1 FF A16	A2 FF A15	A3 FF A14	A4 FF A13	A5 FF A12	A6 FF A11	A7 FF A10	A8 FF A9	ZB
B	EF T CTR	N/N'B	N/N'B	ZB 48 GATE	COMPARATOR MTX ↔	MTX	OR BUFFER	W4 FF	W2 FF W3	W0 FF W1	ZB	B CTR N/N'B WCTR	B4 FF B5	B2 FF B3	B0 FF B1	START/STOP FF
A	A4 FF SCOPE SYNC	MV	FF	T W/D ↔		t ZB t'		FF R/W			FF		DATA R/A	MV M2	DATA SB	
F	N/N'B	N/N'B	B2 FF B1	MV	B3 FF B4											

FIGURE - 55A

REQ. No. 12147	
SHOP NOTES	UNLESS OTHERWISE SPECIFIED 1. DIMENSIONS ARE IN INCHES 2. TOLERANCE ON DIMENSIONS FRACTIONAL ± 1/64" DECIMAL ± .005 ANGULAR ± 1/2° 3. BREAK EDGES 1/64" MAX. 4. SCREW THREADS 30° CHAMFER ENDS 1½ PITCH THD. RELIEF
DRAWN FOR	R.M. COLES
DRAWN BY	D. WHITCOMB
CHECKED BY	H.J.J.
APPROVED BY	R.M. COLES
APPROVED BY	
DATE	JUNE 2, 1961
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13. ABSTRACT

This report describes the scanback subsystem installed at the M.I.T. Arbuckle Neck Site. The machine is capable of storing 1500 points in range, azimuth and elevation, permitting the antenna to be repositioned along a previously traversed path.

14. KEY WORDS

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