STEPPING MOTOR CONTROL CARD MODEL 69335A

OPERATING AND SERVICE MANUAL

FOR CARDS DESIGNATED RUN 1 AND ABOVE*

*For Cards above Run 1
a change page may be
included.

Hewlett-Packard

HP Part No. 69335-90001

April: 1974

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from date of delivery, or in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

MANUAL CHANGES
Model 69335A Stepping Motor Control Card
Manual HP Part No. 69335-90001

Make all corrections in the manual according to errata below, then check the following table for your card's serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
1637A	00201-up	1

CHANGE 1:

All multiprogrammer plug-in cards are now being marked with serial numbers to keep better control of units out in the field. The serials assigned to these models are given in the table. For an explanation of the meaning of the serial prefix, see paragraph 1-44 in the multiprogrammer mainframe manual.

2-1-78

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SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 This instruction manual contains operating and service instructions for the Stepping Motor Control Card, Model 69335A. This card is designed specifically for use in the 6940A Multiprogrammer and 6941A Multiprogrammer Extender Units. The 69335A produces a train of square wave pulses in response to a digital data word that controls the number of pulses in the train and determines which of two output terminals delivers it. When these outputs are connected to the clockwise and counterclockwise input terminals of a stepping motor translator, the output pulses are converted to clockwise or counterclockwise steps of the associated stepping motor. The square wave outputs can also be used for other applications such as the computer control of a process controller equipped for pulse train update of its setpoint.

1-3 DESCRIPTION

1-4 When installed in a multiprogrammer system, the stepper motor output card is programmed by a 16-bit word originating at a remote computer or the 6940A Multiprogrammer front panel switch register. Eleven of these bits control the number of pulses in an output pulse train (1 through 2047), one of them selects output terminal 1 or 2, and the remaining four contain the slot address of the card. The user can increase the maximum number of pulses that can be programmed by a single word to 4095 by converting the directional bit to an additional magnitude bit through a simple modification. If this is done, pulse trains appear simultaneously at both output terminals.

1-5 The output waveform is a train of symmetrical positive square-wave pulses. As the card is supplied from the factory, the nominal frequency of these pulses is 100Hz, but by changing the value of one resistor the user can set the frequency to any value between 10Hz and 2kHz. The nominal amplitude is +12 volts; by moving a jumper on the card it can be changed to +5 volts or by connecting an external bias supply to a pin on the output connector it can be changed to any value up to +40 volts. The output connector also includes connections that permit controlling the frequency externally or via another card.

1-6 In the SYE mode, outputs from the card are inhibited. A data word received while SYE is programmed off is stored until SYE is programmed on, at which time a pulse train will begin immediately.

1-7 As supplied, the card produces a common timing flag output to the multiprogrammer that remains in the busy state for the duration of an output pulse train. The user can modify the card so that the flag to the multiprogrammer lasts only as long as the received data strobe to avoid an excessive loss of processing time when operating in the TME mode. If this is done, an external flag which can be made available at the output connector can be used to generate a computer interrupt (via an input card) to inform the computer that the card has completed its output pulse train and is ready to accept new data.

1-8 The stepping motor card is fabricated on a 4 1/2" x 11" printed circuit card. The inner edge of the card contains a dual 24-pin (48-pin total) printed circuit plug that can mate with any connector in slot 400 through 414 of a master multiprogrammer unit or an extender. A dual 15-pin (30-pin total) printed circuit plug located at the outer edge of the card connects the 69335A outputs to the external device and also allows making the optional external connections that are described above.

1-9 SPECIFICATIONS

1-10 Table 1-1 provides detailed specifications for the Model 69335A.

1-11 INTERFACING

1-12 The 69335A Stepping Motor Card is automatically interfaced with its associated multiprogrammer unit when it is installed in a 400-series slot connector. Once it is assigned to a slot, the card assumes the address of that position and will receive programmed data only when the applicable unit and slot are addressed. Unless an external bias supply is used for the output amplifiers, all operating power and programmed data for the card are derived from the multiprogrammer unit.

1-13 OUTPUT CONNECTOR ASSEMBLY

1-14 One 30-pin output connector assembly (HP

Part No. 5060-7934) is furnished with each stepper motor card for interfacing the card with the external system. Additional 30-pin connector assemblies may be ordered from your local Hewlett-Packard sales office. (Refer to list at the rear of manual for addresses).

1-15 ORDERING ADDITIONAL MANUALS

1-16 One manual is shipped with each order. Additional manuals may be purchased from your local Hewlett-Packard sales office. Specify the card model number and HP Part Number shown on the title page.

Table 1-1. Model 69335A Specifications.

DATA INPUT: 12-bit binary. Bits BØØ-B1Ø specify total number of steps, 0-2047. Bit B11 specifies direction of rotation. (User-connected option of 0-4095 steps, unidirectional). OUTPUT CHARACTERISTICS: A train of positive symmetrical square-wave pulses appears at the output selected by the directional bit. (Pulses appear at both outputs in unidirectional operation). Drive pulse levels: +12V (as supplied), or user-connected options of +5V or External (up on +40V). Output impedance in +12V or +5V operation is 500 ohms and maximum voltage between pulses is +0.5V. Drive pulse frequency: Nominally 100Hz. Can be adjusted from 10Hz to 2kHz by changing resistor (or resistor and capacitor) value on card. Can be programmed externally by connecting external resistor across pins 4 and 6. CONTROL SIGNALS: SYE: Prevents card from generating pulses until SYE is programmed on. TME: Allows flag signals from cards to control busy period of Multiprogrammer flag to computer.	EXTERNAL FLAG OUTPUT: Signal is available at pin 13 when jumper W5 is in position B. A HIGH level (+2.4 to 5.0V) indicates that an output count is in progress ("busy" state). A LOW level (0 to 0.5V, 16mA sink) specifies the "ready" state. OUTPUT CONNECTOR: One 15-pin dual (30-pin total) edge connector. Mating female connector assembly supplied (HP Part No. 5060-9658). This connector accomodates up to 30 wires with outside diameters of up to 44 mils each. TEMPERATURE RANGE: 0°C to 70°C operating in mainframe (allows +15°C internal rise when operating in mainframe at up to +55°C ambient); -40°C to +80°C storage.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, each stepping motor control card is inspected for mechanical and electrical defects. As soon as the card is received, proceed as instructed in the following paragraphs.

2-3 MECHANICAL CHECK

2-4 If external damage to the shipping carton is evident, ask the carrier's agent to be present when the instrument is unpacked. Check the output card for signs of physical damage. If it is damaged, file a claim with the carrier's agent and notify Hewlett-Packard Sales and Service Office as soon as possible. If it appears to be undamaged, perform the electrical check given in the following paragraph.

2-5 ELECTRICAL CHECK

2-6 Check the electrical performance of the output card as soon as possible after receipt. Section V of this manual contains checkout procedures which will verify operation of the output cards. Refer to the inside front cover of this manual for Certification and Warranty statements.

2-7 REPACKING FOR SHIPMENT

2-8 When shipping an output card, it is recommended that the package designed for it be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the output card can be shipped. Be sure to attach a tag to the output card specifying the owner, model number, full serial number, and service required, or a brief description of the trouble.

2-9 OUTPUT CARD INSTALLATION

2-10 Output cards are installed in slots 400 through 414 of a multiprogrammer unit. To install an output card, proceed as follows:

a. Open the hinged front panel of the multiprogrammer unit by turning the recessed screw within the handle counterclockwise.

CAUTION

Always turn off power at the multiprogrammer before installing or removing the output card. If power is not removed, it is possible to short components in the multiprogrammer when installing or removing a card thereby causing possible damage.

b. With the extractor handle on the top and the card components on the right, slide the card into the desired output slot (400 through 414). Note that all output cards are slotted between pins 4 and 5 and all 400 series connectors of the multiprogrammer are keyed between the same points. This makes it virtually impossible to plug an output card in upside down or into any slot other than a 400 series slot.

c. Route all wiring from the output cards through the false-bottom channel and out the back of the unit to the external system.

SECTION III
OPERATING INSTRUCTIONS

3-1 DATA CONNECTOR

3-2 The 69335A Stepping Motor Control Card is controlled by the multiprogrammer in which it is installed. Any connector in slots 400 through 414 of the multiprogrammer mainframe can supply dc operating power, address and data bits, and control signals to the card. Figure 3-1 illustrates the signals present on all multiprogrammer 400-series connectors. (The output connector of this card is also used for making some optional input power and input and output signal connections, which will be explained later in this section).

3-3 PROGRAMMING

3-4 The programming information presented here

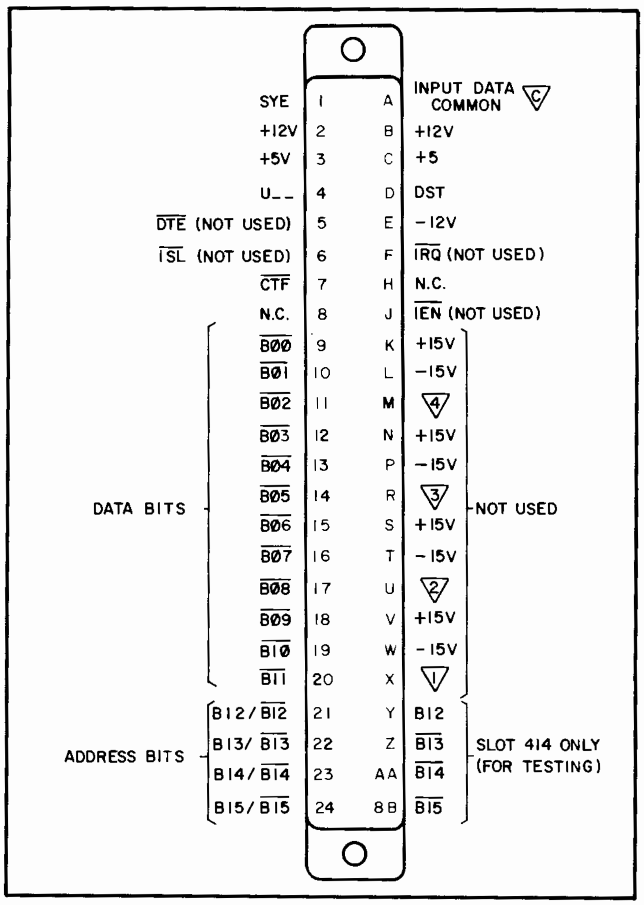

Figure 3-1. Multiprogrammer 400-Series Slot Connector

describes the basic procedures involved in addressing a stepping motor control card. Programming instructions at the system level are given in the Operating and Service Manual for the multiprogrammer master units.

NOTE

> This discussion assumes that the reader is familiar with the functions and contents of the multiprogrammer word formats. A review of Section III of the 6940A instruction manual is suggested if this is not the case.

3-5 There are two general steps involved in programming an output card. They are:

a. Enabling the output card by programming the system enable (SYE) bit to a logical 1 and addressing the appropriate unit.

b. Addressing the multiprogrammer slot containing the output card and programming data that will cause the required number of output pulses to be produced at the desired output terminal.

3-6 SYSTEM ENABLE

3-7 An SYE control line is wired to all multiprogrammer 400-series slots. This control line goes HI when a control word programs the system enable function on. Programming SYE on enables the oscillator control gate and permits an output pulse train to be produced when a properly addressed data word arrives at the card input and is loaded into the counter. If a data word is loaded into the counter while SYE is programmed off, the data is stored by the card and the output pulse train will not commence until enabled by the SYE line. It is also possible to interrupt an output pulse train at any time by programming SYE off. If this is done, the remainder of the programmed output pulses are stored until SYE is programmed on again; the total count will be the number programmed.

3-8 ADDRESSING

3-9 Addressing is accomplished in two steps. First, a control word containing the unit address and an appropriate control mode selection (for this card, either SYE or TME, neither, or both) is issued. The master unit stores and decodes the four-bit address causing the corresponding unit select line (U--) to go HI. This selection will remain in effect until a different unit is addressed by a later control word. All slots of the unit whose U-- line is HI will be partially enabled.

3-10 The second programming step involves a data word which contains a particular slot address in its four most significant bits (bits 12-15) and data (bits 0-11) to be stored on the addressed card. Although both the true and complemented forms of the slot address bits are represented on Figure 3-1 (e.g. B12 and $\overline{\text{B12}}$), only one of the two states is present on each of the four address gate lines when the card is installed in a multiprogrammer slot. For example, if the output card is installed in slot 405, then bits B12 (1), $\overline{\text{B13}}$ (2), B14 (4), and $\overline{\text{B15}}$ (8) will be connected to the card's address lines, and all four lines will be HI when slot 405 is addressed.

3-11 DATA STORAGE AND OUTPUT

3-12 Approximately 4μsec after the data word containing the four slot address and 12 data bits is gated, the mainframe sends a data strobe pulse to the accessory card slots. The addressed card now generates a strobe pulse which enters the 12 data bits ($\overline{\text{B\O\O-B11}}$) into the card's storage register.

3-13 Bidirectional Output. Normally, just 11 of these 12 bits ($\overline{\text{B\O\O-B10}}$) are loaded into the down counter by the strobe pulse. These 11 bits determine the number of pulses in the output train, 0 through 2047. As supplied from the factory, jumpers W2 and W3 are connected and W4 is left open. This strapping arrangement allows bit $\overline{\text{B11}}$ to steer the output pulse train to either of two output terminals. A logical 0 at the $\overline{\text{B11}}$ input directs the pulse train to pin 1 of the output connector (Output 1) and a logical 1 directs it to pin 2 (Output 2). (The pin configuration of the output connector is illustrated in Figure 3-2). Connecting these two outputs to the clockwise and counterclockwise inputs of a stepping motor translator permits bidirectional control of the motor. Being able to program a choice of two output terminals is useful in other applications as well, such as the computer control of a process controller that is equipped for pulse train update of its setpoint. One output would be connected to the increase setpoint and the other to the decrease setpoint terminal of the controller.

3-14 Unidirectional Output. If bidirectional control of the output is not required, the maximum number of output steps that can be programmed by a single data word can be increased from 2047 to 4095. This is accomplished by strapping bit $\overline{\text{B11}}$ to serve as an additional magnitude bit instead of

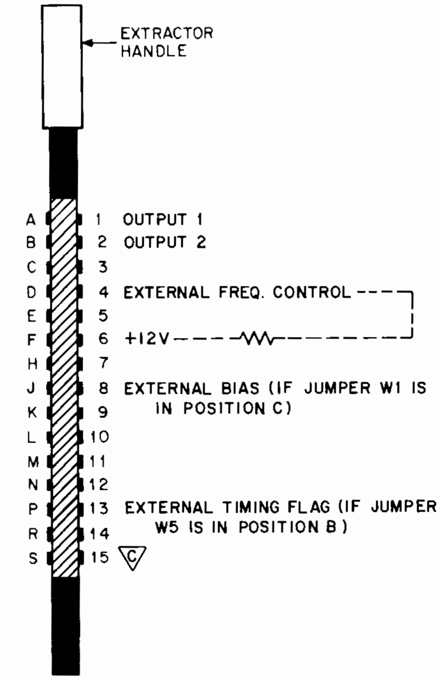

Figure 3-2. 69335A Output Connector

a directional bit. To make this conversion, open jumpers W2 and W3 on the board and connect jumper W4. This bit will now function identically to the other 11 data bits. When bit $\overline{\text{B11}}$ is strapped to serve as a magnitude bit, all output pulse trains will appear at both output terminals.

3-15 Output Frequency. As the card is supplied from the factory, the output waveform is a train of positive symmetrical square-wave pulses with a nominal frequency of 100Hz. If this frequency is not suitable, it can be changed to any frequency in the range of 10Hz to 500Hz by replacing resistor R12 with one having the value: R12 (in ohms) = $10^7/f$. (For example, 1MΩ for 10Hz, 50kΩ for 200Hz, or 20kΩ for a 500Hz output). To obtain output frequencies greater than 500Hz, change the value of C3 from .047μF to .01μF. Now the frequency can be controlled in the range from 100Hz to 2kHz by selecting a value of R12 equal to $5 \times 10^7/f$.

3-16 The output frequency can be made programmable by substituting a Model 69500A Programmable Resistance Card for resistor R12. Connections to an external frequency control resistor are made to pins 4 and 6 of the stepping motor card's output connector.

CAUTION

Shorting external frequency control pins 4 and 6 together will damage the oscillator circuit. For this reason the jumpers on the programmable resistance card must be arranged so as to prevent the contacts of the SYE relay from causing a direct short. The minimum recommended resistance value for R12 is 15kΩ.

The programmable resistance card contains 12 relays which are programmed to apply short circuits or remove them from any combination of resistors in a series string of 12 user-supplied resistors. For further information on the programmable resistance card, refer to the 69500A manual.

3-17 Output Connections and Signal Levels. As supplied from the factory, jumper W1 on the card is connected to pad A and supplies an unregulated +12 volts to the output amplifier. Depending on the requirements of the external device being interfaced, either this supply or a regulated +5 volts can be used (both are from the mainframe), or else an external bias voltage of up to +40 volts can be connected.

CAUTION

Regardless of the collector supply voltage used or the way the loads are connected, the collector current of each output stage must be limited to a maximum of 50mA.

3-18 If the output loads are connected in the usual manner, between each of the output collectors (pins 1 and 2) and output common (pin 15), the open circuit output voltage during a pulse will be +12 volts (nominal) with jumper W1 connected in position A, or +5 ±0.25V with that jumper cut and W1 tied to pad B. In either case, the voltage during the intervals between pulses will be less than +0.5 volts and the source impedance during a pulse will be 500 ohms.

3-19 If neither a 5-volt or 12-volt output is suitable for the user's load, other output voltages can be obtained by connecting an external collector supply to pin 8 of the output connector and moving jumper W1 to position C. When an external supply is used in this way, the following limitations apply:

a. The maximum collector supply is +40Vdc.
b. The maximum collector current is 50mA.
c. The maximum allowable dissipation in each collector resistor (R21 and R22) is 1/4 watt.

Because of these limits, R21 and R22 must be replaced with higher value resistors when a supply voltage greater than 12 volts is used.

3-20 Another method of connecting the output loads is to connect Q13 and Q14 as open-collector drivers by removing collector resistors R21 and R22 from the card and letting the external device supply the collector voltage and the load resistors. The maximum collector supply voltage remains +40 volts and the maximum collector current is 50mA when this method is used.

3-21 Timing Flag Outputs. The card is supplied from the factory with jumper W5 connected in position A. With W5 in this position, the card returns to the multiprogrammer a common timing flag ($\overline{CTF}$) signal that continues for the full length of the output pulse train. When operating in the handshake mode (with the TME bit off), this presents no difficulty because the computer does not wait for the conclusion of the $\overline{CTF}$ signal. When operating in the timing mode (with the TME bit on), the flag line to the computer is held busy by the multiprogrammer for the period of the longest $\overline{CTF}$. Since this card could take as long as seven minutes to finish producing its output data, it may be desirable to eliminate this lengthy flag to allow operation in the timing mode without slowing down multiprogrammer operation. This is easily accomplished by opening jumper W5. With W5 cut, this card will return a $\overline{CTF}$ signal that is the same length as the received data strobe each time a data word is received.

3-22 Since this card can take a substantial length of time to produce its output data, an external timing flag has been provided to avoid the loss of processing time that would be incurred by waiting for the end of a full length $\overline{CTF}$ before continuing to the next data transfer. By using this flag to generate a computer interrupt when the card has timed out, the multiprogrammer can be allowed to handle other data transfers while the stepping motor card is producing its output pulse train. To use this capability, connect jumper W5 in position B and connect pin 13 of the card output connector to the flag input of a 69431A Digital Input Card. This external timing flag is HI (+2.4V to 5.0V) to indicate busy while an output count is in progress, and LO (0 to +0.5V, 16mA max. sink current) to indicate that the card is ready to accept new data. See the 69431A manual for programming instructions.

SECTION IV
PRINCIPLES OF OPERATION

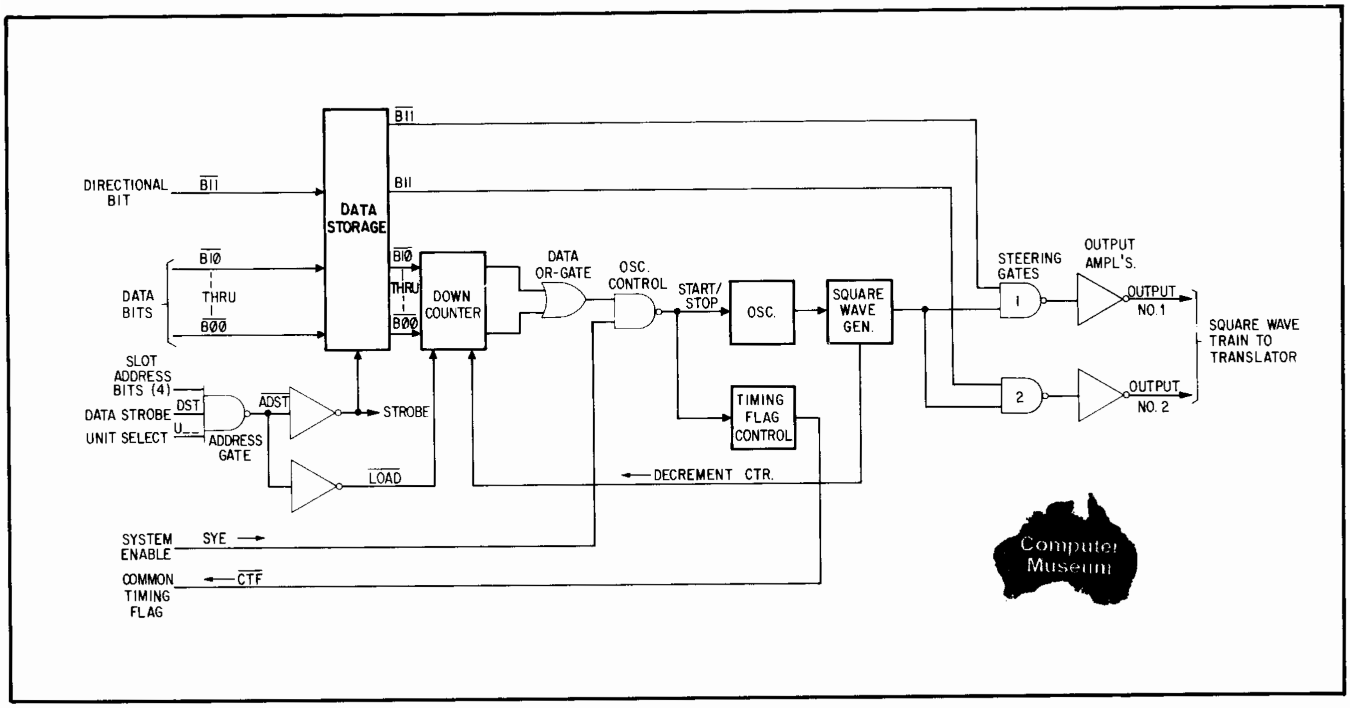

Figure 4-1. Stepping Motor Control Card, Simplified Block Diagram

4-1 INTRODUCTION

4-2 This section contains the principles of operation of the Stepping Motor Control Card, Model 69335A. The following paragraphs describe its operation in terms of the simplified block diagram of Figure 4-1 and then on a more detailed level using the schematic diagram of Figure 7-1.

4-3 SIMPLIFIED BLOCK DIAGRAM DISCUSSION

4-4 Figure 4-1 is a simplified block diagram of the card. It shows only those circuits that produce the primary output square wave train. Less important circuits and those input and output signals not included on this drawing are discussed in a detailed circuit analysis later in this section.

4-5 Before the card can produce an output pulse train, the multiprogrammer or extender in which the card is installed must be selected by a control word in which the system enable bit is HI. The unit address of that control word is decoded in the Multiprogrammer to produce a HI unit select bit (U--) at the address gate input. Next, the card must receive a data word containing the data and address bits. (Refer to Section III of the 6940A manual for an explanation of control and data words). When the slot containing this card is addressed, the four slot address bits go to the HI state so that when a DST pulse appears, the address gate is enabled. The ADST output from this gate (see timing diagram, Figure 4-2) is amplified and strobes data bits BØØ through B11 into local storage and loads the down counter with bits BØØ through B10. The binary number that is initially loaded into the down counter represents the number of square waves that will ultimately appear in the output train and, thus, the total number of steps that will be taken by the stepping motor. If any bit in the down counter is a logical 1, the resulting HI output from the data OR-gate enables the oscillator control gate (provided that SYE has previously been programmed on). The LO output from the oscillator control gate serves as a start signal for the oscillator and also sets the CTF output LO (busy). The square wave generator converts the pulses from the oscillator into a square wave output and also divides the frequency of the oscillator's output pulses by two.

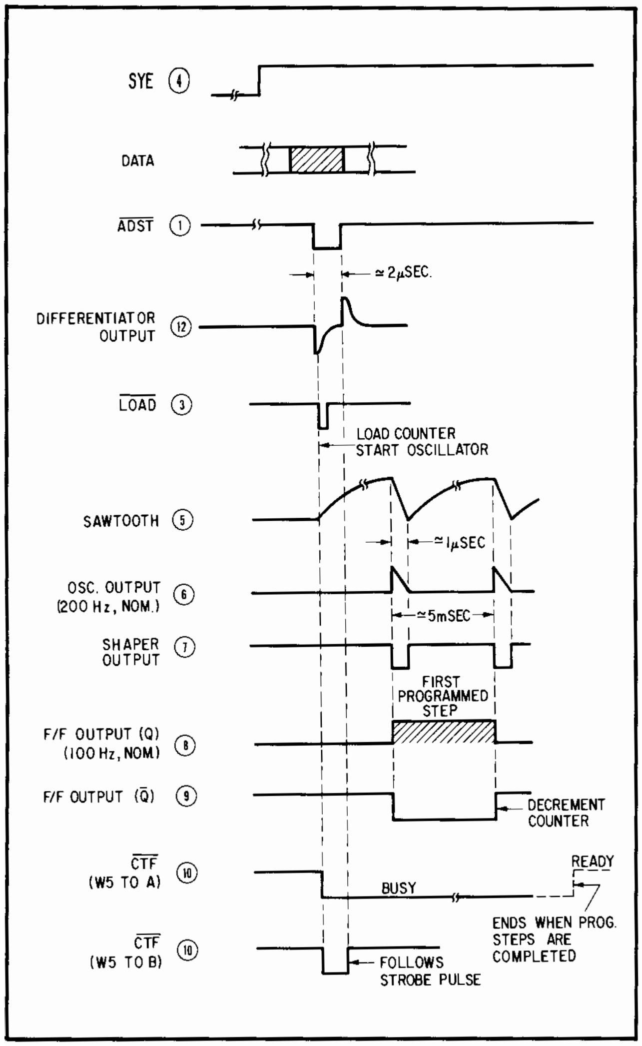

Figure 4-2. Overall Timing Diagram

4-6 The logic level at the $\overline{B11}$ input line to the card determines the direction that the stepping motor rotates. If the logic level at this input is LO (logical 1 at the computer), steering gate 2 is enabled and the output square wave appears on the number 2 output line while the number 1 output remains LO. When a HI logic level is applied to the $\overline{B11}$ input line, the output square wave appears on the number 1 output line.

4-7 At the trailing edge of each output square wave (Figure 4-2) a decrement signal is fed back to the down counter which decreases the number in the counter by one. The square wave train continues until the number in the down counter reaches zero. At this time, a LO output from the OR-gate disables the oscillator control gate which, in turn, stops the oscillator so that no more output pulses are generated.

4-8 The stop signal also sets the common timing flag ($\overline{CTF}$) to its HI (ready) state. An internal jumper in this circuit allows the $\overline{CTF}$ signal to end much sooner, as will be described later.

4-9 DETAILED CIRCUIT ANALYSIS (See Schematic, Figure 7-1)

4-10 Turn-On Preset Circuit. When the stepper motor control card is first energized, outputs from the turn-on preset circuit initialize the down counter and the square wave generator and prevent spurious outputs from the output amplifier. The diodes in series with the base of Q5 keep Q5 turned off until the 5V supply reaches about 4 1/2 volts. Until Q5 begins to conduct, Q7 is held cut off sothat its collector voltage follows the increasing supply. When Q5 turns on, Q6 turns Q7 on to end the positive pulse produced at Q7's collector. This pulse presets the down counter to zero. The output of Q8 remains LO until Q7 turns it off. This LO output presets the square wave generator so that output Q is initially LO and $\overline{Q}$ is HI. Q9 also produces a positive pulse during turn-on. This pulse assures that Q13 and Q14 remain on and their outputs remain LO while the power supply stabilizes. If a serious dip in supply voltage occurs during an output pulse train, the preset circuit will reset the card and end the output train.

4-11 Addressing. Unit select bit U-- remains HI following a control word which selects the multiprogrammer or extender that houses the card. When a subsequent data word addresses the card, address bits 12 through 15 become HI at the inputs of address gate Z10. Data bits $\overline{B00}$ through $\overline{B11}$ appear at the same time. Approximately 12μsec after the data word appears, a data strobe pulse (DST) is received. This pulse enables Z10, which produces a negative pulse at its output. This negative $\overline{ADST}$ pulse is inverted by Q1 and strobes the twelve data bits into the storage register. The $\overline{ADST}$ pulse is differentiated and then clipped and buffered by the load amplifier to produce a negative load pulse input to the down counter. Differentiation is required to shorten the long data strobes that originate at the front panel switch register. A long load pulse would temporarily prevent the counter from being decremented and cause an erroneous increase in the output count.

4-12 Data. Data bits are received by the card in the LO equals true form. Directional bit $\overline{B11}$ must be HI at the card input to steer the output square wave train to output 1 and LO to steer it to output 2. These 12 bits are strobed into the storage register by the leading edge of the positive strobe pulse. The flip-flops that store bits $\overline{B00}$ through $\overline{B10}$ have only their $\overline{Q}$ outputs connected. As a result, the outputs to the down counter are the complement of the input bits. Both the inverting and the non-inverting outputs of the $\overline{B11}$ flip-flop are connected to the output steering gates so that one or the other of these gates is enabled. When the eleven data bits are loaded into the down counter, they appear at its outputs uninverted; thus, all bits that are ones are HI at the inputs of the data OR-gate. The output of the OR-gate becomes HI when the down counter is loaded (unless the magnitude loaded is zero) and remains HI until the count is decremented to zero.

4-13 If the card is being used in an application where its bidirectional capabilities are not needed, bit $\overline{B11}$ can be strapped to serve as an additional data bit. This is accomplished by opening jumpers W2 and W3, and connecting a jumper in the W4 position. Once this modification has been made, the maximum number of output steps that can be programmed by a single data word is 4095 instead of 2047.

4-14 The data OR-gate is followed by a Schmitt trigger buffer which helps to ensure noise immunity. The output of this buffer and the system enable (SYE) signal operate the oscillator control gate which starts and stops the oscillator. If the SYE signal is HI at the card input, it enables the oscillator control gate with a HI. Once enabled, this gate starts the oscillator when a second HI input is produced by the presence of one or more HI bits in the down counter. The oscillator starts when Q10 is turned off and no longer acts as a short across capacitor C3.

4-15 Oscillator Circuit. The oscillator is a conventional unijunction circuit which generates a series of pulses whose frequency depends on the R-C time of R12 and C3. When Q10 permits the oscillator to start, C3 begins charging through R12. Each time C3 charges to the firing potential of the unijunction, Q11 discharges C3 through R14 to produce a 1µsec positive pulse output to the shaping amplifier. The nominal output frequency of the card is factory-set at 100Hz by the 100kΩ resistor installed as R12. (Since the square wave generator divides the oscillator frequency by two, the frequency of the oscillator is twice that of the card output). The user can adjust the card output frequency over the range of 10Hz to 500Hz by replacing R12 with a resistor of appropriate value. Replacing R12 and C3 permits the card to cover the frequency range of 100Hz to 2kHz. (See paragraph 3-15).

4-16 The oscillator frequency can be controlled externally by removing R12 and connecting an external frequency determining resistor across terminals 4 and 6 of the card output connector. By connecting the output of a programmable resistance card across these terminals, the stepper motor speed can be made programmable.

4-17 Square Wave Generator. Each negative pulse produced by the shaping amplifier toggles the flip-flop that forms the square wave generator. The square wave generator had been initialized by the preset circuit so that its Q output was LO and its $\overline{Q}$ output HI. When the first input pulse causes the flip-flop to change state, the Q output becomes HI and is inverted by whichever output steering gate is being held enabled by the $\overline{B11}$ bit stored in storage flip-flop Z5. The negative output of this steering gate turns off its associated output amplifier to produce the start of the first positive square wave at the corresponding output terminal. This first output pulse to the stepping motor translator ends when the second oscillator output pulse causes the square wave generator to change state again. It is at this time, at the end of the output pulse, that the down counter is decremented by one count.

4-18 Counter Decrementing. At the end of each output pulse to the translator, the $\overline{Q}$ output of the square wave generator becomes HI. This HI is combined by the gate of the decrement detector with the already-existing HI output of the data OR-gate output buffer. The resulting LO to HI transition at the count down input (pin 4) of the down counter decrements its output count by one. (Although a LO to HI transition occurs at the count down input of the counter when the counter is loaded, the concurrent presence of a load pulse prevents the counter from being improperly decremented at that time).

4-19 The sequence described in the above two paragraphs continues until the count in the down counter reaches zero and the oscillator control gate stops the oscillator. If SYE is programmed off during an output pulse train, this will cause the oscillator control gate to stop the oscillator and the output pulse train immediately, freezing the output level in whichever state it happens to be. If SYE is programmed on again before a new data word reprograms the counter, the remainder of the interrupted output pulse train will be produced. The total count will equal the number programmed despite the interruption.

4-20 In case the card receives a new data word before the conclusion of the previous output pulse train, the data already contained in the counter will be lost and the card will process the new data normally. The only complication occurs when the new data word calls for an output of zero counts. When a zero-count data word interrupts an output pulse train, the result depends on two factors: (1) whether the new data word happens to be loaded into the counter during an output pulse to the translator or between pulses, and (2) whether the translator responds to the positive-going or the negative-going edge of an output pulse. If the data word is loaded between pulses, no error will occur. If the data word is loaded during an output pulse, the output will stop in its HI state. The effect this has depends on the translator. If the translator responds to positive-going edges, it will miss one count when the next data word is received. If the translator responds to negative-going edges and the multiprogrammer is shut off before another data word is processed, one additional output pulse to the motor will be produced at shutdown.

4-21 Common Timing Flag. The card sends a busy (LO) common timing flag ($\overline{CTF}$) back to the multiprogrammer any time a data word is strobed into the card. A $\overline{CTF}$ is generated even if the data word calls for a zero output or is received while SYE is programmed off. In either of these instances, the $\overline{CTF}$ will have the same duration as the received data strobe. Assuming that jumper W5 is in position A, as it is when the card is shipped, any output produced by the oscillator control gate is OR'ed with the data strobe signal at the input to Q3. As a result, the CTF line carries a busy flag signal during the production of all pulse train output signals. The busy flag, like the output pulse train, can be interrupted by programming SYE off. If jumper W5 is left open, no full length $\overline{CTF}$ will be produced, but a flag of the same length as the data strobe will still be produced.

4-22 External Timing Flag. Connecting jumper W5 in position B makes an external timing flag available at the card's output connector. This signal is produced only during an output pulse train and at no other time. Since this signal is not inverted by Q3, the polarity of the output is HI to signify the busy state. When W5 is in position B and no jumper is connected in position A, full length flags are not returned to the multiprogrammer but a $\overline{CTF}$ of the same length as the data strobe is still returned when a data word is received.

4-23 Output Amplifiers. If the stepping motor card is used to control a stepping motor, one of the output amplifiers is used to drive the clockwise input of the stepping motor translator and the other, the counterclockwise input. (If bit $\overline{B11}$ is being used as a data bit as described in paragraph 4-13, simultaneous outputs will appear at both output terminals). Jumper W1 in the output amplifier circuit selects an internal +12V or +5V collector supply for the output amplifiers or allows an external supply to be used if the translator or other load requires it. The card is shipped with W1 in the +12V position. Resistors R21 and R22 may be removed if open collector outputs are required.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 This section contains preventive maintenance instructions, checkout procedures, and troubleshooting procedures for the Stepping Motor Control Card, Model 69335A.

5-3 TEST EQUIPMENT REQUIRED

5-4 The 6940A Multiprogrammer provides all signal inputs necessary for testing the stepping motor control card. It is assumed that the multiprogrammer, as well as all other test instruments, are functioning properly at the outset of testing. The test instruments required for maintenance of this card are listed in Table 5-1.

5-5 PREVENTIVE MAINTENANCE

5-6 The only preventive maintenance necessary is to keep the printed circuit connector contact fingers clean. A nonabrasive eraser, such as a "Pink Pearl" or a plastic eraser, should be lightly rubbed over the contact fingers to remove any film or foreign material.

Table 5-1. Test Equipment Required

TYPE	CHARACTERISTICS	USE	RECOMMENDED MODEL
Oscilloscope	Bandwidth: dc to 50MHz Sensitivity: 20mV/div.	Checkout and general troubleshooting	HP Model 180A with 1804A and 1821A plug-ins
Multimeter	10Ω to 1MΩ, ±5% 0.1V to 100V, ±2%	General troubleshooting	HP 427A
Logic Probe	Impedance: 25kΩ. Trigger thresholds: 2.0V and 0.8V, nominal. Min. pulse width: 10nsec	Logic circuit troubleshooting	HP 10525T
Electronic Counter	Totalizing mode with 0-10kHz range. DC coupled input	Checkout and troubleshooting	HP 5326C

5-7 CHECKOUT PROCEDURE

5-8 This procedure can be used to check the operation of stepping motor control cards when they are first received, and as an aid in isolating trouble to a general circuit area if a malfunction is noted during operation. Perform the procedure given in Table 5-2 with the output card plugged into an extender card and the extender card plugged into a multiprogrammer unit. If necessary, review the procedures for manually programming the multiprogrammer before proceeding.

5-9 If an output card fails a test, make certain that it was programmed correctly before starting troubleshooting. Also check that the multiprogrammer SYE interlock jumper (pins 18 and 19 of the data input connector) is in place before testing.

5-10 The physical locations of the components referred to in the checkout procedure and in the troubleshooting information which follows, are

Table 5-2. Checkout Procedure

TEST NO.	TEST EQUIP. CONNECTIONS	INSTRUCTIONS	NORMAL INDICATION	EVALUATION
1	Connect dual channel oscilloscope to outputs 1 and 2 (output connector pins 1 and 2)	Energize the multiprogrammer system	No positive output pulses are produced. Output voltages remain less than +0.5Vdc	If a pulse appears at one or both outputs or either output remains at collector supply voltage, check Q5-Q9, Q13, Q14, and CR15-CR19
2	Same as test 1	At the switch register, program a control word with the appropriate unit address and with SYE on. Touch LOAD OUTPUT. Then program a data word with the appropriate card slot address and with magnitude bits 0-10 on and direction bit 11 off. Touch LOAD OUTPUT	A pulse train approximately 20 seconds long is produced at output 1. (See note 1)	If test 2 or 3 fails to produce on output at the proper terminal, check Q13, Q14, Z5, and output steering gates Z12. If the output train fails to stop, check Z7-Z9, Z13, and decrement detector Z11 and Z12. If no output is produced, proceed to the detailed troubleshooting procedure of Figure 5-1
3	Same as test 1	Address the card slot and set data bits 0-10 and magnitude bit 11 on. Touch LOAD OUTPUT	A pulse train approximately 20 seconds long is produced at output 2. (See note 2)	
4	Connect an electronic counter to output 1 and set it up to totalize positive pulses.	a. Address the card slot and set data bits 0-10 on. Touch LOAD OUTPUT b. Address the card slot and set bits 0, 2, 4, 6, 8, and 10 on. Touch LOAD OUTPUT c. Address the card slot and set bits 1, 3, 5, 7, and 9 on. Touch LOAD OUTPUT d. If bit 11 has been strapped to function as a magnitude bit, address the card slot and set bits 0-11 on. Touch LOAD OUTPUT	a. A train of exactly 2047 pulses is produced b. A train of exactly 1365 pulses is produced c. A train of exactly 682 pulses is produced d. A train of exactly 4095 pulses is produced	If a pulse train is produced but the count is not correct, turn SYE off, and then program data bits 0-10 on and then program them off, each time checking the logic levels at the storage outputs and the counter outputs. Also check for open OR-gate diodes CR3-CR14

Table 5-2. Checkout Procedure (Continued)

TEST NO.	TEST EQUIP. CONNECTIONS	INSTRUCTIONS	NORMAL INDICATION	EVALUATION
5	Connect a dual channel oscillo-scope to output 1 and $\overline{CTF}$ (TP10). Also connect the totalizing counter to output 1	Program a control word with the appro-priate unit address and with SYE off. Touch LOAD OUTPUT	No output pulses are produced. $\overline{CTF}$ output re-mains at a HI lo-gic level	
6	Same as test 5	a. With SYE still off, program a data word with the ap-propriate card slot address and with data bits 0-10 on. Touch LOAD OUTPUT b. Program a con-trol word with the appropriate unit address and with SYE on. Touch LOAD OUTPUT	a. No output pulses are produced. $\overline{CTF}$ output goes to a log-ical LO for the dur-ation of the LOAD OUTPUT pulse b. A train of 2047 pulses is produced. The $\overline{CTF}$ output goes to a LO logic level for the duration of the pulse train	If a pulse train is produced, check SYE amplifier Q2/Z11 and oscillator control gate Z12. If $\overline{CTF}$ remains HI in step 1 or 2, check the strobe and timing flag circuits by the procedure in Table 5-3.

Notes: 1. If the value of R12 has been changed to reset the output frequency, the approximate duration of the pulse train should be 2047/f seconds.

2. If bit 11 has been strapped to function as a magnitude bit, the approximate duration of the pulse train should be 4095/f seconds.

illustrated in Figure 7-1.

5-11 TROUBLESHOOTING

5-12 To troubleshoot a stepping motor control card, first follow the checkout procedure of Table 5-2. This procedure exercises all circuits of the card and in many cases identifies the most probable cause of a trouble symptom. If the card produces no output pulse train or Table 5-2 fails to isolate the malfunctioning circuit, follow the more detailed troubleshooting procedure of Figure 5-1. A procedure for locating difficulties in the data strobe input and timing flag output circuits is given in Table 5-3.

5-13 If a defective component is found in the course of troubleshooting, be sure to turn off power at the multiprogrammer and remove the output card from the extender before attempting replacement. When installing an IC, be sure that the notch or dot on the IC is at the same end as the bevel on the IC socket.

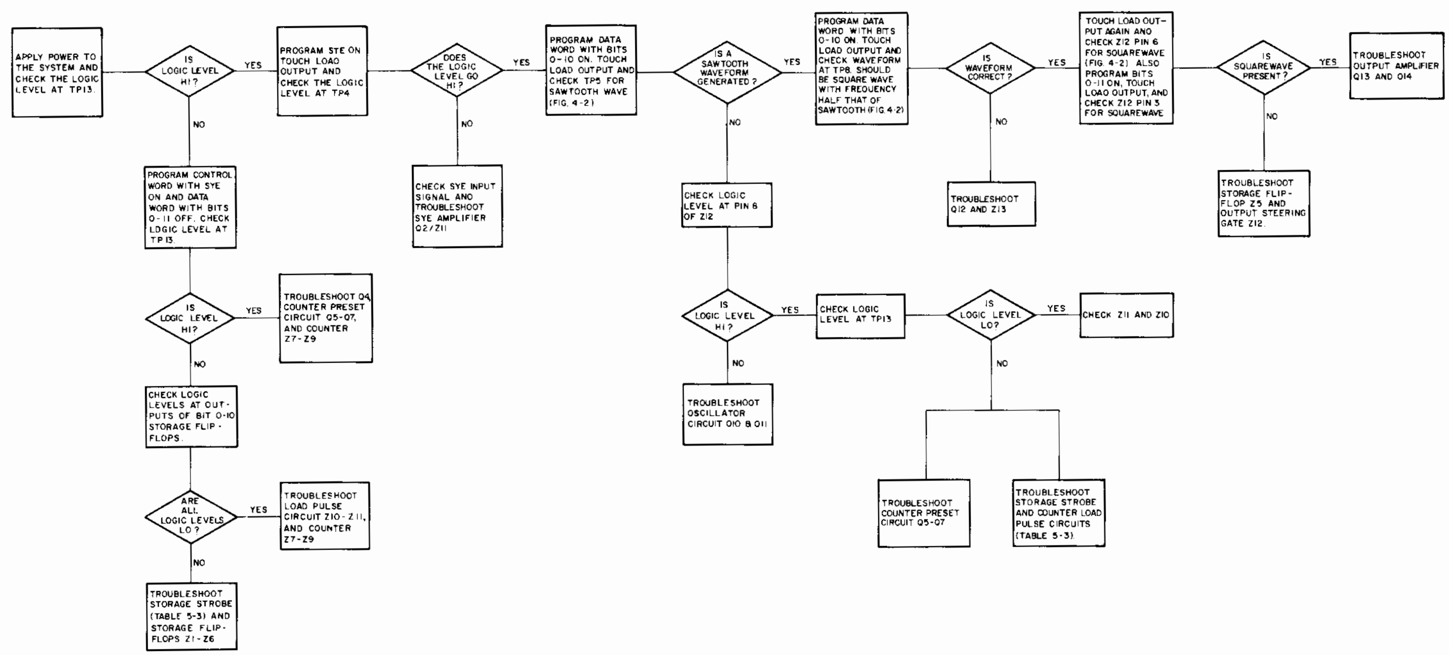

Figure 5-1. Detailed Troubleshooting Procedure

Table 5-3. Strobe and Timing Flag Troubleshooting

TEST NO.	EQUIPMENT CONNECTIONS	INSTRUCTIONS	INDICATION	IF INDICATION IS ABNORMAL
1	Connect logic probe to pin 8 of Z10 (TP1)	Address the unit with a control word that has SYE on; than address the card with a data word that has bits 0-11 set to zero and touch LOAD OUTPUT	Logic probe flashes off for duration of LOAD OUTPUT pulse	Check programming. Replace Z10
2	Connect logic probe to Q1 collector (TP2)	Touch LOAD OUTPUT again	Logic probe flashes on for duration of LOAD OUTPUT pulse	Check strobe amplifier Q1
3	Connect logic probe to pin 6 of Z11 (TP3)	Touch LOAD OUTPUT again	Logic probe flashes off	Check differentiating circuit and load amplifier Z11
4	Connect logic probe to Q3 collector (TP10)	Touch LOAD OUTPUT again	Logic probe flashes off for duration of LOAD OUTPUT pulse	Check timing flag control circuit CR1 and Q3
5	Same as test 4	Address the card with a data word that has bits 0-11 set to one; touch LOAD OUTPUT	Logic probe flashes off for duration of output pulse train	Check timing flag control circuit Z11 and CR2

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor	VR	= zener diode
R	= resistor	X	= socket
S	= switch	Z	= integrated circuit or network
T	= transformer		
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
cd	= card	NP	= nickel-plated
coef	= coefficient	Ω	= ohm
comp	= composition	obd	= order by description
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
DPST	= double pole, single throw	p-p	= peak-to-peak
elect	= electrolytic	ppm	= parts per million
encap	= encapsulated	pvr	= peak reverse voltage
F	= farad	rect	= rectifier
°F	= degree Farenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry	SPST	= single pole, single throw
Hz	= Hertz	SS	= small signal
IC	= integrated circuit	T	= slow-blow
ID	= inside diameter	tan.	= tantulum
incnd	= incandescent	Ti	= titanium
k	= kilo = 10^3	V	= volt
m	= milli = 10^{-3}	var	= variable
M	= mega = 10^6	ww	= wirewound
µ	= micro = 10^{-6}	W	= Watt
met.	= metal		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Div.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co. Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co. Inc.	Indianapolis, Ind.
06751	Semcor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, Ind.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Camera and Instrument Corp. Semiconductor Div.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc. Sylvania Electronic Systems Western Div.	Mountain View, Calif.
07716	IRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div. Semiconductor Operation	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Miniature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Rockaway, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11115	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc. Boone Plant	Boone, N.C.
11711	General Instrument Corp Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co. Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co. Loveland Div.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N.J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N.J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N.H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G.E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N.Y.

CODE NO.	MANUFACTURER	ADDRESS
70563	Amperite Co. Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I.T.T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N.J.
72982	Erie Technological Products Inc.	Erie, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N.Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N.J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J.W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N.J.
77147	Patton-MacGuyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metals Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N.J.
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83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
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86684	RCA Corp. Electronic Components	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N.J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
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93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
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96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N.Y.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
69335A-A4	Stepping Motor Control Card				69335-60020	
A4C1, 2	fxd, mylar .001µF ±10% 200Vdc	3	292P10292-PTS	56289	0160-0153	1
C3	fxd, mylar .047µF ±10% 200Vdc	1	292P47352-PTS	56289	0160-0138	1
C4	fxd, mylar .001µF ±10% 200Vdc		292P10292-PTS	56289	0160-0153	
C5-10	fxd, elect. 1µF ±10% 35Vdc	6	150D105X9035A2	56289	0180-0291	1
CR1-16	Diode, Si 180V 200mA	18	SG3396	03877	1901-0033	3
CR17	Diode, Si 15V 150mA	1	STB523	03508	1901-0460	1
CR18, 19	Diode, Si 180V 200mA		SG3396	03877	1901-0033	
Q1-10	SS NPN Si	11	SKA1124	01295	1854-0071	6
Q11	Transistor Unijunction	1	2N2646	03508	1855-0010	1
Q12	SS NPN Si		SKA1124	01295	1854-0071	
Q13, 14	SS NPN Si	2	SS1147	04713	1854-0448	2
R1	fxd, comp 1.5K ±5% 1/4W	1	CB-1525	01121	0683-1525	1
R2	fxd, comp 15K ±5% 1/4W	3	CB-1535	01121	0683-1535	1
R3	fxd, comp 1K ±5% 1/4W	4	CB-1025	01121	0683-1025	1
R4-6	fxd, comp 3K ±5% 1/4W	7	CB-3025	01121	0683-3025	2
R7	fxd, comp 5.1K ±5% 1/4W	6	CB-5125	01121	0683-5125	1
R8-11	fxd, comp 3K ±5% 1/4W		CB-3025	01121	0683-3025	
R12	fxd, comp 100K ±5% 1/4W	1	CB-1045	01121	0683-1045	1
R13	fxd, comp 680Ω ±5% 1/4W	1	CB-6815	01121	0683-6815	1
R14	fxd, comp 47Ω ±5% 1/4W	1	CB-4705	01121	0683-4705	1
R15	fxd, comp 100Ω ±5% 1/4W	1	CB-1015	01121	0683-1015	1
R16	fxd, comp 1K ±5% 1/4W		CB-1025	01121	0683-1025	
R17, 18	fxd, comp 5.1K ±5% 1/4W		CB-5125	01121	0683-5125	
R19, 20	fxd, comp 1K ±5% 1/4W		CB-1025	01121	0683-1025	
R21, 22	fxd, comp 510Ω ±5% 1/2W	2	EB-5115	01121	0686-5115	1
R23	fxd, comp 2K ±5% 1/4W	2	CB-2025	01121	0683-2025	1
R24	fxd, comp 5.1K ±5% 1/4W		CB-5125	01121	0683-5125	
R25	fxd, comp 15K ±5% 1/4W		CB-1535	01121	0683-1535	
R26	fxd, comp 5.1K ±5% 1/4W		CB-5125	01121	0683-5125	
R27	fxd, comp 15K ±5% 1/4W		CB-1535	01121	0683-1535	
R28	fxd, comp 2K ±5% 1/4W		CB-2025	01121	0683-2025	
R29	fxd, comp 5.1K ±5% 1/4W		CB-5125	01121	0683-5125	
R30	fxd, comp 430Ω ±5% 1/4W	1	CB-4315	01121	0683-4315	1
R31, 32	fxd, comp 750Ω ±5% 1/4W	2	CB-7515	01121	0683-7515	1
Z1-6	Dual D-type edge trig. F/F IC	6	DM74L74N	27014	1820-0596	3
Z7-9	4-Bit up/down counter IC	3	SN18953	01295	1820-0912	3
Z10	8-Input NAND gate IC	1	SN4345	01295	1820-0070	1
Z11	Hex Schmitt trigger inverter IC	1	SN42153	01295	1820-1053	1
Z12	Quad 2-input NAND IC	1	SN4342	01295	1820-0054	1
Z13	Dual J-K flip-flop IC	1	SN4355	01295	1820-0076	1
	MECHANICAL PARTS					
	IC Socket, 16-pin (Z7-9, 13)	4			1200-0507	1
	IC Socket, 14-pin (Z1-6, 10-12)	9			1200-0508	2
	Extractor Handle (marked)	1			5081-4965	
	Connector Assembly Data Output	1			5060-9658	1
	Connector 2X15(30) pin		251-15-30-261	71785	1251-0159	
	Hood Assembly, Right			28480	5060-7981	
	Hood, Right			28480	4040-0233	
	Insert, threaded 4-40			28480	0590-1017	
	Insert, threaded 2-56	3		28480	0590-1018	
	Hood, Left			28480	4040-0232	
	Clamp, Cable			28480	1400-0714	
	Box, Corrugated			28480	9211-0418	

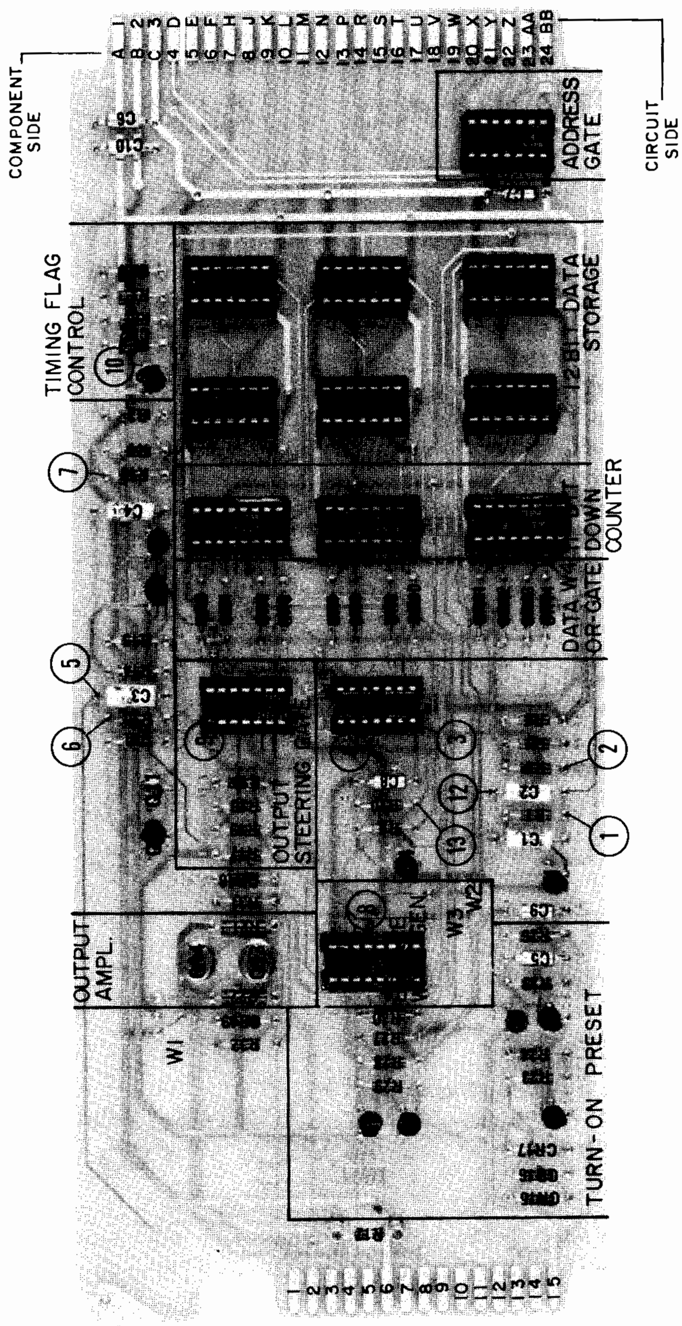
SECTION VII
CIRCUIT DIAGRAMS

7-1 COMPONENT LOCATION ILLUSTRATION

7-2 The component location illustration for the Model 69335A is given below. The illustration shows the physical location and reference designations for parts mounted on the printed circuit card.

7-3 SCHEMATIC DIAGRAM

7-4 The schematic diagram of the Model 69335A is presented on Figure 7-1. The test points (circled numbers) shown on the schematic diagrams correspond to the test points on the component location illustration.



Stepping Motor Control Card, Component Locations

SCHEMATIC NOTES:

1. ALL RESISTORS 1/4W, 5%, UNLESS OTHERWISE INDICATED.

2. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.

3. CARD IS FACTORY CONNECTED TO FURNISH "BI-DIRECTIONAL" OUTPUT (BIT $\overline{B11}$ SERVES AS DIRECTIONAL BIT) WITH JUMPERS W2 AND W3 IN AND JUMPER W4 OUT. CARD CAN BE MODIFIED FOR "UNI-DIRECTIONAL" OUTPUT WITH TWICE AS MANY STEPS ($\overline{B11}$ SERVES AS ADDITIONAL BIT) BY REMOVING W2 AND W3 AND CONNECTING W4 (REFER TO SECTION III FOR DETAILS).

4. JUMPER W1 FACTORY CONNECTED TO 12V BIAS (A). W1 MAY ALSO BE CONNECTED TO +5V (B) OR TO EXTERNAL BIAS SOURCE (C), IF REQUIRED. (REFER TO SECTION III).

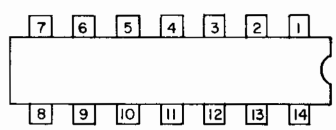
5. JUMPER W5 FACTORY CONNECTED TO "A" AND $\overline{CTF}$ IS FED BACK TO THE 6940A/6941A IN THE STANDARD MANNER. W5 CAN BE CONNECTED TO "B", IF DESIRED, FOR EXTERNAL EVENT SENSING BY MEANS OF THE FLAG SIGNAL. (REFER TO SECTION III).

6. PIN LOCATIONS FOR TRANSISTORS USED ON THIS CARD ARE SHOWN BELOW:

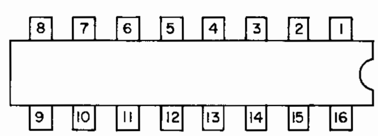
(TOP VIEWS)

TO-5 PL-5

7. PIN LOCATIONS FOR INTEGRATED CIRCUITS USED ON THIS CARD ARE SHOWN BELOW:



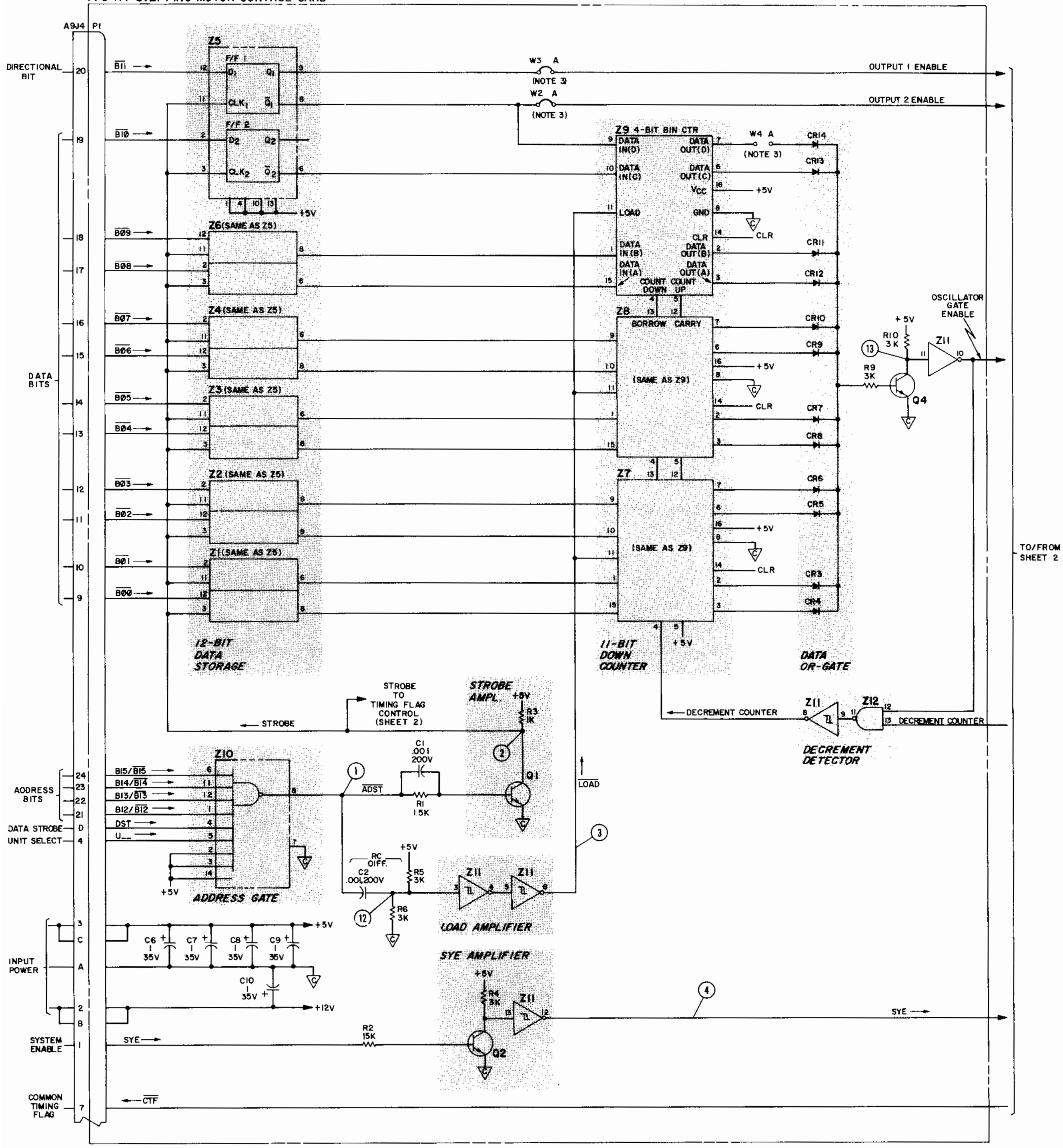
Z1-Z6, Z10-Z12



Z7-Z9, Z13

(TOP VIEWS)

P/O A4 STEPPING MOTOR CONTROL CARD



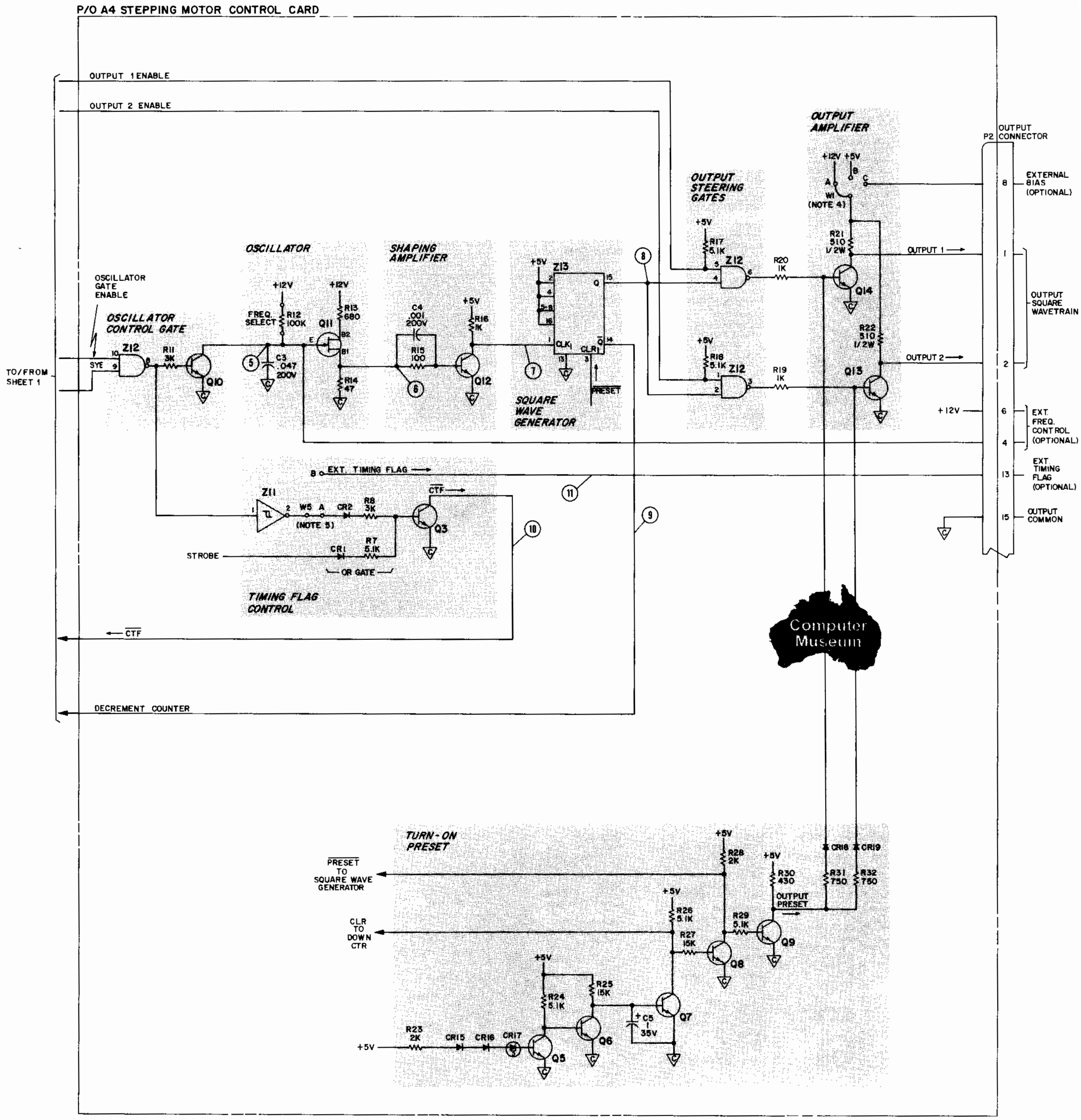


Figure 7-1. Stepping Motor Control Card, Schematic Diagram

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