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Final Report

EN-77 UNIT RECORD PRINTER

Clyde Lefevre

Westwood Division
Houston Fearless Corp.

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Rome Air Development Center
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AFLC, GAFB, N.Y., 4 May 67-91

FOREWORD

This technical report describes briefly the efforts carried on by Westwood Division, Houston Fearless Corporation, 11801 West Olympic Boulevard, Los Angeles, California 90064 under US contract AF30(602)-3521. The work was administrated under project 698DB under the direction of Rome Air Development Center, Mr. Nathaniel J. Miullo, Project Monitor.

The Unit Record Printer EN-77 was modified to determine the various requirements of the US Air Force for making 70x100mm Tactical Target Records (TTR) transparencies used by photo-interpreters as reference material. The printer presently is at 4444 Recc. Tech. Gp. at Langley AFB for further evaluation.

This report is designated RM-130-65 by Houston Fearless Corporation.

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This technical report has been reviewed and is approved.

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ABSTRACT

The EN-77 Unit Record Printer was originally developed with capability for contact printing from input negatives and limited capability for mensuration on the input negatives and for recording auxiliary data. The output film consisted of exposed lengths of unperforated 70mm print film to be developed and cut into Tactical Target Record (TTR) chips.

The task covered by this report was to redesign and rework the unit record printer to give it substantially increased capability in the areas of mensuration and auxiliary data recording and to make it more reliable and more convenient in operation.

Section 1 of the report describes the final configuration of the reworked printer, illustrates all the major components and controls, and describes its capabilities. Section 2 presents the theory of operation of the printer as a whole and of each major functional subsystem and describes the automatically controlled sequence of operation in the printing cycle with each function referenced to the detailed logic diagram bound in Appendix B of the report. Section 3 discusses the changes that are required by contract to bring the printer to its new configuration and describes the methods proposed to achieve the performance goals. Section 4 describes the progress of the development, the problems that were uncovered, and the solutions that were incorporated in the final configuration. Appendix A is a research report on initial studies of approaches to the problem of recording the machine and human-readable codes on the output film. Appendix B contains all the schematic diagrams of the printer.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

ILLUSTRATIONS

Frontispiece- EN-77 Unit Record Printer

SECTION 1
GENERAL DESCRIPTION

The Model EN-77 Unit Record Printer (hereinafter referred to as the URP) consists of two units: a main console and an auxiliary electric typewriter as shown in the Frontispiece. The URP is intended for use in a photographic processing facility for photographic contact printing of selected sections of aerial reconnaissance negatives. The output of the URP consists of exposed lengths of unperforated 70mm positive film in a format to be converted into Tactical Target Record (TTR) chips after processing. The input consists of a variety of aerial photographic roll film negatives in widths of 70mm through 9-1/2 inches and lengths up to 500 feet as well as sheet film up to 24 inches in length.

The URP is capable of exposing 25 identical TTR's automatically at a rate of 5 per minute. Film advance and exposure adjustment are automatic. A mensuration system permits the operator to establish the location of the desired printing area to an accuracy of 0.001 inch with respect to the coordinates of the input negative.

To aid in the storage and retrieval of the TTR chips and to provide supporting information for the user, the URP has the capability of recording several data items on the output film in addition to the contact-printed image. These data items include an accession number in both human-readable and machine-readable form, the security classification of the TTR, a north-indicating arrow, and a block of typed or printed copy photographed at a seven-to-one reduction from a unit photo interpretation record (UPIR) card.

The major functions of the URP are performed at the main console. The auxiliary electric typewriter is a modified Friden Flexowriter Model FL on a stand. It is not connected either electrically or mechanically with

Figure 1. Main Console with Access Door Open

6) Auxiliary data printer
7) Main illuminator assembly
8) System electronics
9) Power supplies

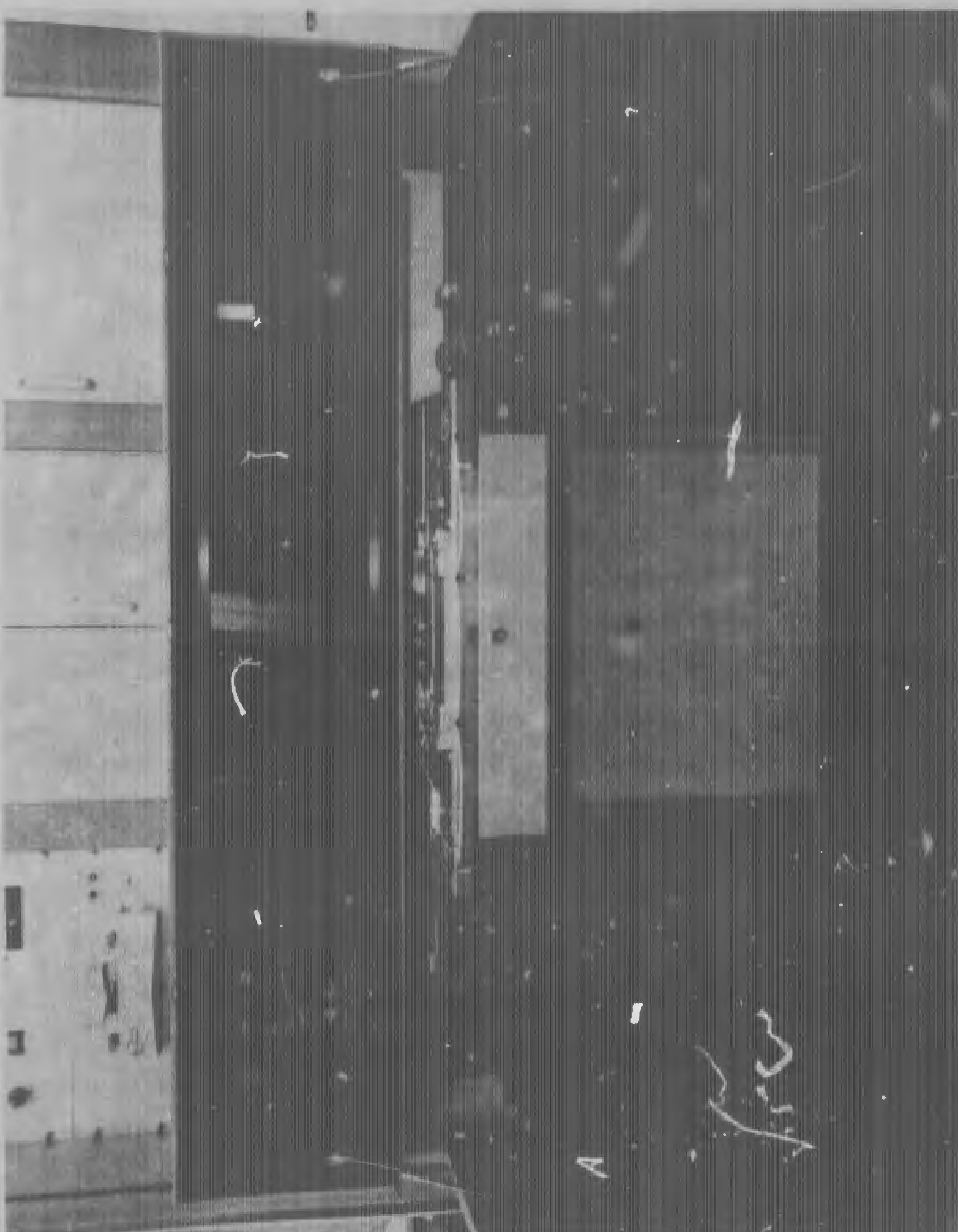
Several of these major assemblies contain significant subassemblies. The major assemblies and subassemblies are described in detail in the following subsections.

1.2 INPUT FILM TRANSPORT ASSEMBLY

The input film transport assembly (Figure 2) holds the input film in position and provides the electric motor drive to wind it in either direction at high or low speed as required. Film spool holders are adjustable to accommodate film in widths of 70mm, 5 inches, and 9-1/2 inches and lengths up to 500 feet. Sheets of cut film up to 24 inches long can also be accommodated. A light box under the film permits the operator to view the negative image. A mensuration unit mounted on top of the transport assembly supports and positions the print frame that outlines the area of the negative selected for printing.

1.2.1 Carriage

The entire film transport assembly and the mensuration unit are mounted on a machined cast-aluminum carriage. The carriage is movable from its normal position (in which a negative is selected and the print frame positioned) to the printing position (in which the print frame is under the contact printer). The carriage movement is from front to back and return. It is initiated by depressing the PRINT CYCLE START control after the necessary preparations have been made. The movement is produced



51912

Figure 2. Film Transport Assembly

by a drive screw rotated by a motor. A potentiometer mounted to the printing frame positions the carriage beneath the camera. Electronic logic circuits cause the carriage to return to the operating position after the required exposures have been made.

A glass platen covers the top of the center part of the carriage, forming a flat surface against which the negative film is held for mensuration and printing.

1.2.2 Film Drive System

The film is driven by a capstan roller at the right-hand end of the transport assembly. The capstan is driven by a 25-watt, 110-volt, 60-cycle, single-phase servo motor that is controlled by the slew control and scan control knobs on the control panel. As the drive motor and capstan move the film through the transport assembly, two torque motors (one at each end) control the action of the film spools. Regardless of which direction the film moves, the spool that is acting as takeup is rotated by its torque motor to wind up the film, and the spool that is acting as supply is retarded by its torque motor to prevent overrunning when the film drive is stopped. Since the torque needed to maintain a given tension changes with the amount of film wound on the spool, automatic torque adjustment is provided by a pivoted idler arm at the left end, controlling the setting of a variable transformer that adjusts the voltage to the left-hand torque motor. When the film transport is stopped, the power to the right-hand torque motor is shut off and a brake is applied while torque is maintained to the left-hand torque motor to keep the film under tension. Since there is no provision for reversing the direction of torque produced by the torque motors, negative film to be loaded on the printer must always be wound with the emulsion side in so that it can be threaded emulsion side up and have proper torque.

Film roll diameter sensors at each film spool stop the film transport automatically when the end of the film is approached.

1.2.3 Film Cleaner

A high-voltage electrostatic film cleaner with dust brushes and a vacuum system is installed in the left-hand end of the film transport assembly. The film passes through the cleaning unit for dust removal after leaving the left-hand supply spool. The power supply for the electrostatic element and the vacuum blower is mounted inside the printer chasis behind the cleaner location. A flexible tube interconnects the cleaner and the vacuum blower. To insure that the film will be cleaned before it passes over the platen, rolls of input negative film are normally loaded on the spindle nearest the cleaner (the left-hand end of the URP).

1.2.4 Film Viewing Light Box

The viewing light box is a shallow box located under the central area of the film transport assembly. It contains four Type F 15T8-D tubular fluorescent lamps and is covered with an opal glass to provide a bright uniform illuminated surface for inspecting negatives and positioning the print frame. The box is hinged to the console along the back edge so that it can be swung down for cleaning or maintenance.

1.3 MENSURATION UNIT

The mensuration unit (Figure 3) consists of a pair of frame assemblies supported over the glass platen of the film transport carriage. The two frames are supported on ball bearing rollers that rest in turn on machined surfaces. The mensuration unit supports the rectangular frame and the printing mask that defines the area of the negative selected for printing. The two

Figure 3. Mensuration Unit

51913

lateral shifts of the mensuration unit (one in the X axis of the negative and one in the Y axis) permit placement of the printing mask anywhere on the negative. The lateral shifts are accomplished with motor-driven lead screws that are directly geared to four-place counters reading in inches and thousandths.

The print frame supports interchangeable brass printing masks. Two masks are supplied, one with a 58 by 58mm aperture and one with a 58 by 84mm aperture. Fiducial notches cut into each side of the aperture define the reference axes of the print.

Slides working against precisely-machined guide rails keep the unit in alignment and prevent any free play that might tend to reduce the accuracy.

1.4 CAMERA ASSEMBLY

The camera assembly (Figure 4) is a box-like structure made of a machined aluminum alloy casting and mounted in the center of the printer chassis. It is light-tight and contains the mechanism that positions and advances the positive film raw stock for the printing operation. The positive film magazine, containing the film supply and takeup spools, mounts on top of the assembly allowing the film to feed into the interior through a slot. A light-tight sliding door closes the opening in the bottom of the camera assembly through which the film is extended by the vertical drive assembly for printing. The camera assembly also supports some optical and mechanical components of the auxiliary data printer and the machine-readable code generator.

Four small motors mounted on the back of the camera assembly are involved in the positive film transport and the contact printing operation. They have the following functions:

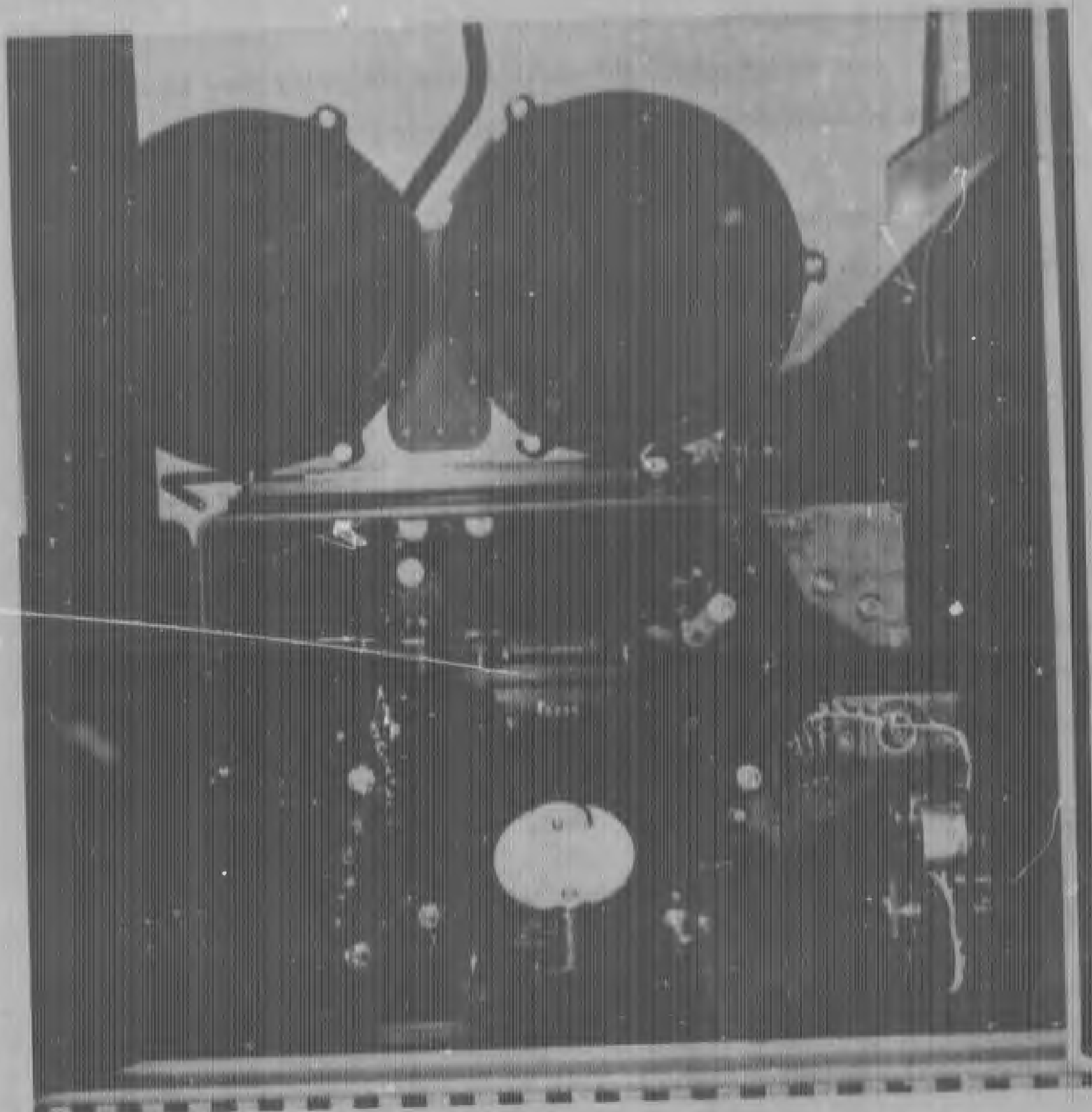


Figure 4. Camera Assembly

1) One motor drives a rotating cam that produces the down and up stroke of the vertical drive assembly that brings the positive film into contact with the negative.

2) One motor moves the light shield out of the way so the positive film can be extended through the aperture in the bottom of the camera assembly.

3) One motor drives a Geneva mechanism that advances the positive film.

4) One is the takeup torque motor for the takeup spool of the film magazine.

The Geneva mechanism rotates the shaft of the large rubber-covered roller (on the left in Figure 4), which acts as a metering capstan to advance the required length of film for each exposure. The film advance occurs in two equal increments of 50mm each, the first during the down stroke of the vertical drive assembly and the second during the up stroke. The takeup torque motor keeps the film under tension and winds up film as it is released by the combined action of the vertical drive assembly and the film advance.

A film cutoff knife is permanently mounted in the camera assembly. It is actuated by a lever on the outside and cuts the film about 3 inches below the entrance to allow the film magazine to be removed.

1.5 AUXILIARY DATA PRINTER

The auxiliary data printer (Figure 5) is a box-like structure mounted in the chassis of the unit record printer immediately to the right of the camera assembly. It contains various components required for recording auxiliary data on the TTR including the following:

Figure 5. Auxiliary Data Printer Assembly and UPIR Card Holder

1) The illuminator and holder for the UPIR card, the north arrow, and the classification indicator.

2) The holder, illuminator, and advancing mechanism for the human-readable code.

3) The code generator for the machine-readable code.

4) The lens and some of the mirrors that reflect the human-readable code onto the film.

5) The mirror that reflects the UPIR card onto the lens that projects the image onto the film.

The holder for the UPIR card is easily removable for changing the card and for changing the classification indication and the north arrow direction.

The accordian-folded lists of human-readable code numbers are placed on a shelf and threaded around the platen roller of the advance mechanism that brings each number into an aperture slot in succession.

1.5.1 UPIR Card System

The UPIR cards have typed or printed data to be photographed onto the TTR at a reduction of seven to one. The card is held in position to be photographed in a frame with a glass front (Figure 5). The frame is opened by removing the back, and the UPIR card is placed in it face down. The frame also contains the north arrow and an insert for the security classification. The proper security classification is inserted and the north arrow is set by rotating the dial with the finger. The back is then replaced and the holder inserted in the slots provided in the auxiliary data printer.

The UPIR card holder is illuminated by four 110-volt, 60-watt lamps. The recording lens is a high-grade f/3.5 anastigmat of 100mm focal length mounted in the contact printer assembly. A mirror directs the image of the illuminated card to the lens. The lens projects the reduced image directly onto the film.

1.5.2 Human-Readable Code Recorder

The human-readable code recorder (Figure 6) consists of a pin-feed platen roller with standard ratchet and ratched release to hold a typed list of numbers. An illuminator and an optical system project the image of the desired number onto the film at a reduction of seven-to-one.

The accession lists are typed on the auxiliary electric typewriter on accordion-folded lengths of white bond card stock that have registration holes punched along each side for positive positioning of the lines of typing. A shelf is provided in the auxiliary data printer to support the folded list. The leading end is threaded under the drive capstan with the pins of the capstan engaging the registration holes in the sides of the paper strip and the first number is brought into position. Thereafter, the paper is manually advanced to bring the next accession number into position before each new print cycle is initiated.

The illuminator is a 450-watt tungsten-iodide lamp. The lens is a 210mm focal length, f/4.5 anastigmat of high quality mounted in the auxiliary data printer assembly. Three front-surface mirrors reflect the image into the lens and two reflect it onto the proper location on the film. The three mirrors in front of the lens rotate the image of the accession code 90 degrees to place the image in the proper orientation on the film.

1.5.3 Machine-Readable Code Generator

The machine-readable code is recorded on the film as a series of 196 parallel rectangular bars, each 6.35mm long and 0.134mm wide.

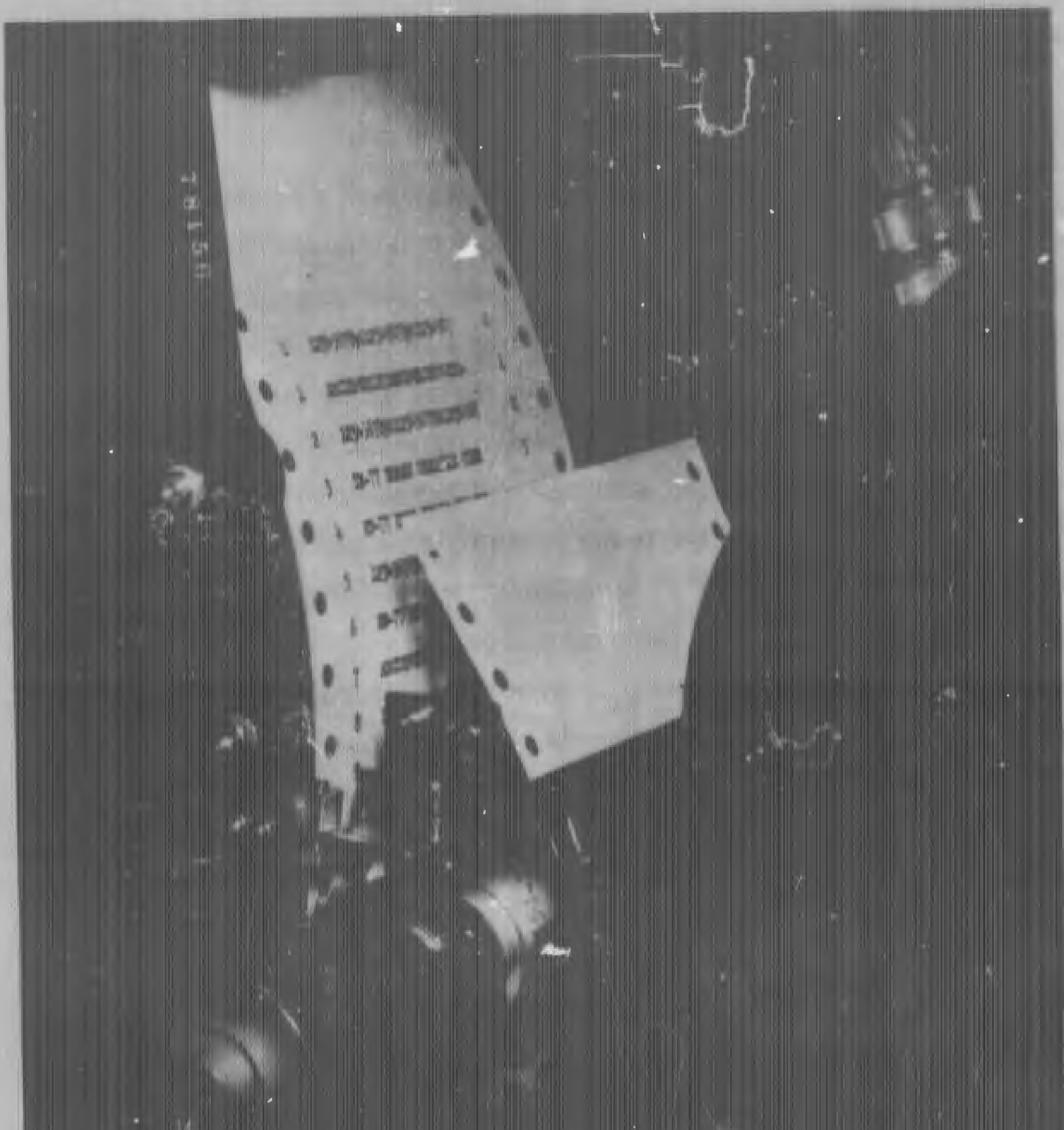
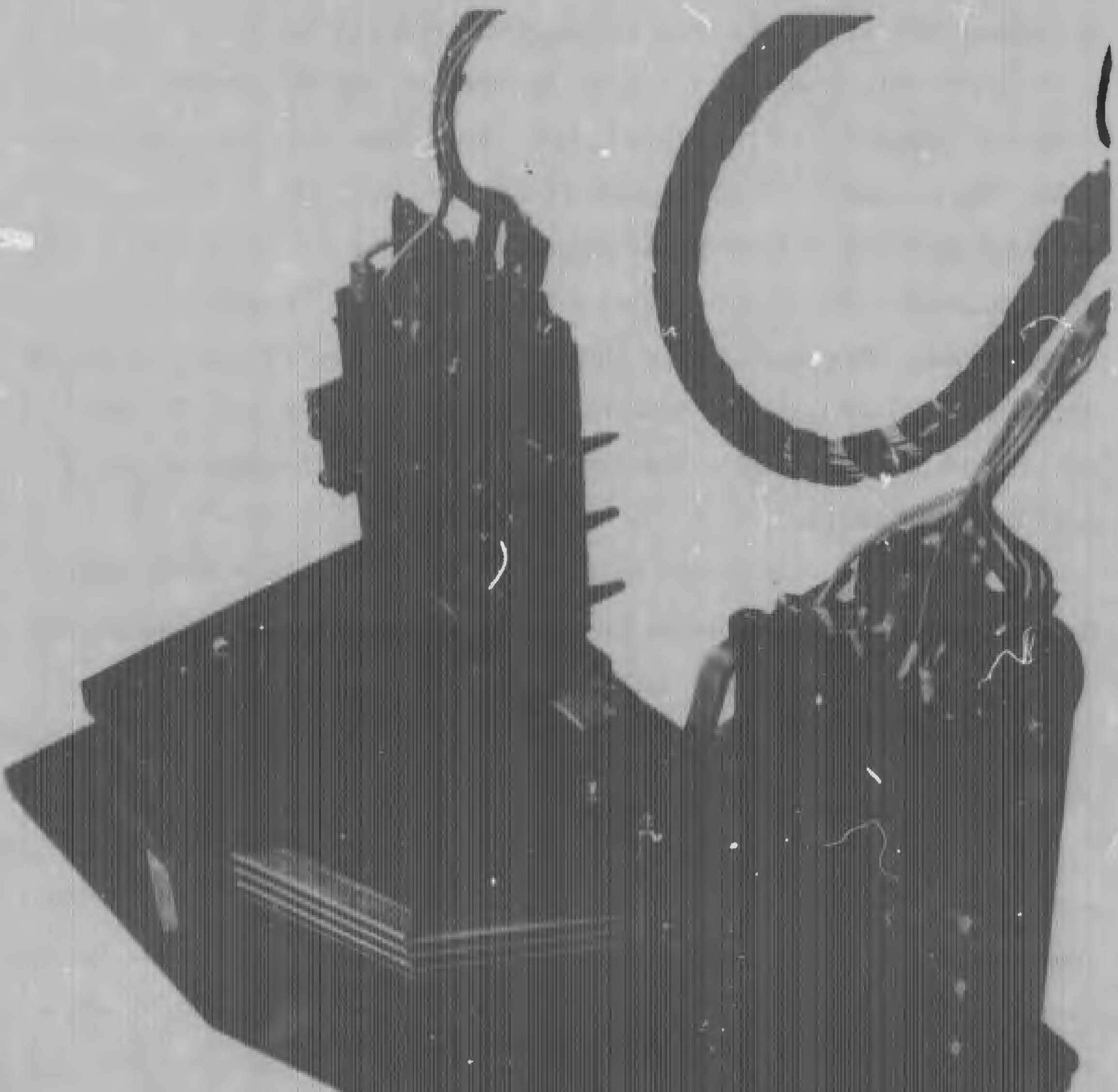


Figure 6. Accession List Advance Mechanism for Human-Readable Code Recorder

Each bar represents one bit of a six-bit-plus-parity code and is read as a binary 1 or 0 depending on whether the bar is in the leading half or trailing half of the allocated space. The codes are generated by photographing the edges of a stack of seven solenoid-actuated metal blades (Figure 7). These edges are each divided down the middle into two halves, one of which is polished and the other black. Each blade has two positions in which the polished and black phases are reversed. Thus the solenoid-actuated position of each blade indicates either a 1 or 0 in binary, and the positions of the seven blades encodes one alphanumeric character or a start code. The positions of the seven blades are controlled (through logic circuits) by the tape reader on the front panel of the URP, which reads the holes punched in the seven-bit tape that is prepared on the auxiliary typewriter.

The code-generating blades are illuminated by a small xenon flash tube (GE FT-31) powered by the discharge of a 16-microfarad 300-volt capacitor. The lens is an f/3.5 anastigmat of 100mm focal length identical to the one used in the UPIR system. Two front-surface mirrors direct the image to the lens, which projects it onto the film.

Since the code generator produces only seven bits (or one alphanumeric character) at a time and since the complete accession number consists of 27 characters plus a start code, the full machine-readable code is recorded by stepping the recording lens mechanically for each successive character. The lens drive assembly is located in the camera assembly. The lens mount is supported on a shaft and moved to each successive position by a Geneva mechanism driven by a small dc motor.



51917

Figure 7. Machine-Readable Code Generator

1.6 MAIN ILLUMINATOR ASSEMBLY

The main illuminator assembly (Figure 8) supplies the light for the contact printing operation. It consists of a 250-watt mercury arc light source, a spherical reflector, a four-element condensing lens system, a heat-absorbing filter, a solenoid controlled shutter, and a pair of circular neutral density filter wedges. The entire assembly is contained in a square housing mounted under the camera assembly in the center of the main console. The alignment is such that the light is projected up through the printing area of the source negative when it has been moved into printing position. The light falls first on the photocells that are mounted on the underside of the sliding door of the contact printing aperture. The brightness measured by the photocells causes the neutral density filter disks to rotate until the intensity has been reduced to a predetermined value that depends on the setting of the film speed adjustment. The shutter then closes, the sliding door opens, positive film is brought into contact with the negative, and the shutter opens for the proper exposure time and then closes. Exposure times range from 1/2 to 5 seconds depending on the output film speed setting.

1.7 SYSTEM ELECTRONICS

The electronic system of the printer provides necessary interlocks and assures the proper sequencing of the automatic functions. It consists of logic circuits on printed circuit boards interconnected with relays, microswitches, and the manual switches for operator control. The circuitry operates from two 18-volt dc supplies.

The electronic system (along with the printer power supplies) is mounted in the panel behind a protective door on the right-hand end of the printer (Figure 9). The system contains 10 printed circuit boards and 15 relays. Schematic diagrams of the electronic system are provided in Appendix B.

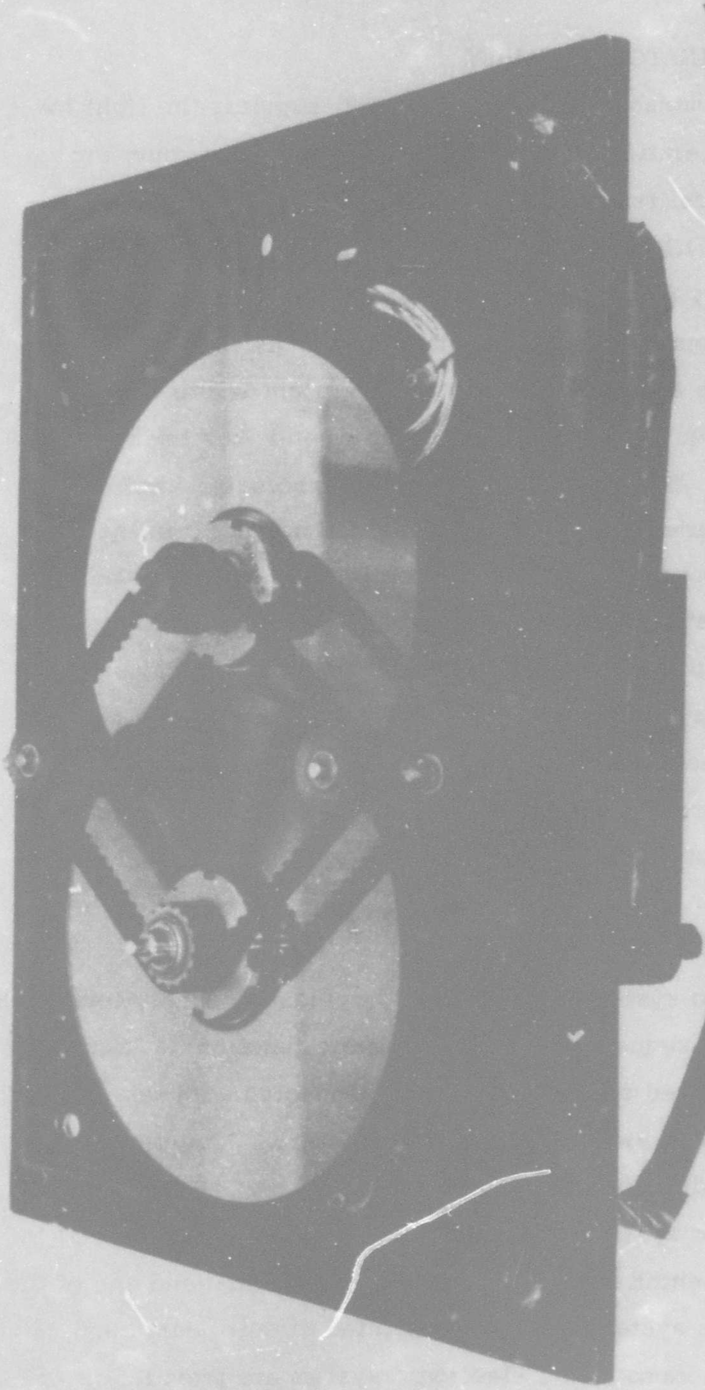


Figure 8. Main Illuminator Assembly

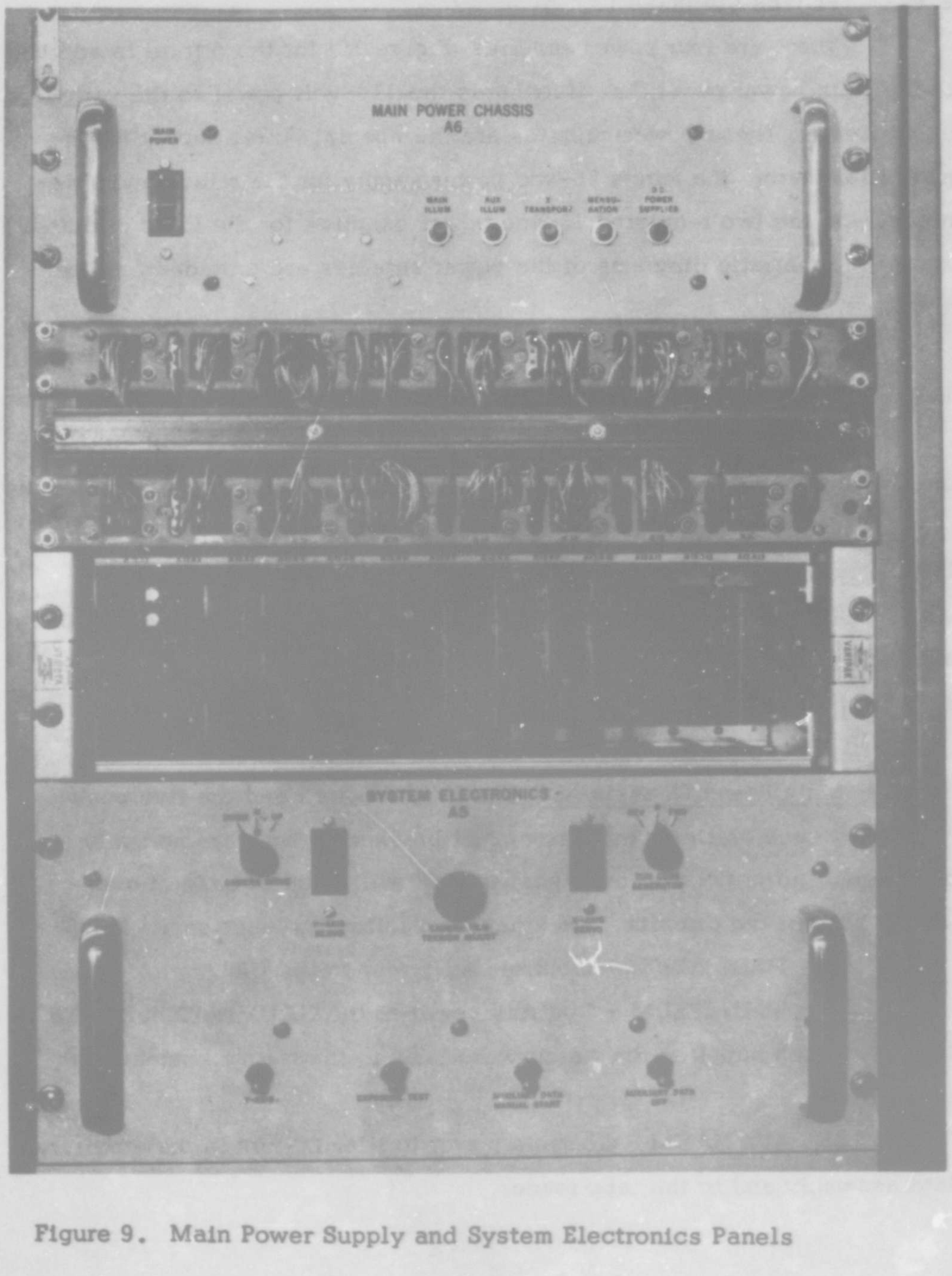


Figure 9. Main Power Supply and System Electronics Panels

1.8 POWER SUPPLIES

There are four power supplies (Figure 10) for the printer in addition to the main power panel that distributes the 110-volt power to the various subsystems. These power supplies are the special power supply for the main illuminator, the minus 26-vdc power supply for the relays and solenoids, and the two regulated 18-vdc power supplies for the logic circuits.

Schematic diagrams of the power supplies are provided in Appendix B.

1.9 CONTROLS AND INDICATORS

The locations and functions of all the controls and indicators of the URP are descirbed in the following subsections by major panel assembly.

1.9.1 Main Power Supply and System Electronics Panels

These panels are located behind the protective door on the right-hand end of the URP and are illustrated in Figure 9. The two panels are described under individual subheadings.

Main Power Chassis A6. The toggle switch and the five push-button switches on this panel are circuit breakers. They are normally maintained in the ON or closed position and will open in case of overload to protect the circuits. They have the following functions:

1) MAIN POWER - Controls all power to the URP.

2) MAIN ILLUM - Controls power to the ILLUMINATOR POWER SUPPLY, which supplies the mercury arc lamp in the main illuminator assembly.

3) AUX ILLUM - Controls power to illuminators in the auxiliary data assembly and to the tape reader.

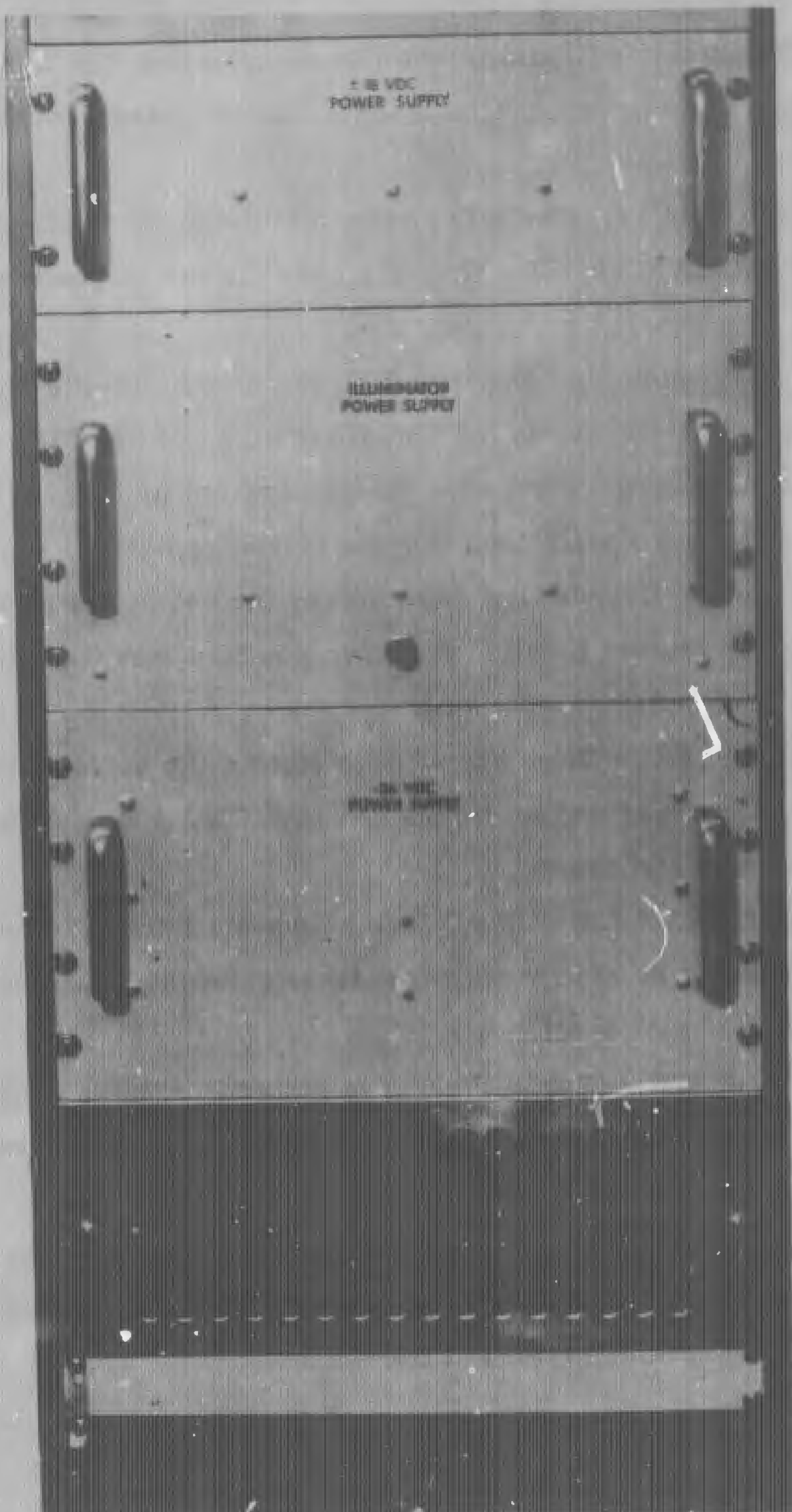


Figure 10. Direct-Current Power Supply Panels

4) X TRANSPORT - Controls power to the negative film transport drive motor, torque motors, brake, film cleaner, and the takeup motor in the camera.

5) MENSURATION - Controls power to the viewing light source.

6) DC POWER SUPPLIES - Controls power to the dc power supplies.

System Electronics A5. This panel contains two circuit breakers and a number of controls for testing individual functions of the URP.

1) CAMERA DRIVE - Drives the camera down or up when appropriately actuated. Must be positioned to N for normal operation. Interlocks prevent the camera from driving down unless the negative film transport carriage is in the full out position or full in position with the print frame centered in the X axis.

2) Y-AXIS SERVO - Circuit breaker to protect the servo amplifier of the film transport carriage drive. Normally set to ON, it will open and must be reset if an overload occurs.

3) CAMERA FILM TENSION ADJUST - Controls tension of takeup motor in camera. Should be kept at maximum tension (which is maximum counter-clockwise position) at all times.

4) X-AXIS SERVO - Circuit breaker to protect the servo amplifier of the capstan drive motor of the negative film transport drive. Normally set to ON, it will open and must be reset if an overload occurs.

5) RUN CODE GENERATOR - Drives the code generator lens forward or reverse when appropriately actuated to FWD or REV, respectively. Must be returned to N for normal operation.

NOTE

When this function is tested, the final test must always be in the REV direction to leave the lens in position to start an operating cycle by moving forward. During normal operation, the lens will reset to the proper position automatically at the completion of the automatic print cycle.

6) Y-AXIS - Toggle switch. When actuated up it drives the negative film carriage in to the printing position. When actuated down, it drives the carriage out. Interlock prevents the carriage from moving unless the camera is up.

7) EXPOSURE TEST - Spring-loaded toggle switch. When actuated it initiates the exposure light control cycle, opening the shutter and adjusting the intensity as controlled by the FILM SPEED ADJUST setting.

8) AUXILIARY DATA MANUAL START - Momentary-action toggle switch. When actuated, it initiates the auxiliary data recording cycle provided that either of the following two conditions are met:

a) Code generator lens at the maximum reverse position and a STOP character under the reading head of the tape reader

b) Code generator lens at the maximum forward position and a START character under the reading head of the tape reader

NOTE

The code generator lens does not reset automatically to the reverse position following this operation.

9) AUXILIARY DATA OFF - Toggle switch. When actuated, it disables the auxiliary data recording function.

1.9.2 Left Front Panel

The left front panel has three sections. The top section is devoted mainly to status indicators. The middle section contains the tape reader. The bottom section is the control panel.

Top Section. A row of eight indicators across the top of the panel (as shown in Figure 11) illuminate appropriately to provide the operator with status information. They have the following significance when illuminated:

1) MAIN POWER - Power is connected to URP and MAIN POWER circuit breaker and MAIN POWER switch are ON.

2) PRINT CYCLE ON - Printer is in the contact printing cycle.

3) AUX PRINT CY ON - Printer is in the auxiliary data recording cycle.

4) MAIN PRINT LAMP - Main print lamp is on.

5) FILM LOW TRANS - Negative film transport has been driven almost to the end of the film causing the automatic end-of-film sensing arm and switch to disable the film drive.

6) FILM LOW CAMERA - Positive film supply is low.

7) OVER EXPOSE STOP - Negative area under printer is too thin for automatic exposure compensation to prevent overexposure.

8) UNDER EXPOSURE STOP - Negative area under printer is too dense for automatic exposure compensation to prevent underexposure.

Two counters and several controls and indicators are also on the top section. They have the following functions:

1) PRINT COUNTER - A nonresettable counter that accumulates the total number of TTR frames exposed.

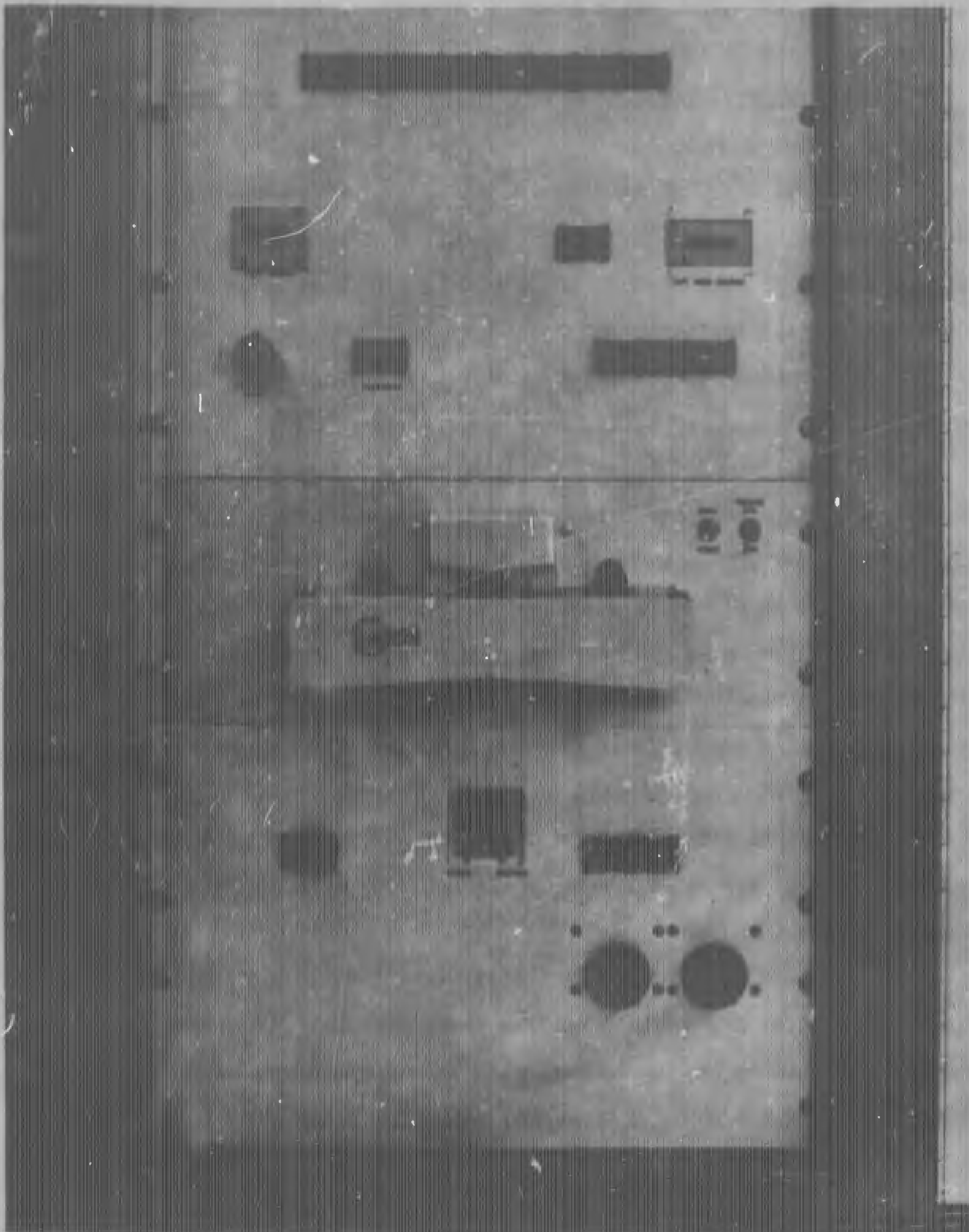


Figure 11. Left Front Panel

2) TAPE INDEX COUNTER - A resettable counter that accumulates the number of new TTR subjects recorded.

3) RESET - Actuator switch that resets the TAPE INDEX COUNTER to zero when depressed.

4) FILM SPEED ADJUST - Control knob to adjust the automatic control system to positive film stock of different sensitivity. It changes the exposure time over the full range from 1/2 to 5 seconds and simultaneously changes the reference set point for the brightness control. The index numbers are arbitrary and must be related to a calibration chart for the film in use.

5) FILM WIDTH - Control button and indicator for selecting and showing the print format in use. When 58 is illuminated, the 58 by 58mm printing mask should be in place. When 84 is illuminated, the 58 by 84mm mask should be in place. Depressing the button makes a change in the circuitry that compensates the automatic exposure control system for the difference in the illuminated area of the two masks. In addition, the shutter for exposing the UPIR card data is prevented from opening when this control is set on 84. (Printing masks must be changed manually.)

6) FILM STEP - Control button for manual control of film advance. Each time this button is depressed and held for 5 seconds, the positive film stock advances one frame.

7) LOAD FILM TRANS - Control button and indicator to put negative film transport system into loading configuration. When the button is depressed, illuminating the indicator, the torque motors, brake, film drive, and film cleaner are shut off to permit loading or removing film.

8) LOAD FILM CAMERA - Control button and indicator to put positive film transport system in camera into loading configuration. When the button is depressed, illuminating the indicator, the camera magazine drive is shut off to permit threading film through the camera.

Middle Section. The Remex tape reader and two toggle switches are located on the middle section of the panel. The switches have the following functions:

1) RUN LOAD - A two-position toggle switch. When set to LOAD, it disables the drive motor of the tape reader for loading. When set to RUN, it allows operation.

2) POWER ON OFF - A two-position toggle switch that controls power to the tape reader. It must be set to ON for tape reader operation.

Bottom Section. Several controls and indicators are located on the bottom section of the panel. These controls are for routine operations of the printer and are within reach of the operator when seated at the console. They have the following functions:

1) POWER ON - Pushbutton and indicator to turn the URP on or off. Power is on when illuminated.

2) REPRINT SELECTOR - Manually-set dial to control the number of automatic reprints of a selected TTR up to 25 reprints.

3) PRINT CYCLE START - Pushbutton and indicator by which the operator starts the print cycle after making necessary preparations. Once the print cycle is started by depressing this button it will continue automatically until the preset number of TTR chips has been exposed.

4) PRINT CYCLE RESET - Pushbutton and indicator to stop reprinting of a given TTR after the print cycle has started. When depressed during a printing cycle, it will allow only that cycle to be completed and will then return the negative transport carriage to the out position.

5) SLEW CONTROL - Control knob for moving negative film in slew mode. When turned to the left it will move the film to the left and when turned to the right it will move film to the right at fast speed.

6) SCAN CONTROL - Control knob for moving negative film in scan mode. Operation is similar to the SLEW CONTROL control knob. This control is used to move film at a slow creep for exact positioning in the X axis.

1.9.3 Control Table (Figure 12)

The control table has the footage counter for the negative film transport and the controls and indicators for the mensuration system. These controls and indicators have the following functions:

1) +X and -X COUNTER - These two four-digit counters indicate the distance to right or left (plus or minus) that the print frame has been moved from the zero point. They read in inches and thousandths.

2) X-AXIS - A spring-loaded lever that can be actuated to right or left, driving the print frame in the corresponding direction along the X axis.

3) Y-AXIS - A spring-loaded lever that can be actuated up or down, driving the print frame in a corresponding direction along the Y axis.

4) Y COUNTER - A four-digit counter that indicates the position of the print frame in the Y axis. It reads in inches and thousandths from a zero point above the field of the input negative, accumulating count as the print frame is moved down in the minus Y direction.

5) MASK - A pushbutton that operates a solenoid to clamp the printing mask against the negative.

6) FOOTAGE - A resettable four-digit counter that measures and records the amount of negative film moved through the transport system. It counts forward in feet as film is moved from left to right and counts backward as film is moved from right to left. The counter can be reset to zero by raising the control table and turning the knurled reset knob manually.

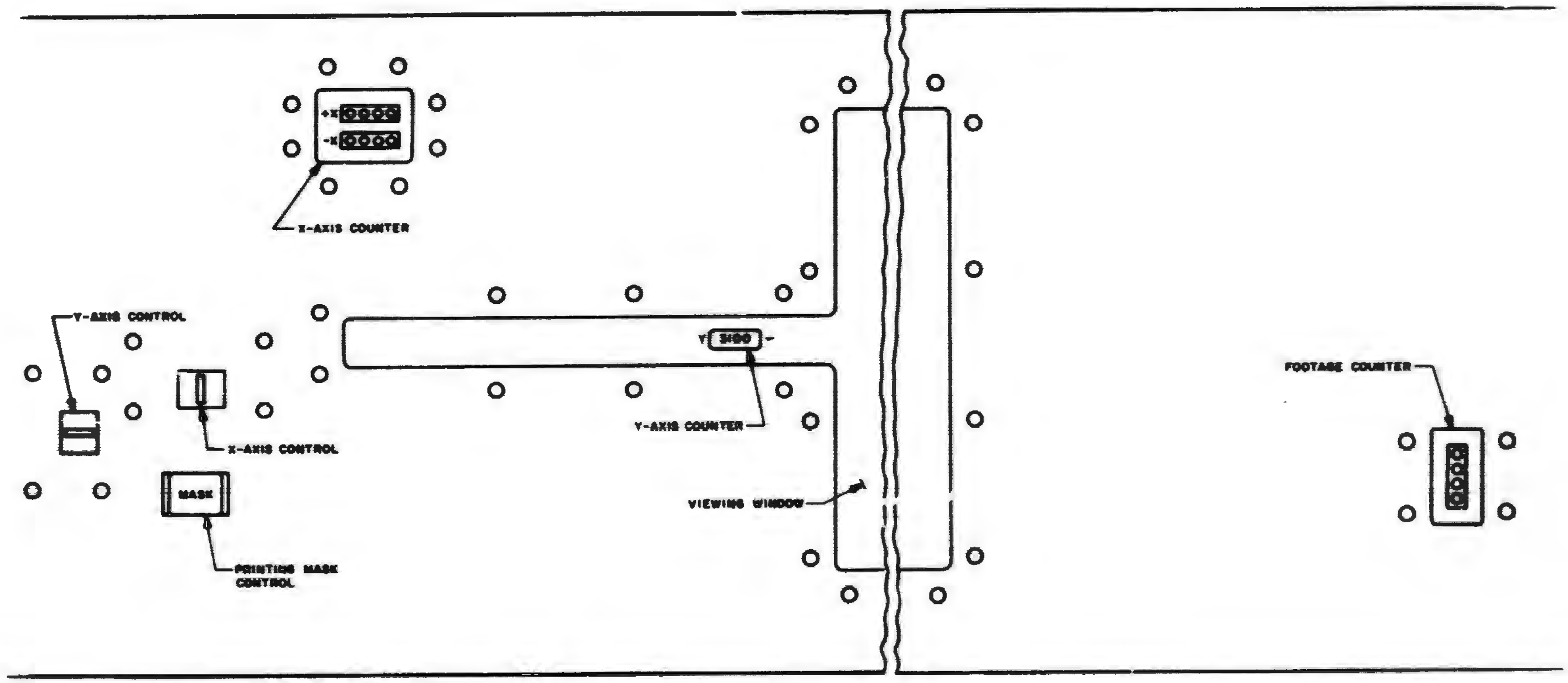


Figure 12. Control Table

1.9.4 Miscellaneous Controls

Miscellaneous controls in various parts of the URP have the following functions:

1) Film Transport Manual Control Switch - This toggle switch is located in the bottom of the right-hand compartment of the film transport assembly. When actuated to the right during the film loading operation, it will energize the film drive to the right and wind film onto the takeup spool.

2) Negative Film Takeup-Torque Potentiometer - This potentiometer is mounted at the back of the lower right-hand compartment of the film transport assembly. It was set at the factory for proper torque on the negative film takeup motor and requires no further adjustment.

3) Diaphragm Controls of Auxiliary Data Lenses - Each of the three auxiliary data recording lenses has a diaphragm ring to control the amount of light passed by the lens. The rings are marked with f numbers. Changing from one f number to the next larger f number will reduce the amount of light by one-half.

SECTION 2
THEORY OF OPERATION

The Unit Record Printer is essentially a photographic contact printer with auxiliary data recording. Its function as a contact printer is to hold a section of unexposed positive film in intimate contact with a selected negative area while sufficient light is transmitted through the negative to expose the film. To meet the requirements for convenience, speed, and capability of the printer, the basic function is supplemented to provide for automatic advance of the positive film stock, automatic exposure control, automatic recording of accession number and other supporting data, precise location of the selected negative area, and automatic recycling of the exposure to produce up to 25 identical TTR's. These extended capabilities require considerable sophistication in optical, electromechanical, and electronic assemblies. The operating principles of many of these assemblies are self evident or are covered adequately in the descriptions of the equipment in Section 1. Theory of operation of the more complex items is covered here.

2.1 NEGATIVE FILM TRANSPORT (Schematic Diagrams 4090851 and 4090852)

The negative film transport is controlled by relays A13K1 and A13K2 and the SLEW and SCAN CONTROL knobs on the front panel. When relay A13K1 (the x-axis power relay) is energized, it applies 110 vac to the x-axis servo amplifier and right-hand torque motor A7B2, and removes the -26 vdc from brake A3L1 on the right-hand film spool. Relay A13K2 (the x-axis slew relay) determines which solenoid in the two-speed gear box is energized. Relay A13K2 is energized when the x-axis slew control is operated, energizing slew solenoid A3L4.

The film-low switches on each film spool prevent x-axis power relay A13K1 from being energized by the front panel controls. These switches can be overridden by energizing FILM LOAD TRANS switch A1S11 and operating AUX FILM DRIVE switch A3S5. The AUX FILM DRIVE switch allows the film to be driven to the right during film loading.

The x-error detector on circuit card A12A7 receives a signal from the x-axis tachometer and holds in relay A13K1 until the transport speed has been reduced to zero.

2.2 MENSURATION SYSTEM (Schematic Diagram 4090853)

The function of the mensuration system is to permit the operator to select the area of the input negative that is required for printing. The accuracy requirements are severe: image position must be within ±0.001 inch of nominal position as measured at the displacement of the X and Y axes of the selected area with respect to the reference axes of the input negative.

The X and Y (reference) axes of the input negative are defined by the fiducial marks recorded on the four sides of the negative. The axes are the zero lines of the coordinate system used by the photointerpreters to measure the positions of image points of interest that appear in the pictures. A cross road, for example, appearing somewhat down and to the right of the center of a picture might have been measured and found to have coordinates of X = 1.764 and Y = -0.842, meaning that the center of the cross roads is 1.764 inch to the right (along the X axis) and 0.842 inch down (along the Y axis) of the negative. If a TTR chip were required of this cross roads area it could be requested and identified by these same values, meaning that the image area of the TTR chip should be centered on these coordinates. The axes of the image area of the TTR chip are defined by fiducial cuts into the sides of the thin brass frame that masks the printing area. These marks record on the TTR print in the same manner as the fiducial marks of the input negative.

Movement of the negative image in the X axis for proper placement of the selected area in the printing frame is accomplished by moving the film in transport. Movement in the Y axis for proper placement is accomplished by moving the printing frame from front to back. The printing frame can also be moved from side to side (along the X axis of the negative) for mensuration, but it must be centered for the printing operation. The movement of the printing frame is accomplished by a motor-driven lead screw in each axis. The amount of movement is indicated by four-digit counters reading to one thousandth of an inch and geared directly to the lead screw drive as described in Section 1.3.

The mensuration drive system consists of two small dc motors, each producing movement in one of the axes through a two-speed gear drive and a lead screw. Operating either of the mensuration control levers on the control table applies -26 vdc to the respective motor, which drives the printing frame through the low speed of the gear train. Direction of motor rotation and result-printing frame movement is controlled by direction of operation of the control lever. Speed of movement of the printing frame is controlled by the range of movement of the lever. When the lever is operated to the extreme position in either direction, the -26 vdc is also applied to a clutch that switches the motor drive from the low-speed gear train to the high-speed gear train. Four limit switches, one for each direction of each axis, shut off the drive motors when the printing frame is driven to the limits.

The X axis of the mensuration system has the additional feature of a detent bar at the center of travel (zero position). When the printing frame is driven to the center position, the detent bar slides into place, actuating the zero switch, A4S7. The zero switch is an interlock and must be actuated before the automatic print cycle can be made to start.

The mask switch applies power to the two mask solenoids, A4L1 and A4L2, which lower the printing mask into contact with the film.

An interlock is provided by means of A3S7A that removes all -26 vdc power from the mensuration system (except the mask solenoids) when the negative film carriage is not in the full out position. This interlock prevents the printing mask from being moved during the printing operation.

2.3 FILM VIEWING LIGHT BOX

The ballasts for the fluorescent tubes in the film viewing light box are on the floor of the right-hand compartment of the console. The lamps are normally on during URP operation but are turned off automatically by print cycle start relay A13K3 during the print cycle. They can be turned off manually by pulling out MENSURATION circuit breaker A6CB5. (See Logic Diagram 4093507.)

2.4 MAIN ILLUMINATOR (Schematic Diagrams 3090735 and 3093526)

The 250-watt mercury arc lamp in the main illuminator is powered from a special transformer in the illuminator power supply. The input to the transformer is regulated by a Sola transformer. The mercury arc lamp is normally on during URP operation but can be turned off if desired by pulling out MAIN ILLUM circuit breaker A6CB2.

A photocell in the main illuminator assembly responds to the light from the lamp and, through the detector circuit on A12A10 (Diagram 3090870), causes MAIN LAMP indicator A1DS4 to illuminate on the front panel.

A solenoid-operated shutter is located just above the lamp. Shutter operation is controlled by the logic circuits of the automatic print cycle.

Two neutral-density filter disks are located just above the shutter. These disks control the intensity of the light reaching the film during the print cycle and are driven by a dc motor that is in turn controlled by exposure sequence controller A12A9.

2.5 AUTOMATIC PRINT CYCLE (Schematic Diagram 4093507)

The automatic print cycle is a relay-controlled operation initiated by closing PRINT CYCLE START switch A1S8. Once the cycle is started, the completion of each phase starts the next phase. Switching and control are provided by relays A13K3 through A13K15. The sequence of operations and the logic can be traced on Logic Diagram 4093507. The sequence is as follows:

1) Manual closure of PRINT CYCLE START switch A1A8

2) Print cycle start relay A13K3 energizes closing the motor circuit and driving the film carriage under the camera

3) Shutter opens, initiating the exposure sequence

4) Exposure controller A12K9 closes the motor circuit, driving the neutral density disks to adjust the illumination level

5) Shutter closes

6) Light shield in camera opens

7) Camera drives down and film advances first half frame

8) Shutter opens and exposure time delay begins

9) Time delay ends and shutter closes

10) Camera drives up and film advances second half frame

11) Light shield closes

12) Auxiliary data print cycle relay A13K12 energizes, opening auxiliary data shutters, energizing lamps, and starting lens drive for machine-readable code recording

13) Lens drive moves lens through 28 exposure positions, stepping tape reader and exposing machine-readable code. At end of travel, relay A13K12 is deenergized closing shutters and deenergizing lamps

14) If the desired number of prints has not been made, the cycle repeats from step 3. If the desired number of prints has been made, film carriage returns to full out position, lens drive returns to rear position, and tape steps to next accession number.

2.5.1 Film Carriage Drive System (Schematic Diagram 4090850)

The film carriage drive system operates in the following manner. When the PRINT CYCLE START button is depressed, an error signal appears at the input to the Y-axis servoamplifier and is detected by Y-axis error detector A12A7, which, in turn, energizes Y-axis error relay A13K4. This relay releases Y-axis brake A3L1 by applying power to it and also applies power to Y-axis servo amplifier A5A1, which energizes the drive motor and moves the film carriage in. When the carriage nears the proper position under the camera, potentiometer A4R3, mounted on the mensuration assembly, hits a fixed limit that causes the potentiometer to reduce the error signal. When the error signal is reduced to zero, relay A13K4 is deenergized, removing power from the servoamplifier and allowing the brake to lock. An interlock prevents the carriage from moving unless the camera mechanism is in the raised position.

Two overtravel limit switches are provided, one at each end of the film carriage travel, to stop the carriage if the servo error system fails. If either of the overtravel limit switches is actuated, relay A13K4 must be manually actuated to return the carriage to its operating range.

2.5.2 Automatic Exposure Control

The automatic exposure control system adjusts the printing light to compensate for variations in the average density of the input negatives to produce output prints of consistent average density.

During the automatic print cycle after the film transport carriage has been positioned under the camera, the shutter in the main illuminator opens, allowing the light to pass through the negative area to be printed and impinge on the array of photocells mounted on the underside of the light shield in the camera assembly.

The light intensity is adjusted automatically. The output from the photocells, which is a 120-cps signal resulting from the 60-cps current in the lamp, is amplified and filtered in the photocell amplifier (Schematic Diagram 3090734). The signal is attenuated by potentiometer A1R3 (connected to the FILM SPEED knob) and fed to the exposure amplifier card (A12A8 Schematic Diagram 4090732). There the signal is further amplified, rectified, and compared with a fixed reference voltage of opposite polarity. If the difference between the rectified voltage from the photocells and the reference voltage is greater than 0.25, one of the two relays (depending on polarity) on the exposure sequence controller (A12A9 of Schematic Diagram 3090733) is energized. These relays apply power to the motor that rotates the neutral density disks that control the illumination level being sensed by the photocells.

While the illumination level is being adjusted, a circuit on A12A9 prevents the automatic print cycle from continuing. When the adjustment is complete, the circuit allows the print cycle to continue and also prevents the illumination level from being changed during the remainder of the cycle.

2.5.3 Reprint Selector

The number of reprints made during the automatic print cycle is controlled by REPRINT selector switch A1A2 on the front panel and a 26-position stepping switch (A5S7) located in the system electronics chassis. The desired number of prints is set on the REPRINT selector before initiating the print cycle. Each position of the REPRINT selector from 1 to 25 corresponds to one position of stepping switch A5S7. Each time the camera drive actuates to make a print, the stepping switch is stepped to the next position. When the stepping switch reaches the position corresponding to the position selected by the REPRINT selector, a circuit is closed that energizes reprint complete relay A13K6, which then terminates the automatic print sequence at the end of the current cycle. After the print cycle has been completed, the stepping switch is automatically returned to the starting position.

The reprint selector may be set to any number from 0 to 99. At the 0 setting, one print will be made. At any setting over 25, twenty-five prints will be made.

2.6 AUXILIARY DATA RECORDING

Recording auxiliary data to identify and supplement the photographic image on the TTR chip is an important function of the URP. The data items that can be recorded and their locations on the TTR format are shown in Figures 13 and 14. The recording or the auxiliary data is accomplished as a separate step following the film advance after the image area has been contact printed. The film advance brings the auxiliary data area of the film into the recording platen of the contact printer assembly and holds it accurately in the common focal plane of the three recording lenses. Printer logic then energizes the solenoids that open the light shields over the recording platen and initiates the various recording functions.

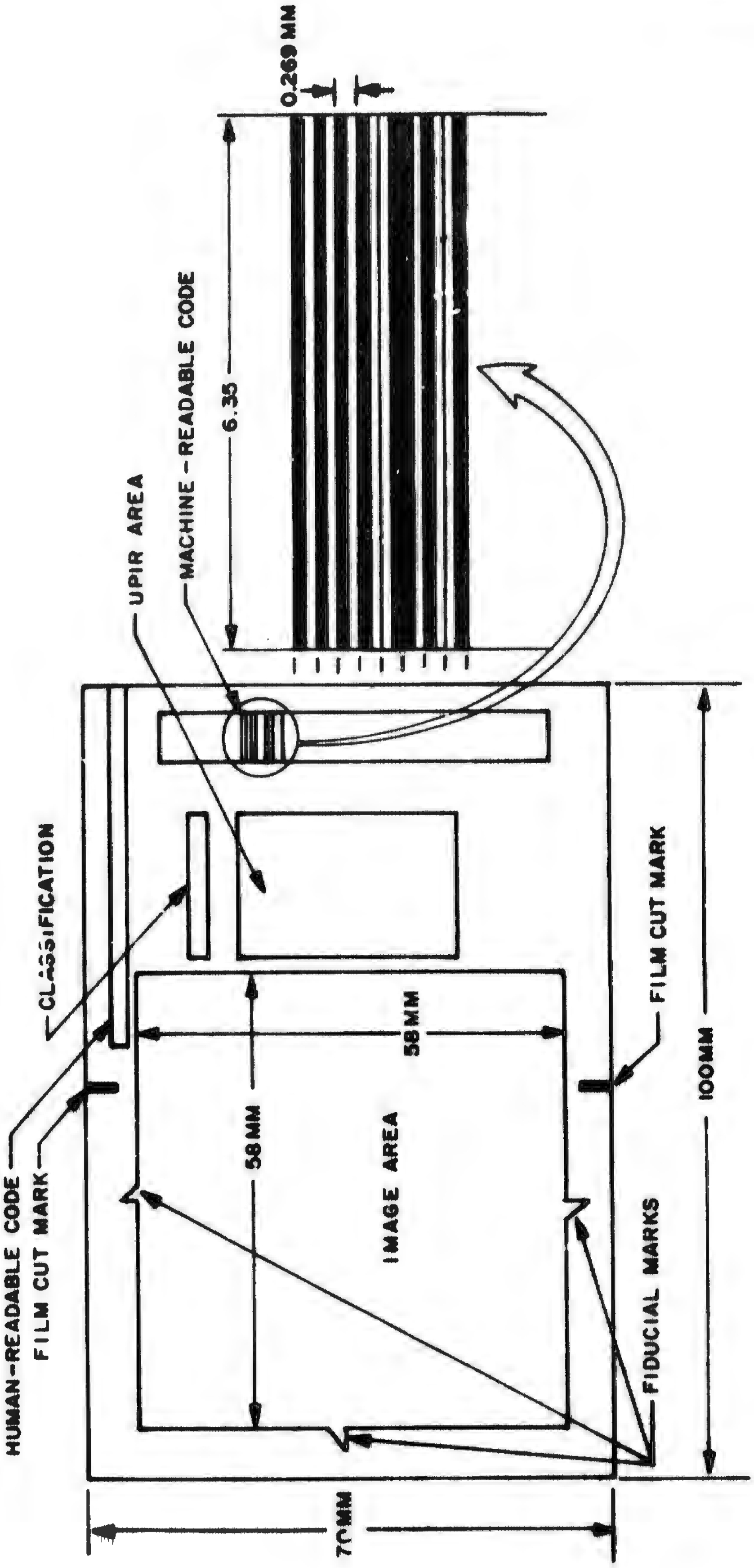


Figure 13. Tactical Target Record Format with 58 by 58mm Image

2.6.1 General Auxiliary Data Recording

The trim line for cutting the unit record from the continuous strip of developed film is exposed by a special lamp shining through a narrow slot in the recording platen. Recording the UPIR card, the north arrow, and the classification is a straightforward photographic operation complicated only slightly by the mirror in the path. Recording the human-readable accession number is similar but requires five mirrors to orient and position the image on the film.

Exposure time for each of the auxiliary records is limited by the recycling time of the printer and is fixed in the design of the machine. Exposure level is established by setting the diaphragms of the recording lenses and must be adjusted when print films of different sensitivity are loaded.

2.6.2 Machine-Readable Code

Recording the machine-readable code is far more complex than recording the other data items, since the code must be generated within the printer and then photographed seven bits (one character) at a time until all 28 characters have been recorded. The densities, bit spacings and dimensions, and positioning of the machine-readable code on the unit record are critical since the developed density and contrast of the unit record cannot be predicted with certainty and since the code must be read by machines of unknown characteristics.

Code Theory. To avoid mechanical complexity in the code reader, the code is designed to be read with one sweep of a light beam in a straight-line scan modulating a photosensor. The information is recovered by measuring the time intervals between light-dark and dark-light transitions. This

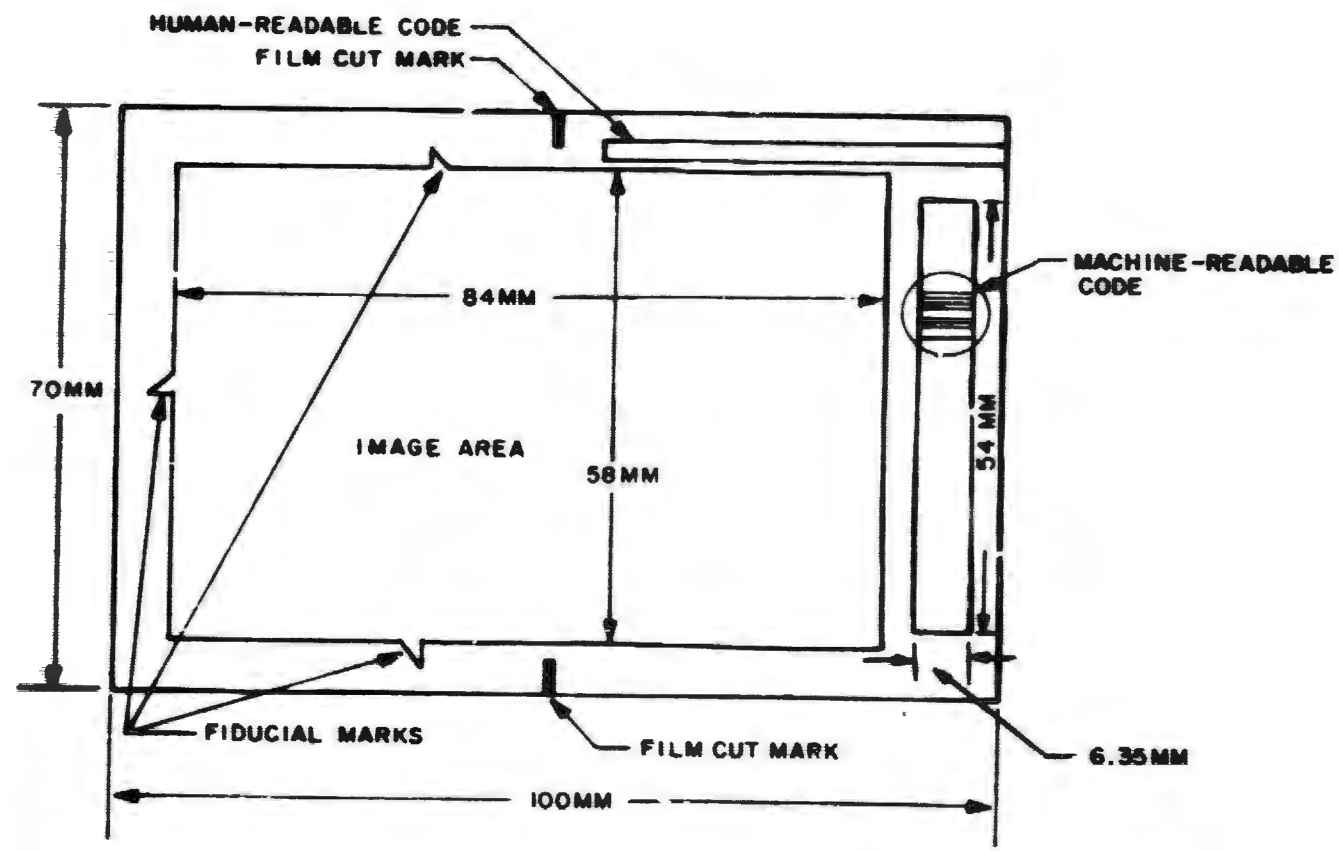


Figure 14. Tactical Target Record Format with 58 by 84mm Image

scheme, called phase modulation, has constant average density from character to character, since each character consists of bits that are half light and half dark. Since the average density is independent of the information encoded, only the variations in density and their transition intervals (which correspond to the ac signal component from the photosensors) need be considered in deciphering the code. The dc component is removed by the scanner circuitry, making the scanner independent of the average density of the TTR and the condition of the scanning system.

In phase modulation, each recorded bit has a transition and a direction of transition. The transition (dark-to-light or light-to-dark) occurs at the center of each bit and its direction determines whether the bit should be read as a 1 or a 0. In this application, each character has seven bits; six determine one coded character (out of a possible 64) and the seventh is a parity check. Each accession number has 27 alphanumeric characters; a 28th character recorded is a start character. Although the code generator will encode any combination of holes punched into the tape, the only characters meaningful to the code reader will be those listed in Table 2.

A space of 6.35mm ±0.127mm by 52.7mm is allotted on the unit record format for the encoded accession number. The 28 characters encoded by 7 bits each make 196 bits in the number. Each encoded bit extends the full width of the code area, 6.35mm. The allocated width of each bit in the direction of scan is 0.269mm, but the bar or half bit is recorded in only half that width.

Code Conventions. Binary codes for the characters that comprise the unit record printer character set are given in Table 2. The code is a subset of the ASCII code promulgated by ASA Standard No. X3.4, with the parity bit added in the most significant position.

TABLE 2

UNIT RECORD PRINTER CHARAC__R SET AND CODE

Binary	Alphanumeric	Binary	Alphanumeric
0 000 001	A	1 110 000	0
0 000 010	B	0 110 001	1
1 000 011	C	0 110 010	2
0 000 100	D	1 110 011	3
1 000 101	E	0 110 100	4
1 000 110	F	1 110 101	5
0 000 111	G	1 110 110	6
0 001 000	H	0 110 111	7
1 001 001	I	0 111 000	8
1 001 010	J	1 111 001	9
0 001 011	K	1 000 000	START
1 001 100	L	0 100 000	STOP
0 001 101	M	0 111 110	LOWER CASE
0 001 110	N	1 111 100	UPPER CASE
1 001 111	O	1 101 101	CARRIAGE RETURN
0 010 000	P	0 101 101	TABULATOR
1 010 001	Q	0 111 011	COLOR SHIFT
1 010 010	R	0 111 101	SPACE
0 010 011	S	0 011 111	BACK SPACE
1 010 100	T	0 011 100	STOP TAPE READ
0 010 101	U	0 101 111	1 OVER
0 010 110	V	1 011 101	- OVER =
1 010 111	W	1 101 110	. OVER ,
1 011 000	X	0 101 100	? OVER -
0 011 001	Y	1 111 111	DELETE
0 011 010	Z		

The following arbitrary conventions have been established in the use of this coding scheme:

	POSITIVE RECORD	NEGATIVE RECORD
Film Background:	Light	Dark
Binary "0":	Light area followed by dark	Dark area followed by light
Binary "1":	Dark area followed by light	Light area followed by dark

These transition directions are in the direction of the scan, which is from right to left (opposite normal reading direction). The scanner reads the least significant bit of the start character first and the parity bit of the most significant alphanumeric character last. The corresponding human-readable identification, if aligned adjacent to the code, would read correctly from left to right but the start character would be at the right-hand end.

2.6.3 Data Recording Control Sequence

Each time the camera mechanism is driven down to make a print, set relay A13K11 is energized. This relay provides the command to start the printing of auxiliary data when the contact print exposure is complete.

When the camera mechanism rises, relay A13K11 provides a signal to energize auxiliary data print cycle relay A13K12. This relay energizes at this time if one of two conditions are met. These conditions are as follows:

1) A STOP code is positioned at the reading station of tape reader A1A1, and the lens drive of the machine-readable code generator is in the forward position (nearest the inside wall of the camera).

2) A START code is positioned at the reading position of the tape reader and the lens drive is at the back position.

When relay A13K12 energizes, it opens the three auxiliary data shutters, clamps the film in the auxiliary data platen, energizes the UPIR and human-readable accession code lamps (through relay A14K1, Schematic 4090722) and energizes code generator motor relay A13K8. Relay A13K8 causes the code generator motor to drive the code generator lens by means of a Geneva mechanism and a lead screw. As the lens steps from each position to the next, a signal is applied to tape reader A1A1, advancing the tape by one character. The seven outputs of the tape reader control the seven code-generator mirrors through code generator driver cards A12A2 and A12A3. At each position of the lens, the flash tube in the auxiliary data assembly is fired, exposing one character of the accession number. When the code generator lens reaches the last position, a signal is provided to stop detector A12A4, which momentarily energizes stop relay A12A4K1, which in turn deenergizes auxiliary data print cycle relay A13K12. If multiple prints are being made, the cycle is repeated for each print; but on the even-numbered prints, the code generator lens is driven in reverse and the tape reader is stepped in reverse.

When the required reprints have been completed, reset auxiliary data relay A13K15 is energized. The relay causes the code generator lens to be driven back to its starting position and also steps the tape reader to the STOP character of the next accession number by means of the multivibrator on code generator control card A12A5. Next-start relay A13K14, which is energized during the first auxiliary data print cycle, momentarily inhibits the action of the STOP character detector and therefore insures that the tape reader will advance the tape to the next STOP code in order.

A circuit on code generator control card A12A5 serves to hold in reset relay A13K15 until the lens has returned to its starting position and the tape has advanced to the next STOP code.

SECTION 3
TECHNICAL DEVELOPMENT

3.1 INITIAL CONFIGURATION AND CAPABILITY

When the Houston Fearless portion of the program was initiated, the EN-77 consisted of a main console and an electronics cabinet. The main console housed the input film transport and the camera, while the electronics cabinet housed the power supplies and most of the power switching control components.

The input film transport was essentially the same as was finally used. It consisted of a capstan drive system with alternating current torque motors providing film tension. The film transport mechanism was driven beneath the camera by a two-motor, two-speed drive system using a three-quarter horsepower motor for the main drive.

The camera produced a contact print by driving the output film down into contact with the input film on the film transport. Film was indexed in the camera by means of a sprocket hole punched at 100mm intervals as the film moved through the camera.

Orientation of the contact printed image on the output film chip could be controlled by rotating the camera through a full 360 degrees around the vertical axis.

Auxiliary data was contact printed onto the film by inserting a previously prepared transparency of the desired auxiliary data into the camera each time the data changed.

The following items summarize the capabilities of the EN-77 in its initial configuration:

Input film transport	500 ft spool capacity 70mm, 5 inch, and 9.5 inch width Transport speeds from 1 ft/min to 100 ft/min

Measurement accuracy	Approximately 1/8 inch
Camera	Contact prints on 70mm film with orientation adjustable through 360 degrees
Exposure control	Automatic control to maintain density of output film chip constant (Operation was inadequate)
Exposure illumination	Illumination source capable of printing onto S0-230 film from input negatives with density of 2.0 in 4 seconds or less
Auxiliary data printing	Capable of printing from a manually inserted film chip of the desired data

3.2 CHANGE REQUIREMENTS

The changes to be incorporated in the Unit Record Printer EN-77 (A) were defined in RADC Exhibit 5141 and ammended by RADC Letter 13442 dated February 27, 1964. These requirements are described in the following paragraphs.

3.2.1 Mensuration System

Design and incorporates a mensuration system for the input negatives capable of measuring both the X and Y axes to an accuracy of 0.001 inch. The mensuration device must be capable of establishing the coordinate distances between the fiducial marks on the negative and selected targets anywhere in the negative image area and must further be able to relate these coordinates to the fiducial marks of the output film chip to the same accuracy.

3.2.2 Output Camera

Redesign the output camera so that it will have the following features:

1) Precision film advance

2) Easy-threading magazine

3) Provision for contact printing the selected area of the input negative and optically recording auxiliary data including an accession number in both machine readable and human readable form, the security classification, a north-pointing arrow, and the UPIR card (a block of typed or printed information)

4) Provision for optically recording a mark on the margin of each output film chip to be used as a guide for cutting the chip from the continuous roll after development

5) A device for counting the number of duplicate chips exposed (up to 25)

6) An end-of-film warning indicator for the output film stock

7) Automatic exposure control

8) An operating rate of 10 exposure cycles per minute.

The human-readable code in the auxiliary data block must provide for 27 alphanumeric characters. The UPIR card data block must be recorded at a linear reduction of one seventh of the original. The north-pointing arrow must be manually controllable, and three levels of classification must be manually insertable.

3.2.3 Code Generator

Develop a code generator for machine-readable code capable of producing a 27-character, 7 bit per character code on the film in the form of opaque and transparent bars. The system must encode the same accession number as is recorded on the film chip in human-readable form.

3.3 ANTICIPATED PROBLEM AREAS

3.3.1 Mensuration System

It was apparent that there would be a number of problem areas in the redesign of the mensuration system to meet the requirements. The following were the major items:

1) Accuracy. The requirement for an accuracy of 0.001 inch in the measurements is severe. The targets may lie anywhere in the input negative area of 9 by 18 or 9 by 24 inches and must be related to the ficucial marks of the output chip as well as those of the input negative.

2) Measurement Transfer. Moving the film and mensuration system from the measuring to the printing position without disturbing the relation between them requires an extremely stable electrical and mechanical system.

3) Film Curl. Because of the limited space between the input film carriage and the camera platen, film curl in the input negative could be troublesome.

4) Counters. High speed counters are required for the mensuration system. Since the smallest count is .001, the counters will register 18,000 counts over the longest measure distances of 18 inches. Even if the total scan period were five minutes (which is probably excessive) the counters will be operating at 3600 counts per minute, a very high value.

5) Mensuration System Mounting. Mounting the mensuration Y-Y system requires a considerable amount of rework of the original transport.

3.3.2 Output Camera Transport System and Magazine

The film transport system for the output camera must be capable of moving the output film with sufficient accuracy to insure proper placement of all the items recorded on the chip and proper mounting of the chip in the final frame without wasteful trimming. The accurate transportation of film that has no sprocket holes has always been a problem.

The design of the magazine would require considerable study to assure easy loading and threading. The success of the camera would depend partly on the design of the magazine.

3.3.3 Code Generator

The problems associated with producing a machine readable code on the film are related to the spacing accuracy required and the contrast between the light and dark areas. Since only one 7-bit character would be photographed at a time, the device which transports the character generator would be required to do so with considerable accuracy. The actual spacing deviation of succeeding parallel transitions, i.e., one dark to light to the next dark to light is +.001 inches, -.002 inches. The deviation of nominal spacing of opposite transitions, i.e., one dark to light to the next light to dark is +.0005 -.001 inches from 1/2 bit to 1/2 bit. The optical densities required are:

Light areas	-	02 to 2.00
Dark areas	-	.52 to 2.50

The density spread between light and dark areas must fall between .50 and 1.50 and the average transmission of the light areas must not exceed 12.5 times the average transmission of the dark areas. In addition, the edge sharpness of the bits on the film defined by the width of the fall off from maximum to minimum densities at the boundary of the dark and light areas must not exceed .002 inches. The optical and illumination systems required to achieve the prescribed configuration are discussed in the section dealing with proposed solution.

3.4 PROPOSED SOLUTIONS TO ANTICIPATED PROBLEMS

3.4.1 Mensuration System

The following solutions were proposed for the anticipated problems in development of the mensuration system:

1) Accuracy. To achieve the accuracy requirement of 0.001 inch in measuring the position of the imagery in relation to a given position in the original record, the equipment must be capable of an accurate least count measurement, and must retain this relationship during the recording phase. A measurement capability of 0.001 implies component parts accuracies exceeding this.

The lead screw driving the X-Y table carrying the mask with which measurements are made would need to be accurate to within .0005 in the 24 inch length. The lead screws should be provided with preloaded ball nuts and be mounted in preloaded bearings to preclude axial motion. The X-Y carriages must ride on ground stock, and be supported by precision bearings. The fixed support bearings must be opposed by spring loaded bearings to assure accurate registration. Since the measurement accuracy will be a function only of the X-Y table accuracy instead of film travel accuracy, no difficulties beyond the usual care required in designing this type of mechanism was anticipated.

2) Transport. The transport system for the input material appeared to require no modification. Since the proposed mensuration system accuracy is not dependent upon film travel accuracy, the function of the transport system is to bring the desired negative into position and to remain stable during the recording period. If the transport were found to be unstable, electro-mechanical brakes could be added to immobilize it. Figure 15 shows the proposed threading.

3) Film Curl. Some difficulty had been experienced with the film transport system because the edge of the input film would curl up and catch the camera mask when the film transport system was moved under the output camera. Plastic bands, which were added to the film transport, were ineffectual in preventing this difficulty. The proposed design for the mensuration system was to use rollers on both sides of the mask so that the significant area would be held flat. An alternate proposal would use a frame that could be lowered against the film and held during the recording cycle. This arrangement would have the added advantage of immobilizing the film between mensuration and recording.

4) Counters. As noted in Paragraph 3.3.1, the required counting rate could easily approach 3600 counts per minute during the mensuration sequence. Since it seemed unlikely that a mechanical counter could be found that could be actuated at this speed, the alternatives were either to reduce the speed to accommodate the fastest mechanical counter (about 2000 counts per minute) or to supply an electronic counter actuated by counts from an analog to digital encoder. It was recommended that the customer be requested to specify a suitable traverse time to scan the entire illuminated area.

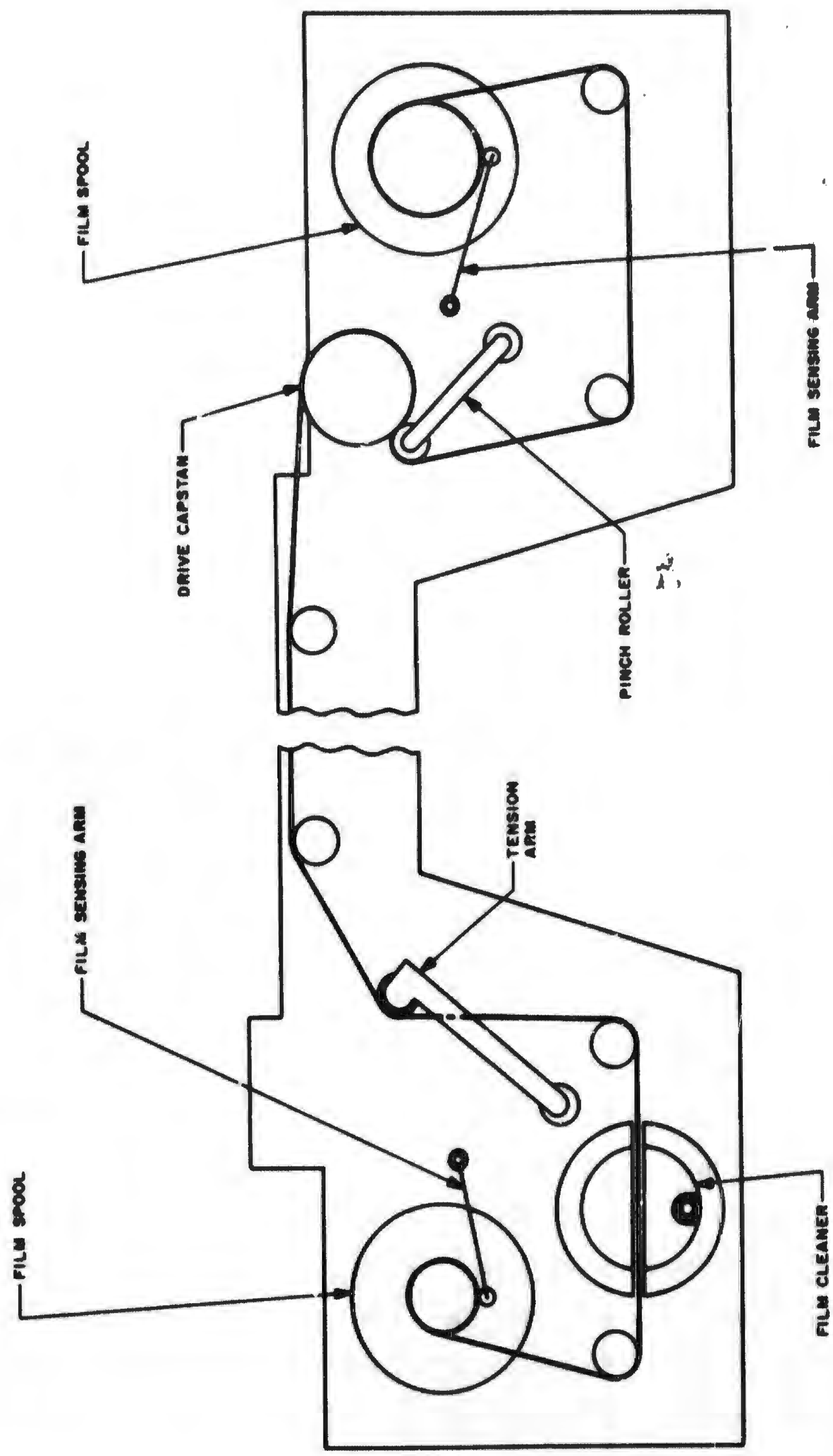


Figure 15. Threading Diagram for Negative Film

5) Mensuration System Mounting. The existing mensuration system consisted of an X-Y coordinate drive system, a reticle and magnifier, and means for accurately determining the location of the reticle in the coordinate system. It was proposed to mount the mensuration system directly on the existing input film transport so that X = 0 would define the location of the center of the output camera. For future reference the center of the output camera (X = 0 and Y = 0) was defined as a point contained in a line bisecting the film in the long dimension and 1.418 inches from the left side of the TTR. This dimension bisects the 57mm image in the vertical direction. For 84mm images, a special mask would be required which would place X = 0 at a position 0.531 inches to the left of the center of the image. It should be noted that although the exhibit required that provisions be made for accommodating 24 inches of film, the opening in the existing input film transport was only 18 inches long.

3.4.2 Output Camera

The proposed design for the film transport system of the output camera was to have the capability for advancing the film in even increments of 100mm ±0.4mm. The film advance was to be accomplished with an accurate vertical drive mechanism that would unroll the required length of film from the supply roll. A braked drum would be permitted to rotate during the down stroke by means of a cam-actuated mechanism that would prevent motion during the return stroke. A torque motor on the takeup reel would wind the released film into the takeup magazine. A one-way clutch on the takeup side of the camera would prevent film from being pulled from the takeup side. A port on the side of the camera would allow auxiliary information to be recorded optically on the film. The pressure pad would assure film flatness. A new design was required for the magazine to hold the supply and takeup reels. The magazine would need an end-of-film alarm, light shields, a friction clutch, and a torque motor for the takeup reel. The entire camera assembly would need to be raised about 2 inches to allow room for the mensuration assembly. The proposed threading diagram for the redesigned camera is shown in Figure 16.

3.4.3 Machine-Readable Code Generator

The proposal for generation the machine-readable codes was to use a mechanical device containing pivoted mirrors controlled by solenoids. The pivoted mirrors would be rotated in or out of the field depending on whether the binary 1 or 0 is required. Since the accession number to be encoded consists of 27 alphanumeric characters plus a stop code, and since each character requires 14 half bits to record, it was obviously impractical to attempt to record the entire encoded number at one time. For example, if each bit were controlled by one relay, 7 times 28, or 128 relays would be required. To simplify the mechanism, it was proposed to record only one character at a time and move the code generator the required 28 steps in even increments controlled by an accurate Geneva mechanism. The solenoids that position the mirrors and the advancement of the Geneva mechanism would be controlled by a punched tape prepared in advance on the Flexowriter typewriter that was part of the URP system.

Illumination for recording the image of the codes was to be provided by a tungsten ribbon filament lamp mounted to move with the stepping mechanism so the correct lamp-to-mirror relationship would be maintained. Illumination control would be provided either by a graduated shutter or by counter-rotating neutral-density wedges. Since the variable

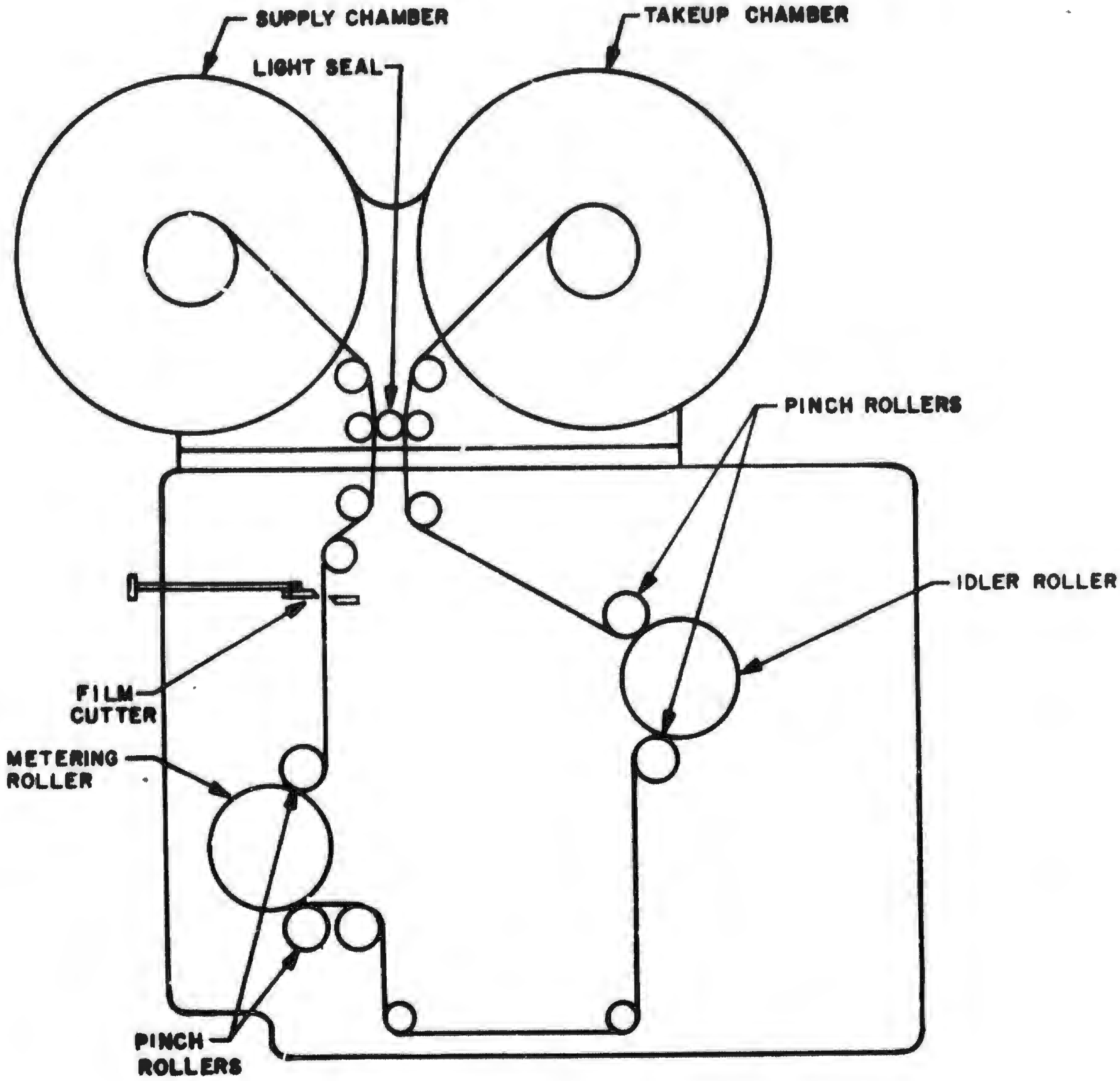


Figure 16. Threading Diagram for Positive Film

was film sensitivity, the rotating wedges could be driven to discrete positions by a manual input for film sensitivity.

The required speed for code generation is governed by the specification requirement that the URP be capable of printing 10 TTR's per minute, allowing 6 seconds per chip. Allowing 1 second for transporting film, the speed requirement for generating one character is 5/28= .178 seconds/character. Since this figure includes the time to transport the code generator, the actual printing time per character may be closer to .1 sec. The area to be illuminated consists of seven bits, 1.75 long x .52. The diagonal is 1.82 inches. This corresponds to a f/2 condenser with 1" focal length. The flux collected in an f/2 lens system =

$$\emptyset = \frac{1.96 \times 10^5}{4} \times \frac{066^2}{12} \times \frac{11}{4} = 1.1 \text{ lumens.}$$

This flux illuminates an area on the film of

$$A = \frac{1}{4} \times \frac{1.82^2}{12} \times \frac{1}{49} = 36 \times 10^{-5} \text{ sq. ft.}$$

Assuming a transmission of 60 percent, the illumination on the film is

$$I = .6 \times \frac{1.1}{36 \times 10^{-5}} = 1833 \text{ lumens/sq. ft.}$$

Assuming an exposure requirement of 185 lumen-seconds per sq. ft., the illumination on the film is

$$\frac{1833}{10} = 183.3$$

The illumination is therefore adequate for film with a .02 C rating.

3.4.4 Human Readable Code Generator

It was proposed that the human readable code be generated on the Flexowriter at the same time that the tape is punched for the machine readable code. There are several alternate methods for recording and employing the human readable code. One method employs a two part form, one of which is a hard copy perforated approximately every one half inch. The required code is torn off this form, and the one half inch by two inch slip is inserted in the printer. Another method, which eliminates the possibility of error, is to type the human readable material on a two part form which is perforated on both sides and consists of a continuous tape. The completed tape would be inserted into a drum mechanism that steps each time a new number is desired. In spite of the increased cost, this method appears to be the most satisfactory from the standpoint of operating ease and reliability.

3.4.5 North Pointing Arrow

It was proposed to record the north indicator on the bottom edge of the chip immediately below the UPIR card. The indicator would be set by a manually controlled knob on the control panel and a synchro follower moving a dial on the reflecting image area. The north-pointing arrow would be photographed at 1/7X. Assuming that the recorded image is 2mm high, the overall size of the arrow would be 14mm.

3.4.6 UPIR Card

The UPIR card would be photographed at 1/7X. It would be inserted on an easel accessible from the front. The location of the image would be 3mm to the left of the machine readable code and approximately 18.1mm by 29.03mm in size.

3.4.7 Classification

It was planned that a manually operated classification designation photographed at 1/7X would consist of a rotating triangle with the various classifications printed on the sides. The classification device would be approximately 14mm on one side and 40mm long. The information consisting possibly of the words "classified", "secret", "top secret", would be white on a black background so as to reproduce black on the positive film chip.

3.4.8 Illumination

Proposed illumination for the UPIR card, classification level, human readable code, and north arrow would be provided by a General Electric H400R, 400 watt reflector mercury vapor lamp providing 20,000 integral lumens.

Illumination for the film cutting marks would be provided by spot illuminations. Illumination for the machine readable code would be provided by a ribbon filament tungsten lamp operating at 3000° to 3200°K. This lamp would be mounted on the movable carriage of the code generator and pivoted to adjust for carriage travel by means of a worm and rack drive. The degree of pivoting required is determined by the amount of carriage travel and the conjugate distance. Assuming a 100mm f3.5 lens at 1/7X the conjugate distances are 4.56 and 31.92 inches. If the objective lens is centered on the carriage travel - 13.72 inches, the maximum angular adjustment for the lamp is

$$\text{Tan } \Theta = \frac{7}{31.92} \qquad 12\text{-}1/2 \text{ degrees}$$

3.4.9 Exposure Control for Auxiliary Data

Exposure control for the UPIR card, north arrow, human readable code, and classification index would use a manually operated neutral density filter turret. The extent to which control must be exercised for this data will require exploration. At the present, 4 degrees of control with filters, and fine control by varying the lamp voltage seems adequate. Filters will be provided to control exposure with films varying in "C" speed from .02 to .515, .515 to 1.010, 1.010 to 1.505, 1.505 to 2.00. The maximum deviation from correct exposure will be

$$\frac{.495}{2} \quad 2.247$$

or an exposure difference of 162 meter candle seconds for a density of .9 since the total exposed area is one square foot and the exposure time is .1 second, the exposure error is equivalent to

$$\frac{162}{10.5} \times 10 = 1.5 \text{ ft. candles}$$

SECTION 4
DEVELOPMENT PROGRESS

4.1 DESIGN AND FABRICATION OF CABINET

With the planned elimination of some of the bulky electronic equipment, it was evident that the new electronic system could easily be packaged in the main console and the separate electronic cabinet eliminated.

The console itself required modification to accept the new camera. A door was installed in the right-hand panel space to permit loading the auxiliary data. A new table cover was installed to provide room underneath for the mensuration system. It was originally felt that these changes to the cabinet would be all that were required, however, toward the end of the program, it was found that a slightly deeper cabinet would have allowed printing from either border of the 9.5-inch film. (The equipment in final configuration will print over an 8.9-inch width instead of the full 9.5-inch width.)

4.2 NEGATIVE FILM TRANSPORT

The negative film transport was considered essentially adequate for the system. Only one significant feature was changed. The original system did not actively maintain tension on the input film when the transport was stopped, it merely braked the two reels. This arrangement was modified so that when the transport was stopped, only one reel was braked while the torque motor on the other reel maintained constant tension on the film.

4.3 MENSURATION SYSTEM

It was decided that to obtain the required accuracy of 0.001 inch, the measurement on the input film must be made with the mask that carried the fiducial marks that will record on the output film. Once the measurements have been made, the prints will be made without disturbing the relation between the mask and the input film. In this way, the exact position of the image area on the output film is of no consequence since the image of the fiducial marks and the actual imagery are always in exact agreement according to the measurements recorded.

Precision ground stainless-steel rails were used to provide accurate guides for the print mask. The mask was supported by ball bearings riding on the precision rails and was driven by a small direct current motor through a precision gear train and a ball-bearing lead-screw.

In the interest of keeping the cost within limits, a mechanical counter was selected as a readout device. The only disadvantage in using this type of counter is that it limits the maximum speed of travel of the print mask to approximately 0.25 inches per second.

A two-speed control was considered adequate for this application: a high-speed for coarse positioning and a very slow speed (less than 0.005 inch per second) for fine positioning.

The completed equipment showed an accuracy of 0.0015 inches as opposed to the specified requirement of 0.001 inches. The accuracy was checked by attaching a dial indicator graduated in 0.001 inch increments to each axis and comparing the counter reading to the dial indicator.

4.4 OUTPUT CAMERA

After inspecting the original camera, it was decided that an all new camera would have to be designed. Specific deficiencies of the old camera were inaccurate film metering, difficult film loading, and no suitable means for adding the automated auxiliary data printing feature.

4.4.1 Magazine

A simple two-chamber magazine similar to that used on other types of 70mm cameras was selected. A torque motor provided film take up and a slip clutch provides drag on the supply spool

4.4.2 Film Metering

The original redesign plan called for metering film by a precision pull-down mechanism (the same mechanism that lowered the output film into contact printing position). This mechanism pulled film from the supply spool on the down stroke and allowed the film to be taken up on the up stroke. It was found, however, that this type of indexing did not move the film far enough in one operation to bring the contact print image into position for the adjacent printing of the auxiliary data. A new film metering system was designed that indexed the film by means of a capstan drive-roller driven by a 90 degree Geneva indexer. The indexer advanced the film in two steps totaling 100mm for each exposure. The indexing accuracy obtained was approximately 0.030 inch or 0.8mm.

4.4.3 Machine-Readable Code Generator

Development of the machine-readable code generator presented many problems before it was complete even though the final design used the general configuration of the inital design (seven solenoid-operated mirrors and a stepped recording lens).

Since the mirrors had to be adjacent to each other, they had a tendency to rub, causing wear and increased friction. The friction became a major problem since the size of the solenoids was limited by the mirror spacing. The problems were ultimately resolved by two modifications. The sides of the mirrors were relieved behind the actual mirror surface and a brass shim washer equal in thickness to the material removed was inserted in each of the spaces between the mirrors. With this arrangement, the mirrors rotated against the brass shim washers instead of each other and the friction remained within acceptable limits. The second modification involved increasing the voltage on the solenoids by a factor of 6 for a brief period during which they are initially energized. This arrangement gave the solenoids enough force to pull in the mirrors quickly but prevented overheating.

It had been planned originally to use a filament type lamp and a mechanical shutter to expose the machine-readable code. However, no suitable shutter could be found that would operate at the required speed of seven times per second. A xenon flash tube was then selected, eliminating the need for a shutter except between prints.

4.4.4 Human-Readable Code Recorder

No practical means could be found, within the scope of the contract, to fully automate the human-readable code recorder. However, since it would be necessary to manually insert the UPIR card, align the north arrow, and set the classification, it was evident that the human-readable code could be advanced manually at the same time if a typed list of the required numbers were provided. The light source originally planned for exposing the human-readable code was found to be inadequate. The final choice, a tungsten iodide lamp, was installed and found to be very satisfactory.

4.4.5 UPIR Card, North Arrow, and Classification Recorder

Development of the UPIR recorder proceeded in a straightforward manner. Since the output print of the contact printed image was assumed to be a positive reading correctly from the emulsion side, it was necessary to install a folding mirror in the optical path of the recorder so the image of the UPIR card would also read correctly from the emulsion side of the film.

The original light source selected was a battery of four, 150-watt photoflood lamps. However, it was found that ordinary 150-watt lamps provided enough illumination, so they were installed instead.

4.4.6 Exposure Control for the Auxiliary Data

No automatic exposure control for the auxiliary data was considered necessary since the data to be printed would be of consistent reflectance and contrast. The only variable is the sensitivity of the output film stock, and this can be compensated for by adjusting the diaphragm openings of the recording lenses during the initial setup of the printer.

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

The original concept of a tactical target record chip printer was demonstrated to be both feasible and practical. The addition of auxiliary data to the contact print was also shown to be feasible and with certain modifications to be quite practical. The machine, as a whole, proved to be quite reliable. Many aspects of the machine have proven to be useful for future designs, while some aspects should be investigated further.

In particular, the inclusion of a high accuracy measuring capability in the unit record printer should be reevaluated. This capability, while of significant value, seriously affects the flexibility of design, increases the complexity of the machine resulting in a decrease in reliability, and, to an extent, interferes with the primary function of the printer. Deleting the measuring system would be ideal, but reducing the desired accuracy would provide some improvement.

In the area of the auxiliary data, the printing of the machine-readable code presents the greatest difficulty. It is recommended that the entire code format be reviewed the the problems of both high speed code printing and code reading considered in the light of recent experience. The amount of data recorded in the code should be kept to an absolute minimum to reduce the complexity of both the printing device and the reading device. The remainder of the auxiliary data should be reorganized to allow the printing of all data through a single optical system.

Finally, the requirement for a contact print as opposed to an optical print should be thoroughly examined. Contact printing imposes severe limitations on the flexibility of the machine. For example, in an optical printer, the input film transport would not have to be moved under the camera and the film could be in full view at all times, which also greatly simplifies the design of an effective mensuration system. Rotation of the image could be easily provided and insertion of auxiliary data would be greatly simplified.

APPENDIX A

INVESTIGATION OF TECHNIQUES FOR GENERATION OF UNIT RECORD CHARACTER CODE

The tests conducted were somewhat restricted by the lack of an adequate camera and by a poor selection of film. The camera employed was an oscilloscope type with an f1.9 fixed focus lens. No variation in magnification ratio was possible so all tests were approximately 1:1. The film employed was Eastman Kodak SO-230, a very high definition aerial duplicating film.

It should be pointed out that the generated field to be photographed should be made as small as possible to minimize the optical reduction required for imaging on the film. The light power transmission through the optical system can be characterized by the equation

$$W_o = k' \sin^2 \left[\tan^{-1} \frac{FM}{2(M+1)} \right]$$

where F = f number of the optical system and M = the image magnification accomplished by the optical system. Plugging some numbers into the equation, assuming an f2 lens, and normalizing to

$W_o = 1$ for $M = 1$ we obtain

M = 1	W = 1
M = 1/4	W = .1925
M = 1/7	W = .078
M = 1/8	W = .061

It can be seen that a character generator design utilizing a 7:1 reduction in image size will require approximately thirteen times the light of a system employing a 1:1 optical system.

The test targets utilized consisted of a very dense image of the machine readable code and an etched metal plate containing holes of various sizes and shapes.

APPROACHES

Three general approaches to generation of the unit record character code were investigated. These were:

1) Electroluminescence
2) Aperture disks
3) Light ducts.

Electroluminescent Displays

Several exposures were made using SO-230 film and an electroluminescent panel with the test target taped to the front of the panel. The panel was excited with an 800 cycle signal of approximately 400 volt amplitude peak to peak. Eight hundred cycles provided the highest light output from the panel employed and was used throughout the tests. Even with exposures as long as ten minutes and with a forced image development only a thin image of the clear portions of the metal target was obtained. The dense machine readable code field could barely be seen on the ten minute exposure. It was obvious, therefore, that electroluminescent panels do not provide an adequate amount of light for printing on this very slow, blue sensitive film.

Mechanical Pattern Generator

A test setup was made to investigate an approach suggested by A. Le Grand. This character generator consists of a glass disk with all thirty-six characters inscribed upon it. A complete image format, both machine and human readable, is provided for every character with the same character located in each of the 26 information positions. This disk would operate in conjunction with a second mask which would select which of the 26 information position was to be printed.

Tests were conducted using the test targets mounted to a disk which was rotated at approximately 115 rpm. The machine readable code was positioned with the nearest point of field located 1.7 inches from the hub of the disk. This was calculated to be the minimum radius for locating the image fields that all characters could be placed on one disk. The light source employed was a Type 1531-A Strobotac which provides a 10° beamwidth of light rich in blue and UV. Energy input to the discharge tube employed is approximately .45 watt seconds which generates a light pulse six microseconds long between 10 percent power points. The source was capable of being synchronized to the disk speed to provide a stationary image for multiple exposures. Several exposures were made utilizing a single flash of the lamp which display good image quality especially when the density of the test target is taken into consideration.

As a result of these tests it seems safe to include that the approach outline above is completely feasible. The use of a continuously rotating character disk and a strobed light source should reduce both the mechanical and electrical design problems considerably.

Light Ducts

The final method investigated employs lucite or plexiglass materials to transmit light from controlled light sources to the point where the image format is constructed. The main advantage of this system lies in the ability to generate the desired display with no moving parts and with sufficient light intensity to expose the slow copy film. The machine readable code can be generated using thin lucite strips for each segment of the code with a thin layer of reflecting material interspersed between adjacent segments. The human readable characters can be generated using an eleven segment matrix for generating each character. It is obvious from the above description that such a system capable of generating the entire code field at one time would require a tremendous number of controlled light sources and attendant control circuits. It appears desirable to combine some mechanical information position selection system with the character generation system to reduce the total number of light sources to a reasonable number.

Tests were conducted using .030 plexiglas for the segments with strips of .00075 aluminum foil sandwiched between adjacent elements to form a reflective barrier layer. The strobcscope gas discharge light source was again employed so that a feel for the relative transmission loss experienced in the test setup of approach two and three could be obtained. The near-UV absorption characteristics of Plexiglass were easily discernable in the test results. Image density on test negative for the type three system was considerably less than that obtained with the type two system exposing film through the dense machine readable code test target. However, an acceptable image was obtained with the type three test setup with a single .45 watt second discharge. Maximum achievable image density was obtained with only two light pulses.

Due to the extreme insensitivity of SO-230 film to long wavelength light energy, the use of incandescent light sources appears foredoomed to failure, especially if lamps having an extended service life are used. The exception to the statement may be the tungsten iodide lamp which operates at a high color temperature. It appears that the most desirable light sources will turn out to be either the xenon gas discharge lamp or a cold cathode light source designed to provide a high UV output.

POSSIBLE SYSTEM CONFIGURATIONS

The attempt has been to configure a character generation scheme which would provide the desired results at a minimum of expense and complexity. An initial consideration was to avoid any mechanical motion if possible to provide a completely static character generation scheme. The most promising methods, electroluminescent panels or ducted light employing separate incandescent light source for each duct failed due to the inability of the light sources to properly expose the slow copy film.

The approach finally chosen assumes the use of a punched paper tape input and a single line tape recorder. This choice of input material seems advisable from both a cost and availability standpoint. It is further proposed that the code format be generated on the film one character at a time using the tape reader as a single character information buffer. The serial approach to character generation eliminates any requirement for a serial to parallel information storage capability within the equipment. The main drawback to the serial approach is the time required for the repetitive printing operations. Since 27 characters are to be generated, a safe time figure for the complete operation would be in the order of twelve seconds, or approximately two characters per second. This time can probably be reduced by a factor of two as experience is gained with the prototype equipment.

Two approaches to the mechanics of character generation suggest themselves; one based upon approach two and the other on approach three.

ROTATING DISK CHARACTER GENERATOR

The disk character generator consists of a high speed light source, a glass character disk, a character position selection disk, and an optical system for imaging the character field on the film.

The light source should be capable of providing short pulses of light having a high blue and UV content. A likely source of such light energy is the line xenon flash tubes manufactured by Edgerton, Germeshausen and Grier, Inc. These tubes are similar to the light source employed in the test program.

The character disk consists of a glass backing plate with 36 code fields, both human and machine readable deposited upon it. Each code field is composed of a single character repeated in each information position. Associated with each code field is a second code field and an associated timing track which is utilized in the electronic character selection process. This selection is accomplished by comparing the desired character code as provided by the tape reader against the signals emanating from the character disk. When a coincidence is established, the timing mark associated with the desired character fires the strobe lamp, exposing the film.

The character position selection disk provides the means for selecting the position within the information format in which a particular character is printed. The disk is divided into thirty angular segments with a set of apertures for a particular position in the information field associated with each of 27 positions. The remaining three positions are not used. This division into 12° increments was made to allow the use of a Slo-Syn stepping motor which is capable of stepping in 1.8° increments with a non-cumulative positional accuracy of ±0.1°. A third fixed aperture is associated with the two disks described previously so that only a single character is seen at the output of the optical system at any time. In operation, a 27 step counter controls the advance of the tape reader from the start code position and at the same time indexes the character position selection disk. The output of the tape reader is compared with the signals read from the rotating character selection disk and the light source fired when both the character position selection disk and the character selection disk are properly oriented behind the fixed mask. No mention has been made of verification and checkback circuits as yet. For the prototype system it would seem desirable to operate the system slowly enough so that sequential operations can take place without fear of timing or overlap problems. The checkback features can be added at a later date after the basic system concept is checked out. The main disadvantage to the system outlined above lies in the cost of generating the two disks due to the high accuracy requirements of the system. Also, a problem arises in positioning of the two disks in relation to each other. One mounting method might be to utilize the long shaft on the slow-syn motor used for the character position selection disk as a mounting shaft for a concentric roller bearing supported character selection disk and the rotor of the associated driving motor. The stator of the character selection disk drive motor would also be mounted concentric to the shaft but would have no contact with it. The digital information and timing track associated with each code field would be printed on the character selection disk at a greater radius than the code field and positioned such that this information could be scanned without interfering with the character generator optical system.

The second approach to the problem relieves the mechanical accuracy problems inherent in the previous system by replacing the character selection disk with a system of light ducts and controlled light sources. This system has the disadvantages of requiring considerably more light intensity due to losses in the plastic ducts but has the advantage of being able to utilize a light source other than the strobe lamp. Character generation is still accomplished one character at a time utilizing the character position selection disk as described earlier. Two approaches are available for generating a desired character, one of which employs multiple light sources and is completely static while the second system can employ a single light source and a mechanical code selection system.

For the static system the fourteen ducts comprising a character would have their source ends fanned out horizontally to provide a finished machine readable array consisting of fourteen columns of 27 elements each. Each column would be illuminated by a controlled light source which is switched on and off by the signals from the tape reader. More tolerance could be gained in the aperture size on the character position selection disk by subdividing the columns of the first and last character segments into four columns representing even and odd character positions within the code frame. This would then allow the apertures to be made slightly oversize to assure transmission of a full character without the possibility of light leakage through the first and last segments of adjoining segments.

The multiplicity of light sources required for the generation of the machine readable code can be replaced by a single source if a mechanical interposer controlled by the signal information is provided for adjacent sets of ducts so that when one duct is illuminated the other is dark.

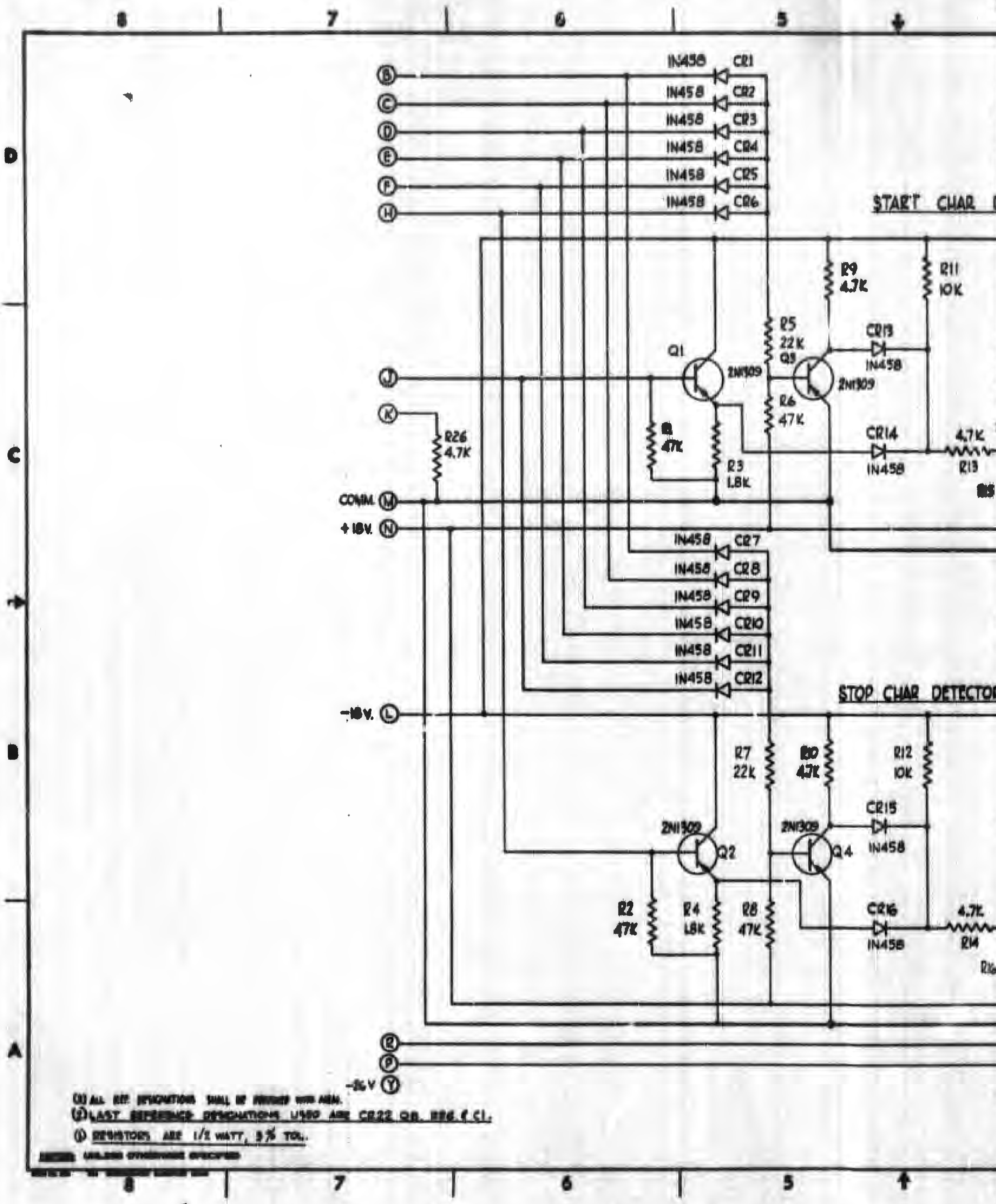
The human readable code can be generated by an eleven bar matrix of light ducts. Twenty-seven of the matrices would be provided with like elements of all 26 matrices tied together to one of eleven controlled light sources. A code conversion matrix will be provided to convert the punched tape code into the information required to control the illumination of various segments of the matrix. Generation of the human readable code is the same regardless of the method employed for generation of the machine readable code.

APPENDIX B

EN-77 SCHEMATIC DIAGRAMS

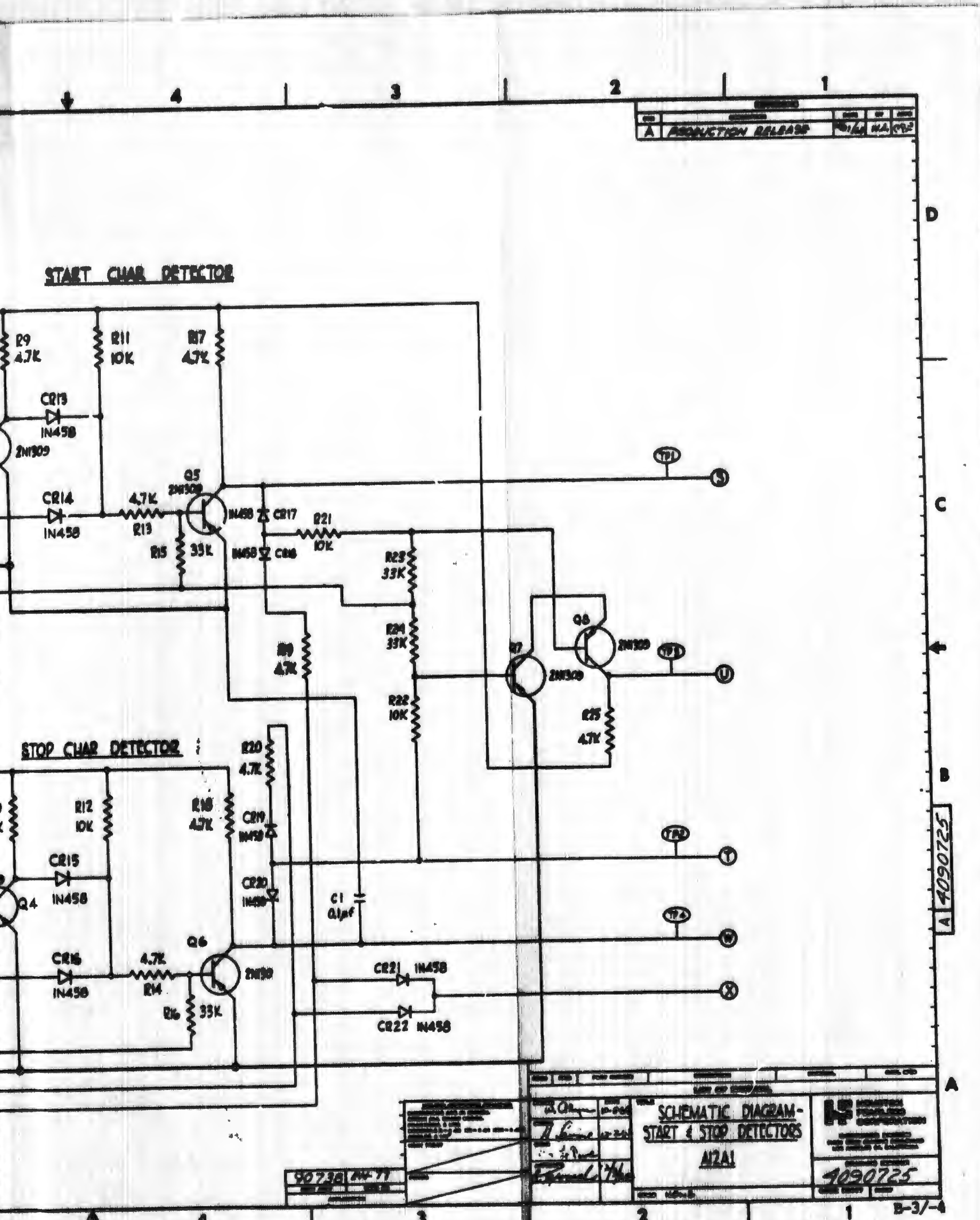
The following schematic diagrams are supplied with this report as an aid in following the discussion of theory of operation.

4090725	Start and Stop Detectors A12A1
3090726	Code Generator Drivers A12A2
3090727	Code Generator Drivers A12A3
3090728	Motor Run and Stop Relays A12A4
3090729	Code Generator Control A12A5
3090730	Auxiliary Data Print Cycle Circuit A12A6
3090731	Y-Axis Error Detector A12A7
4090732	Exposure Amplifier A12A8
3090733	Exposure Sequence Controller A12A9
3090734	Photocell Amplifier
3090735	Main Illumination Chassis A8
3090736	Main Power Chassis A6
3090748	Power Supply ±18 VDC
3090769	Voltage Regulator ±18 VDC
3090870	Lamp Detectors A12A10
3093526	Illuminator Power Supply
4090850	Y-Axis Drive System
4090851	X-Axis Drive System A7
4090852	X-Axis Film Drive
4090853	Mensuration System A4
4093507	Logic Diagram (Seven Sheets)
5090737	System Electronics A5
4090722	Auxiliary Data Elec. A14

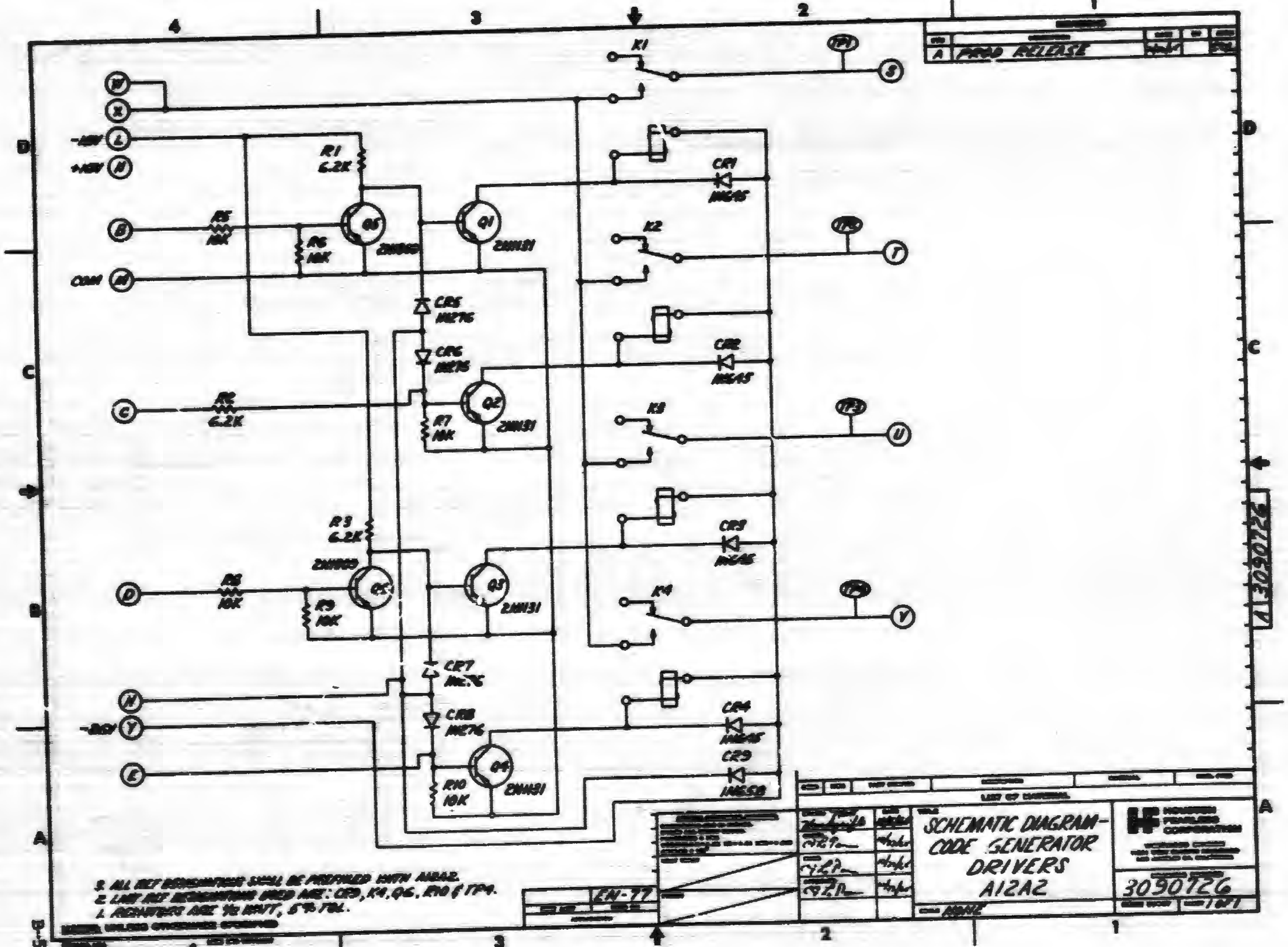


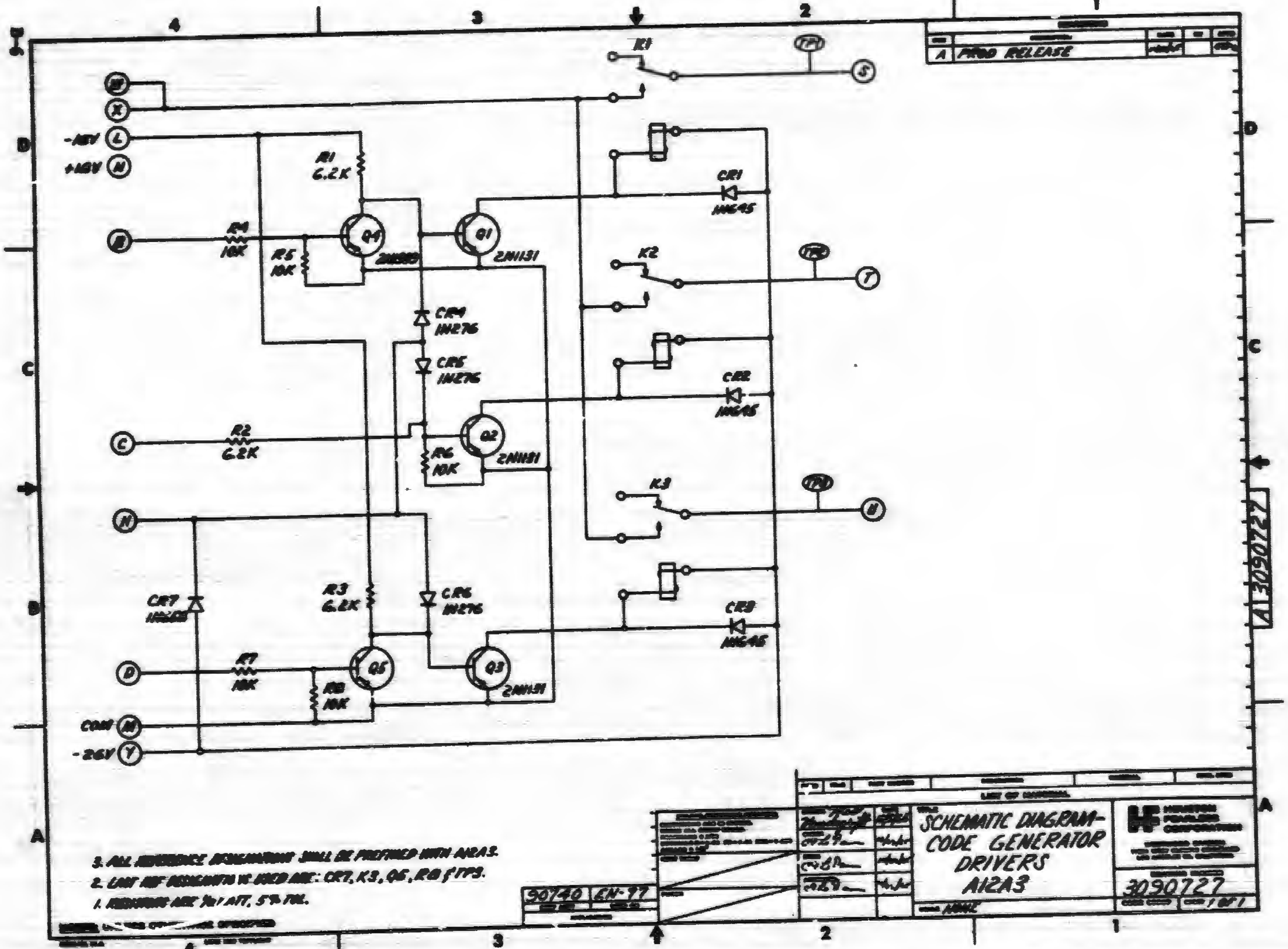
START CHAR
STOP CHAR DETECTOR
1N458 CR1
1N458 CR2
1N458 CR3
1N458 CR4
1N458 CR5
1N458 CR6
1N458 CR7
1N458 CR8
1N458 CR9
1N458 CR10
1N458 CR11
1N458 CR12
CR13 1N458
CR14 1N458
CR15 1N458
CR16 1N458
Q1 2N1309
Q3 2N1309
2N1309 Q2
2N1309 Q4
R1 47K
R2 47K
R3 1.8K
R4 1.8K
R5 22K
R6 47K
R7 22K
R8 47K
R9 4.7K
R10 4.7K
R11 10K
R12 10K
4.7K R13
4.7K R14
R26 4.7K
COMM. M
+18V. N
-18V. L
-26V Y
B
C
D
E
F
H
J
K
R
P
(2) LAST REFERENCE DESIGNATIONS USED ARE CR22 Q8, R26 & C1.
(1) RESISTORS ARE 1/2 WATT, 5% TOL.
UNLESS OTHERWISE SPECIFIED
8
7
6
5
4
D
C
B
A

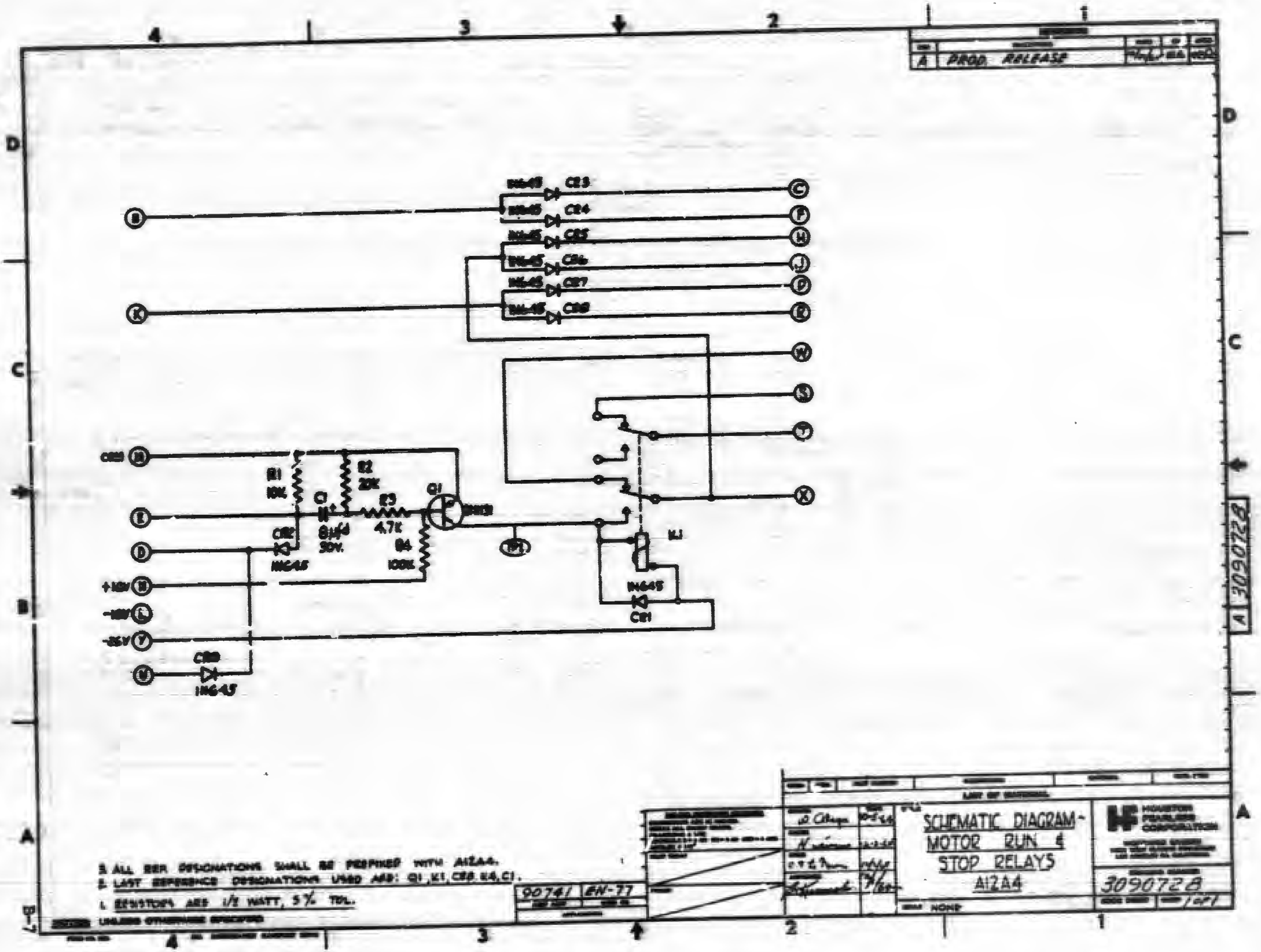
1



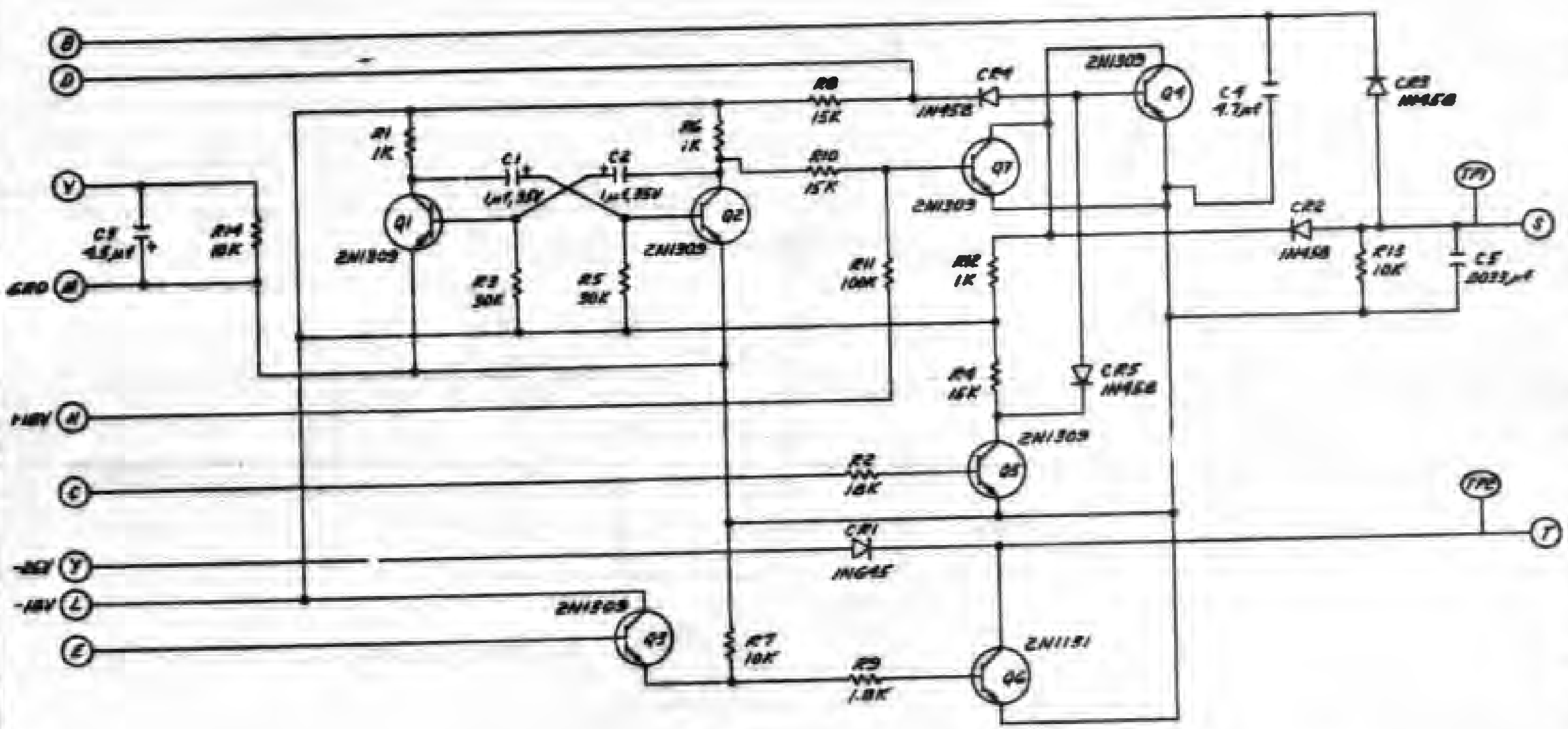
PRODUCTION RELEASE
START CHAR DETECTOR
STOP CHAR DETECTOR
R9 4.7K
R11 10K
R17 4.7K
CR13 1N458
2N1309
Q5 2N1309
CR14 1N458
4.7K R13
R15 33K
1N458 CR17
1N458 CR18
R21 10K
R23 33K
R24 33K
R19 4.7K
R22 10K
Q7 2N1309
Q8 2N1309
R25 4.7K
TP1
TP2
TP3
TP4
S
U
Y
W
X
R20 4.7K
R12 10K
R18 4.7K
CR19 1N458
CR20 1N458
CR15 1N458
Q4
C1 0.1µf
Q6 2N1309
CR16 1N458
4.7K R14
R16 33K
CR21 1N458
CR22 1N458
90738
SCHEMATIC DIAGRAM-
START & STOP DETECTORS
A12A1
4090725
A 4090725
B-3/-4
2


A PROD RELEASE
K1
K2
K3
K4
TP1
TP2
TP3
TP4
R1 6.2K
R3 6.2K
R5 10K
R6 10K
R7 10K
R8 10K
R9 10K
R10 10K
RC 6.2K
Q1 2N1131
Q2 2N1131
Q3 2N1131
Q4 2N1131
Q5 2N1893
Q6 2N1893
CR1 1N645
CR2 1N645
CR3 1N645
CR4 1N645
CR5 1N2976
CR6 1N2976
CR7 1N2976
CR8 1N2976
CR9 1N658
-18V
+18V
COM
-8.5V
SCHEMATIC DIAGRAM-
CODE GENERATOR
DRIVERS
A12A2
3090726
EN-77
3. ALL REF DESIGNATIONS SHALL BE PREFIXED WITH A12A2.
2. LAST REF DESIGNATIONS USED ARE: CR9, K4, Q6, R10 & TP4.
1. RESISTORS ARE 1/2 WATT, 5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED


A PROD RELEASE
K1
K2
K3
CR1
1N645
CR2
1N645
CR3
1N645
CR4
1N276
CR5
1N276
CR6
1N276
CR7
R1
6.2K
R2
6.2K
R3
6.2K
R4
10K
R5
10K
R6
10K
R7
10K
R8
10K
Q1
2N1131
Q2
2N1131
Q3
2N1131
-18V
+18V
COM
-26V
3. ALL REFERENCE DESIGNATIONS SHALL BE PREFIXED WITH A12A3.
2. LAST REF DESIGNATIONS USED ARE: CR7, K3, Q5, R8 & TP3.
1. RESISTORS ARE 1/2 WATT, 5% TOL.
90740
EN-97
SCHEMATIC DIAGRAM-
CODE GENERATOR
DRIVERS
A12A3
3090727
A13090727


A PROD. RELEASE
CR3
C23
CR4
C24
CR5
C25
CR6
C26
CR7
C27
CR8
C28
1N645
W
S
T
X
R1
10K
R2
20K
C1
8 µf
30V.
R3
4.7K
R4
100K
Q1
CR2
CR1
K1
CR9
+10V
-10V
-35V
3. ALL REF. DESIGNATIONS SHALL BE PREFIXED WITH A12A4.
2. LAST REFERENCE DESIGNATIONS USED ARE: Q1, K1, CR9, R4, C1.
1. RESISTORS ARE 1/2 WATT, 5% TOL.
UNLESS OTHERWISE SPECIFIED
90741
EN-77
SCHEMATIC DIAGRAM - MOTOR RUN & STOP RELAYS
A12A4
HOUSTON FEARLESS CORPORATION
3090728
A 3090728
1 OF 1

A | PROD RELEASE



3. ALL REFERENCE DESIGNATIONS SHALL BE PREFIXED WITH A12A5.
2. LAST REF DESIGNATIONS USED ARE: C5, CR5, Q7 & R14.
1. RESISTORS ARE 1/2 WATT, 5 % TOL.

NOTES: UNLESS OTHERWISE SPECIFIED

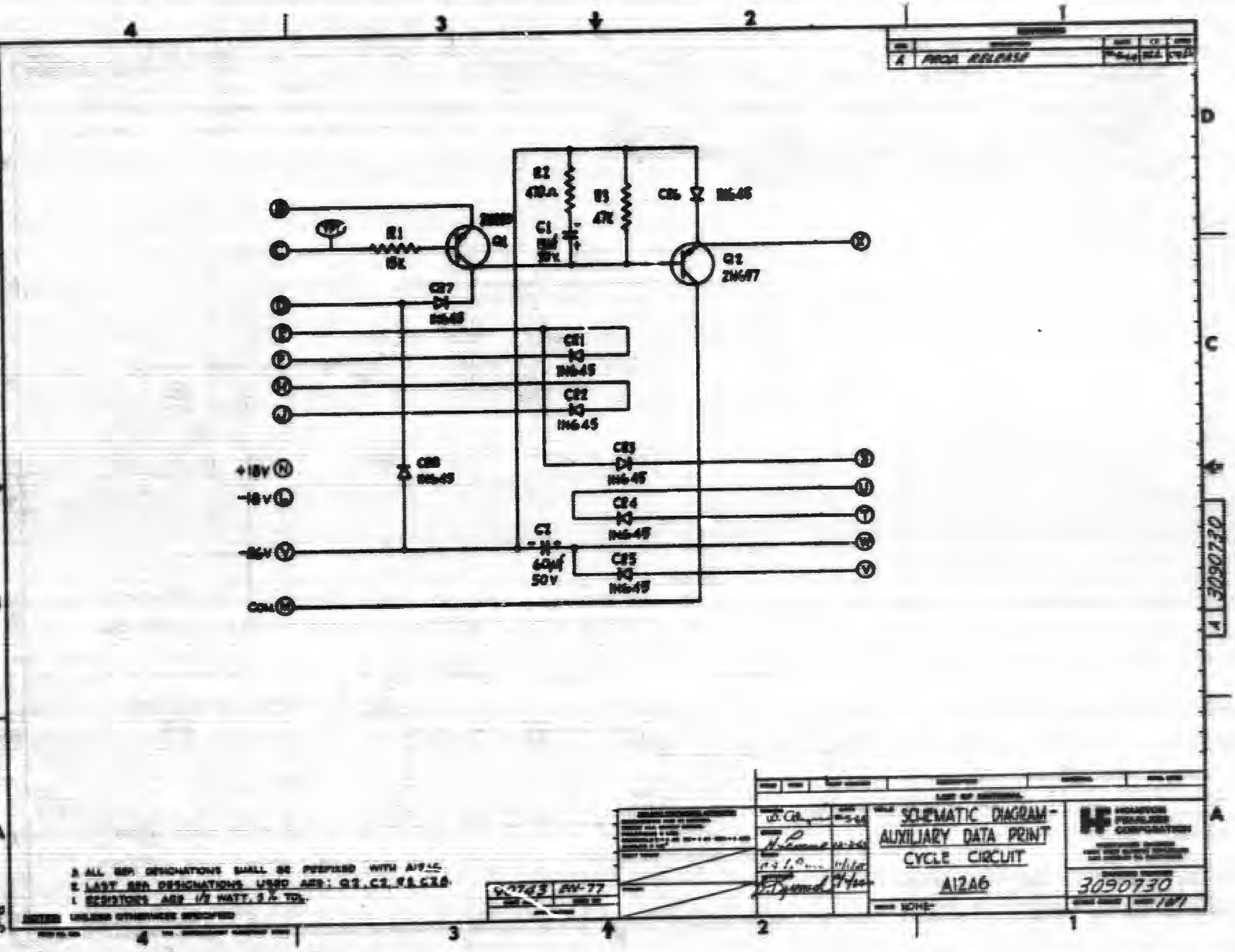
90742 | EN-77

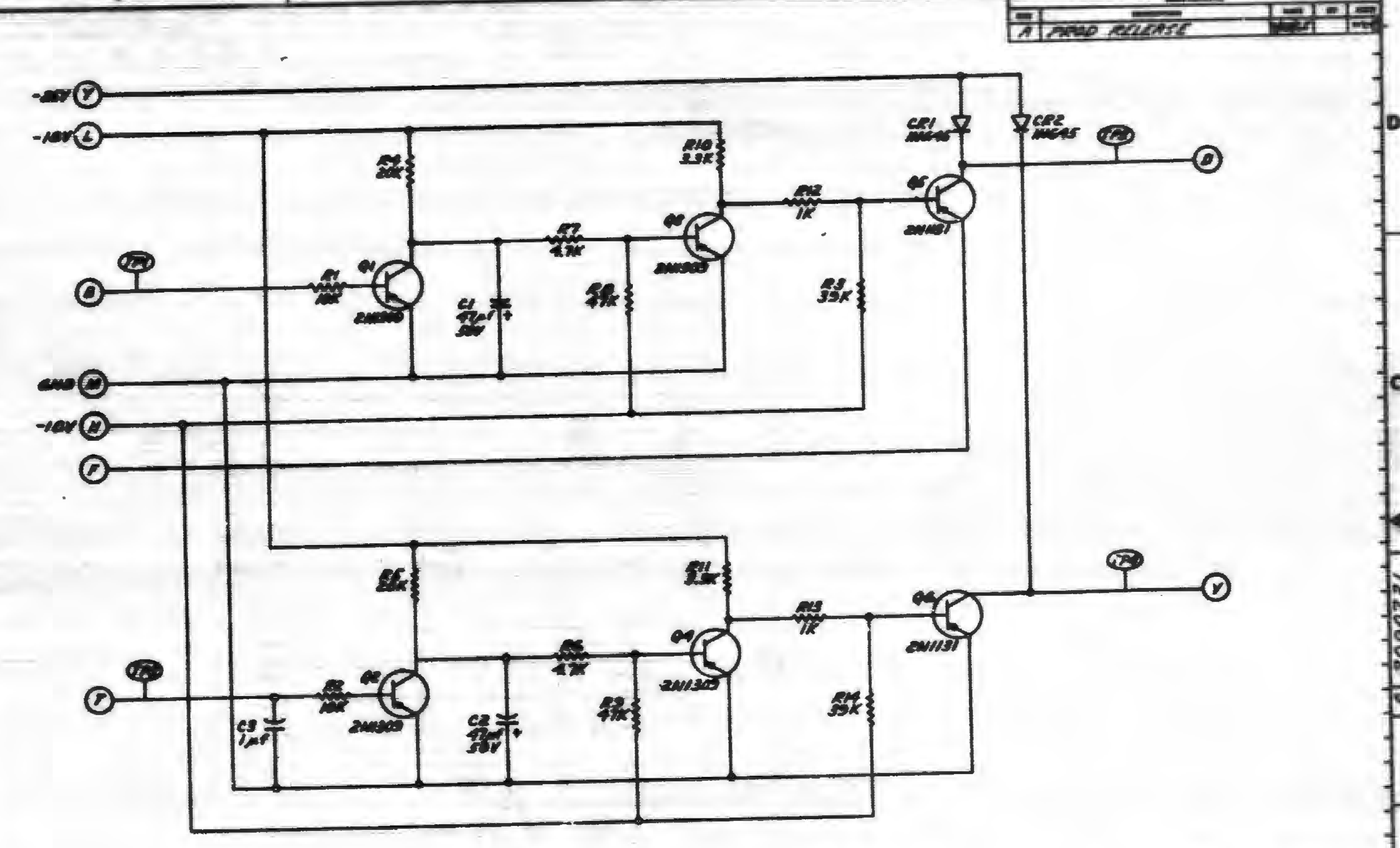
SCHEMATIC DIAGRAM-
CODE GENERATOR
CONTROL
A12A5

HOUSTON FEARLESS CORPORATION

3090729

A 3090729


A PROD. RELEASE
R1 15K
Q1
CR7 1N645
CR1 1N645
CR2 1N645
CR8 1N645
+18V N
-18V L
-16V
COM
R2 470Ω
C1
R3 47K
CR6 1N645
Q2 2N697
CR3 1N645
CR4 1N645
C2 60µf 50V
CR5 1N645
3090730
3. ALL REF. DESIGNATIONS SHALL BE PREFIXED WITH A12A6.
2. LAST REF. DESIGNATIONS USED ARE: Q2, C2, R3, CR8.
1. RESISTORS ARE 1/2 WATT, 5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED
SCHEMATIC DIAGRAM - AUXILIARY DATA PRINT CYCLE CIRCUIT
A12A6
HOUSTON FEARLESS CORPORATION
3090730



3. ALL REF DESIGNATIONS SHALL BE PREFIXED WITH A12A7.
2. LAST REF DESIGNATIONS USED ARE: C3, CR2, Q6 & R14.
1. RESISTORS ARE 1/2 WATT, 5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED.

90744	EN-77

REVISIONS: A PROD RELEASE

LIST OF MATERIAL

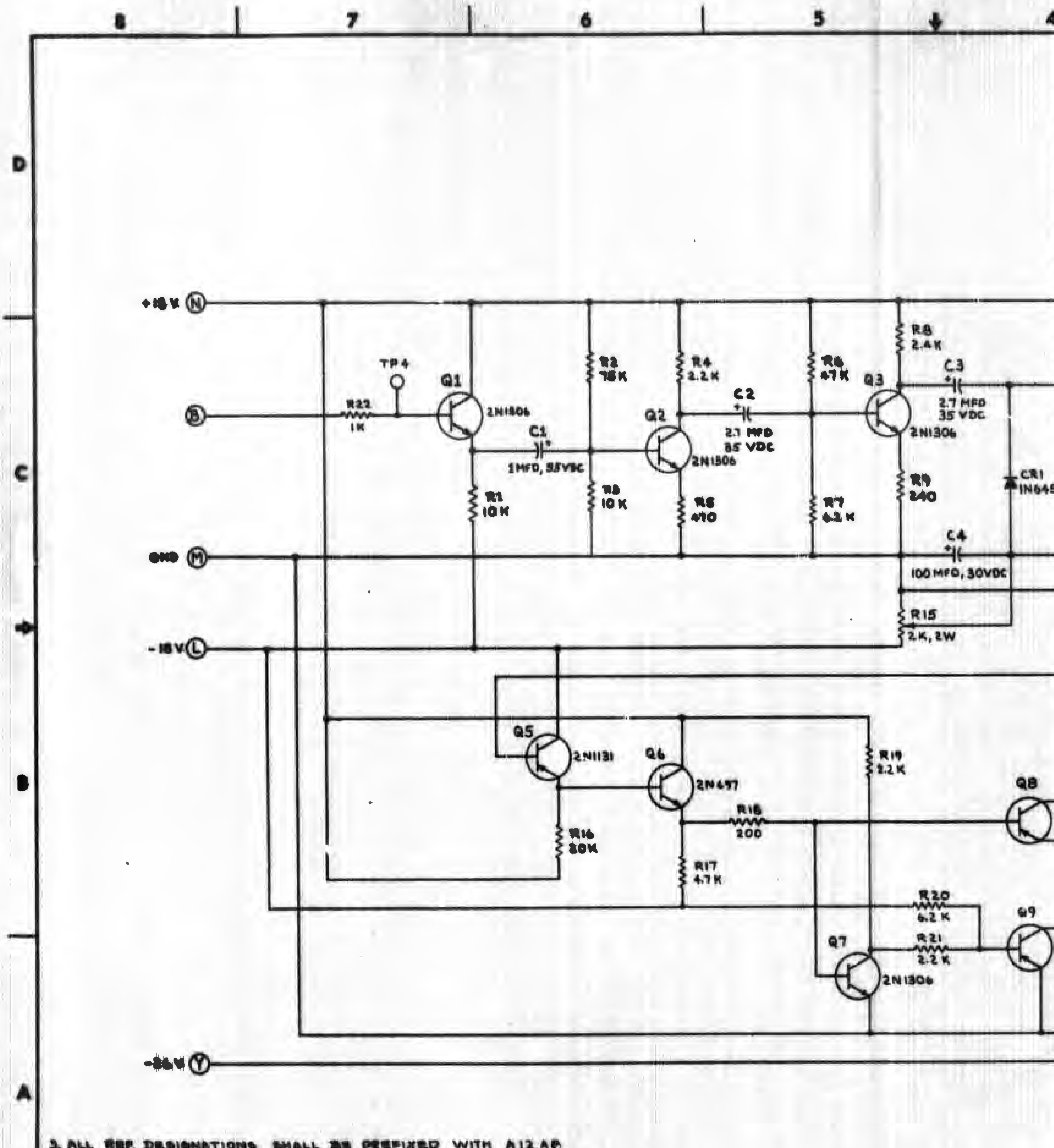
SCHEMATIC DIAGRAM- Y-AXIS ERROR DETECTOR A12A7

HOUSTON FEARLESS CORPORATION

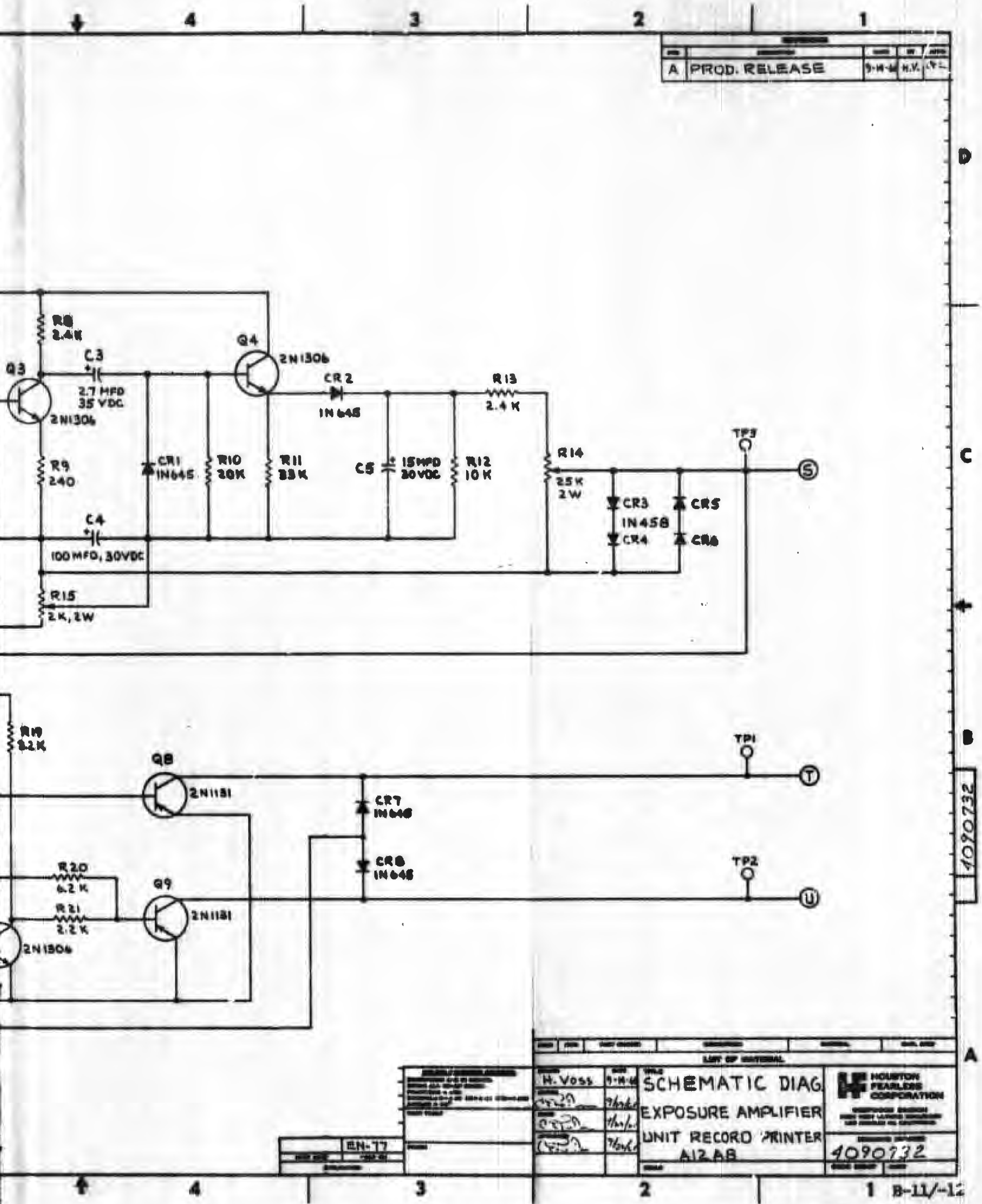
3090731

A 3090731

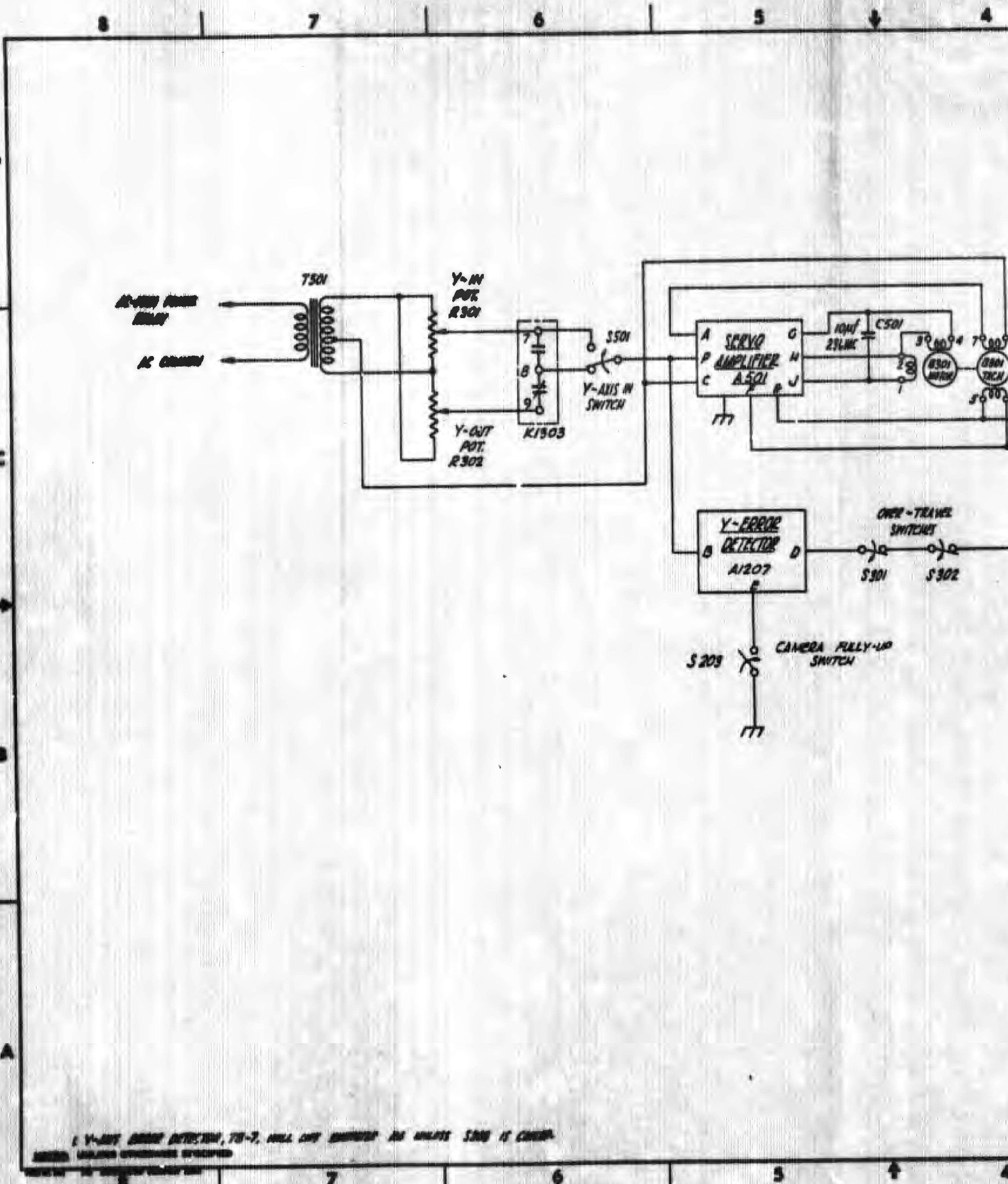
SHEET 1 OF 1



3. ALL REF. DESIGNATIONS SHALL BE PREFIXED WITH A12A8
2. LAST REF. DESIGNATIONS USED ARE: Q9, CR8, R22, C5, TP4,
1. RESISTORS ARE 1/2 W 5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED

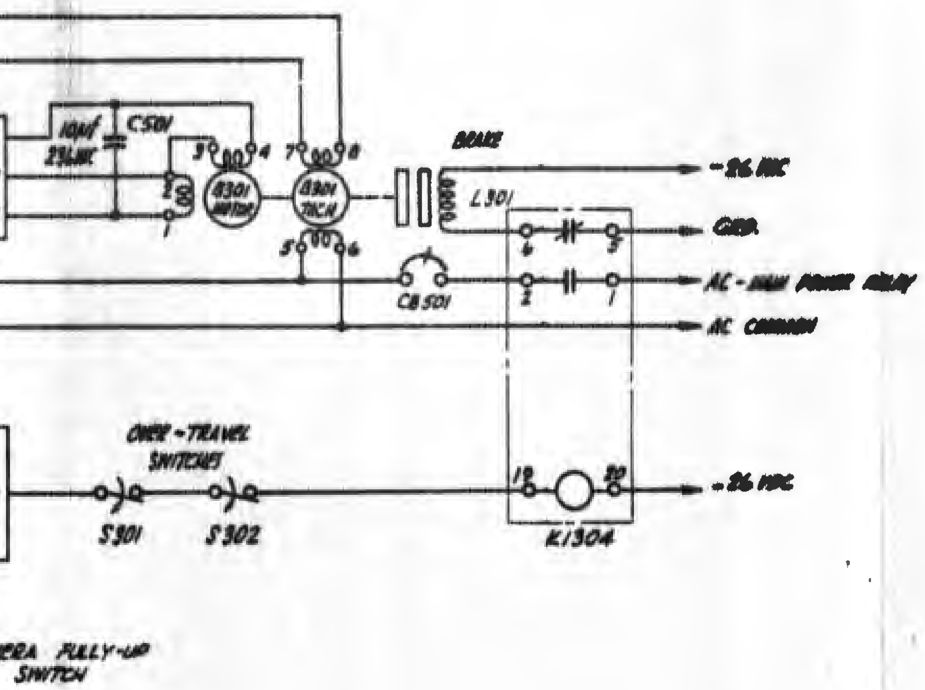

A PROD. RELEASE
R8 2.4K
Q3
C3 2.7 MFD 35 VDC
Q4 2N1306
2N1306
CR2 1N645
R13 2.4 K
R9 240
CR1 1N645
R10 20K
R11 33K
C5 15MFD 30VDC
R12 10 K
R14 25K 2W
TP3
S
CR3 1N458 CR4
CR5 CR6
C4 100 MFD, 30VDC
R15 2K, 2W
R19 8.2K
Q8 2N1131
TP1
T
CR7 1N645
CR8 1N645
TP2
U
R20 6.2 K
R21 2.2 K
Q9 2N1131
2N1306
EN-77
H. VOSS
SCHEMATIC DIAG. EXPOSURE AMPLIFIER UNIT RECORD PRINTER A12A8
HOUSTON FEARLESS CORPORATION
4090732

2



T501
Y-IN POT. R301
Y-OUT POT. R302
K1303
S501
Y-AXIS IN SWITCH
SERVO AMPLIFIER A501
C501
Y-ERROR DETECTOR A1207
OVER-TRAVEL SWITCHES
S301
S302
S203
CAMERA PULL-UP SWITCH

REV	DESCRIPTION	DATE	BY	APPD
A	PROD. RELEASE			



SCHEMATIC DIAGRAM - Y-AXIS DRIVE SYSTEM

HOUSTON FEARLESS CORPORATION

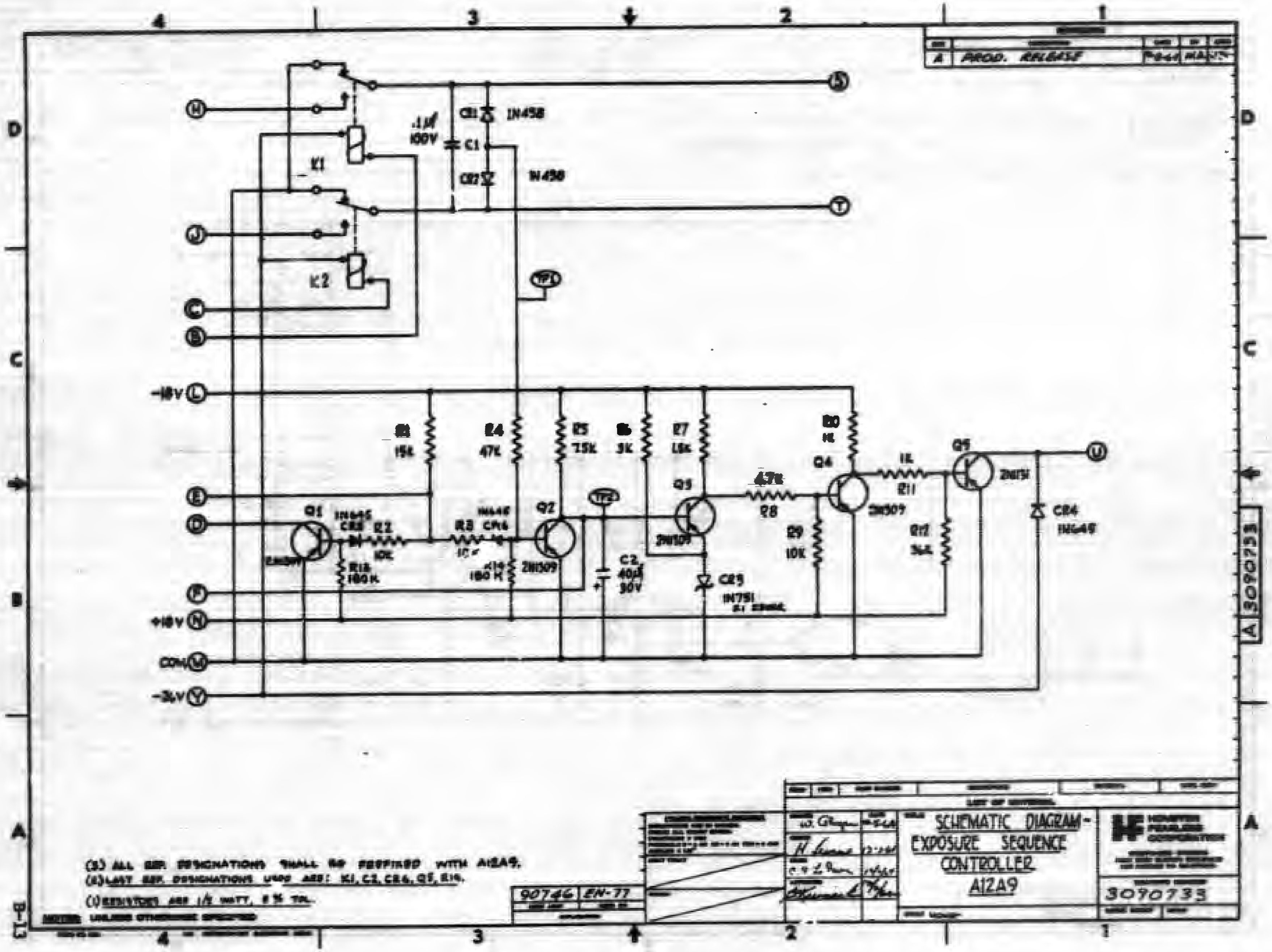
4090850

A 4090850

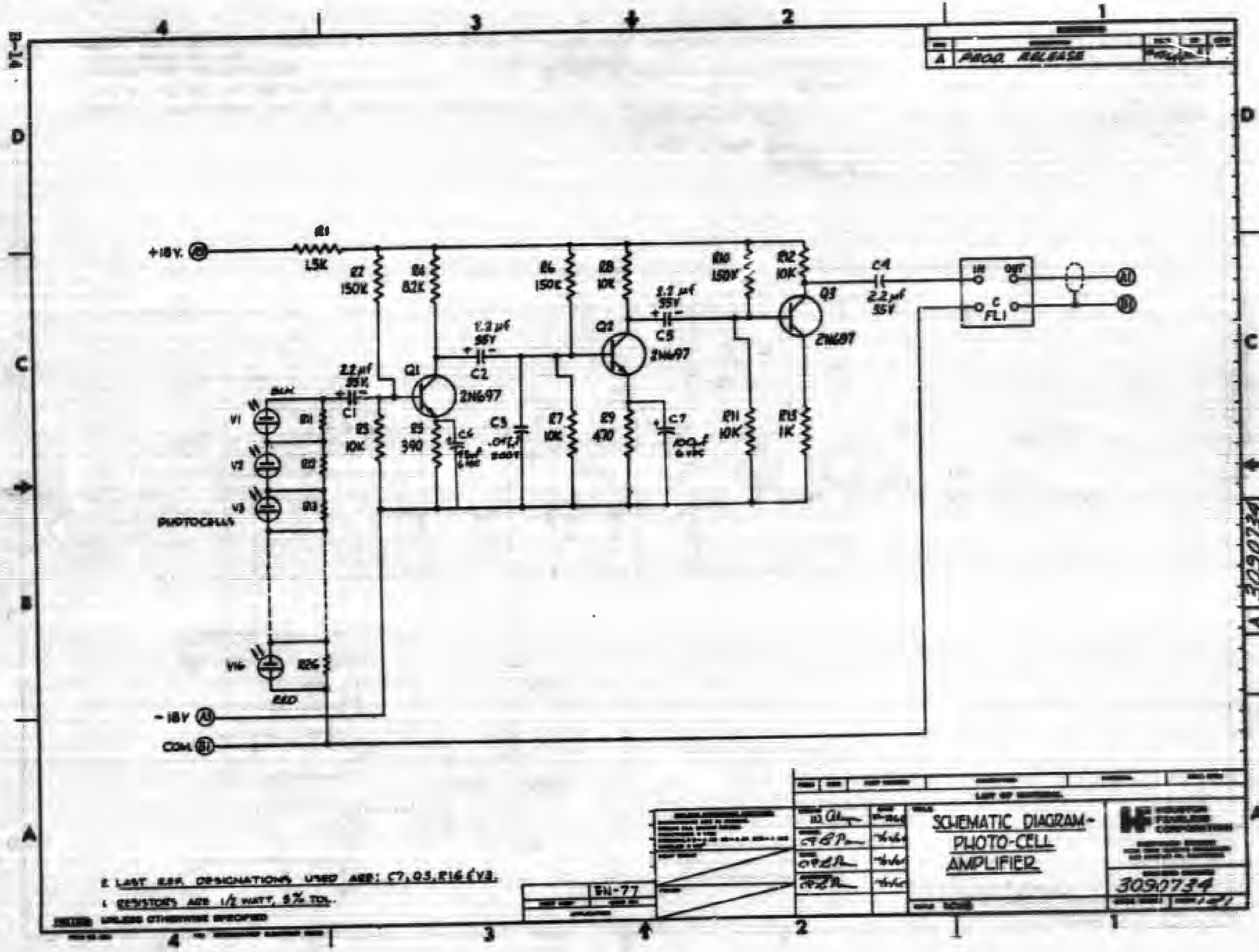
1 of 1

B-21/-22

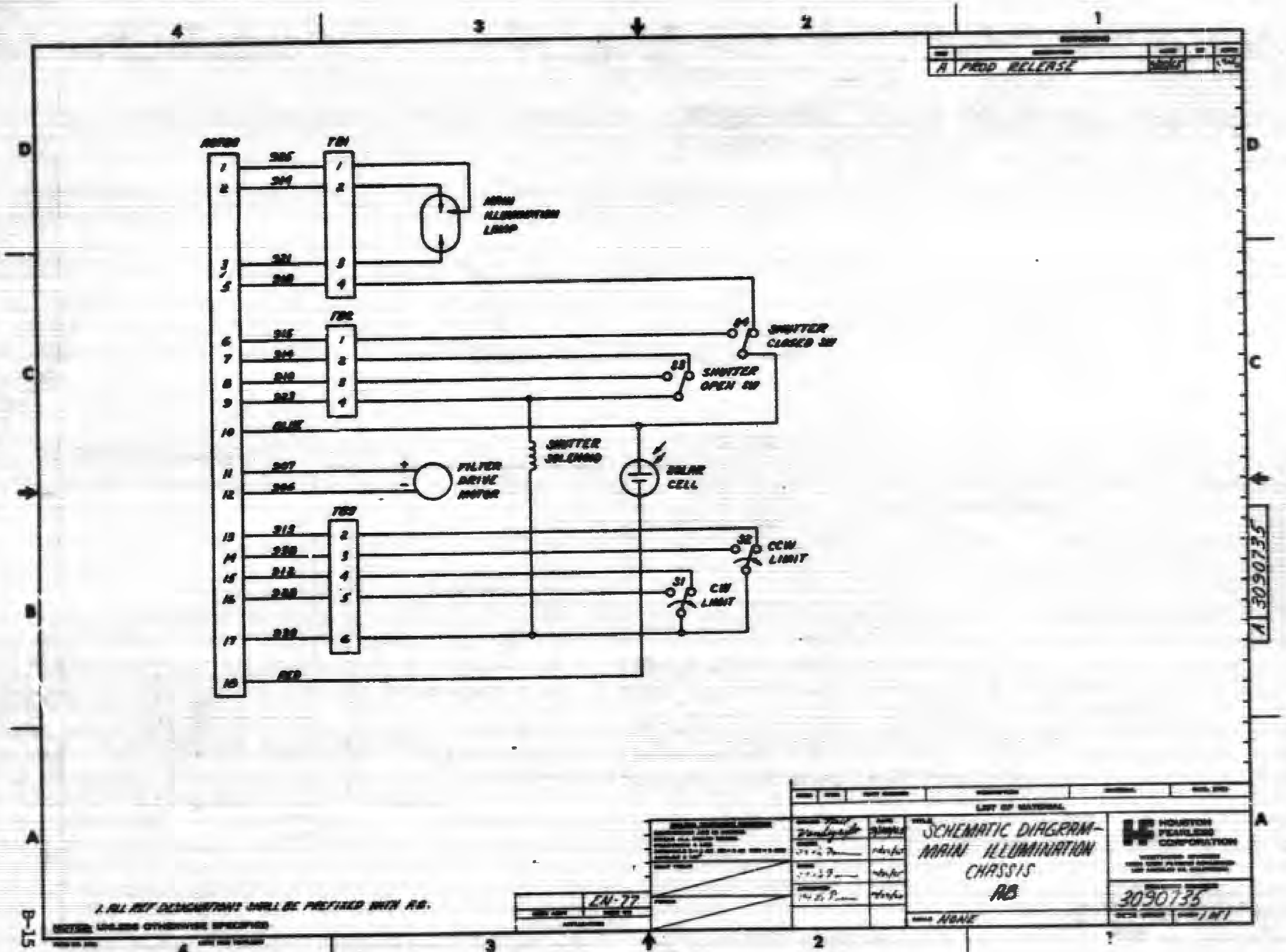
2

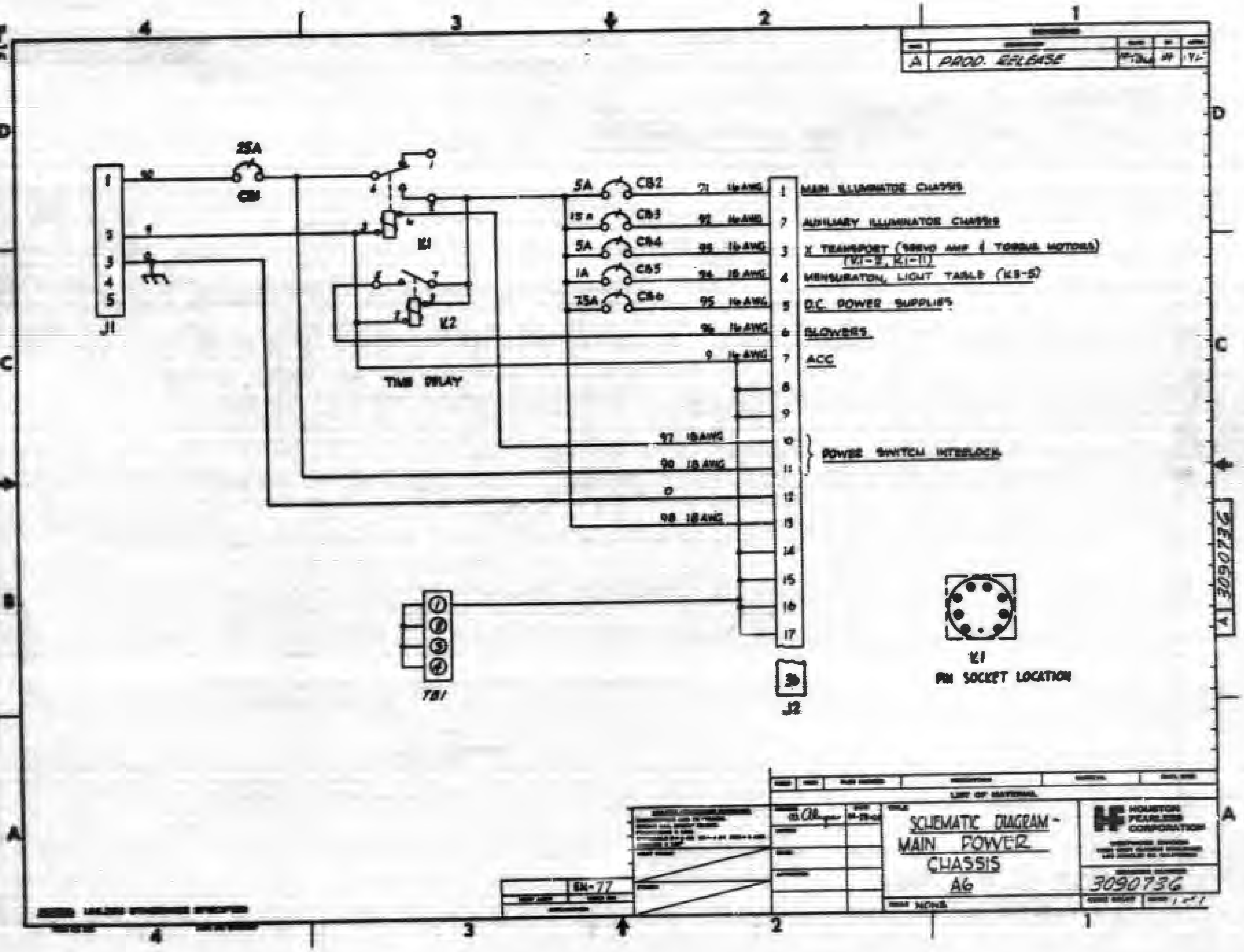


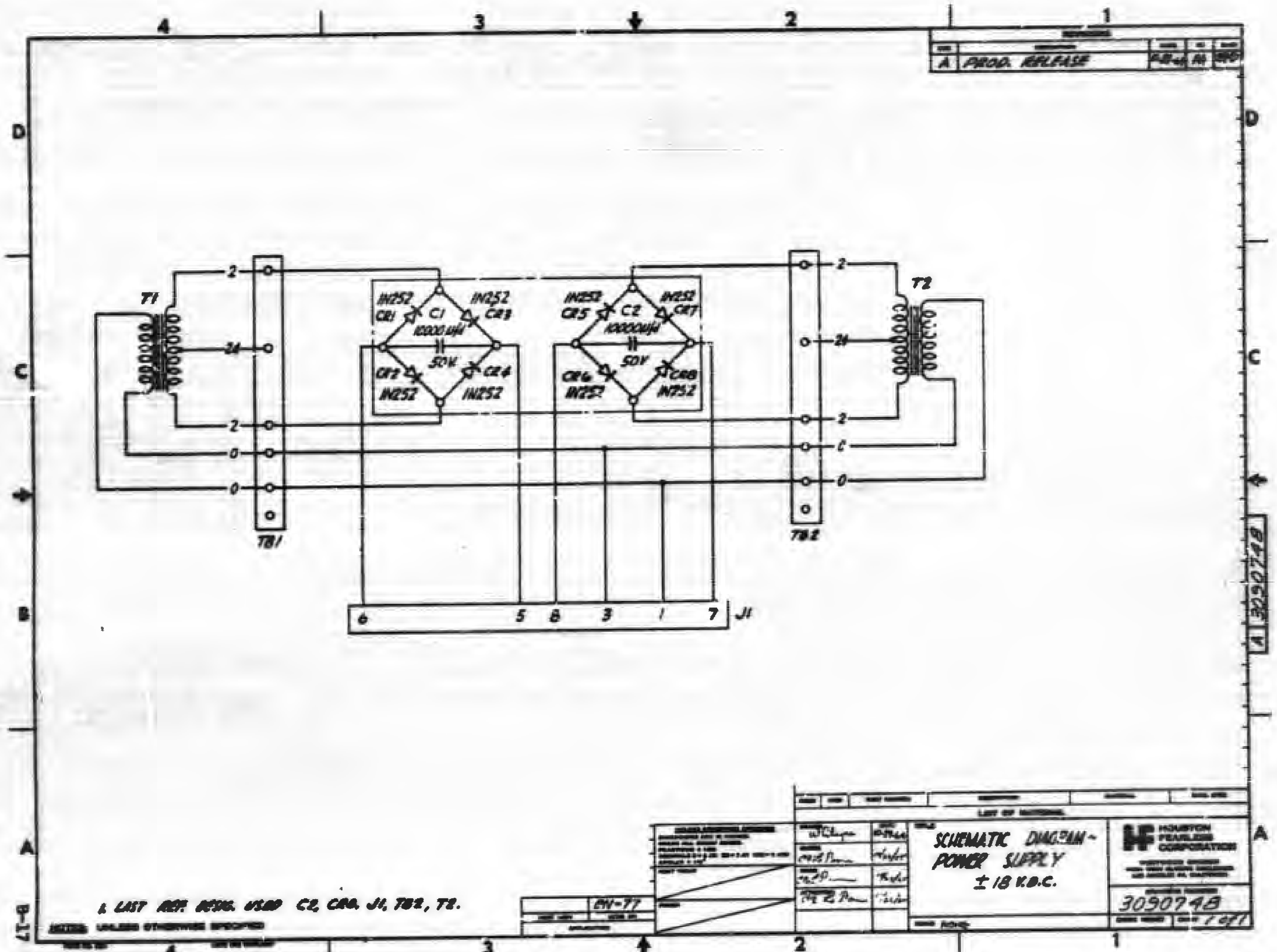
SCHEMATIC DIAGRAM - EXPOSURE SEQUENCE CONTROLLER A12A9
3070733
A PROD. RELEASE
90746 EN-77
(3) ALL REF. DESIGNATIONS SHALL BE PREFIXED WITH A12A9.
(2) LAST REF. DESIGNATIONS USED ARE: K1, C2, CR6, Q5, R14.
(1) RESISTORS ARE 1/4 WATT, 5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED
K1
K2
Q1
Q2
Q3
Q4
Q5
2N509
2N1131
C1
.1µf 100V
C2 40µf 30V
CR1 1N458
CR2 1N458
CR3 1N645
CR4 1N645
CR5 1N751
CR6 1N645
R1 15K
R2 10K
R3 10K
R4 47K
R5 7.5K
R7 15K
R8 4.7K
R9 10K
R10 1K
R11 1K
R12 5.6K
R13 180K
R14 180K
TP1
TP2
-18V
+18V
COM
-36V



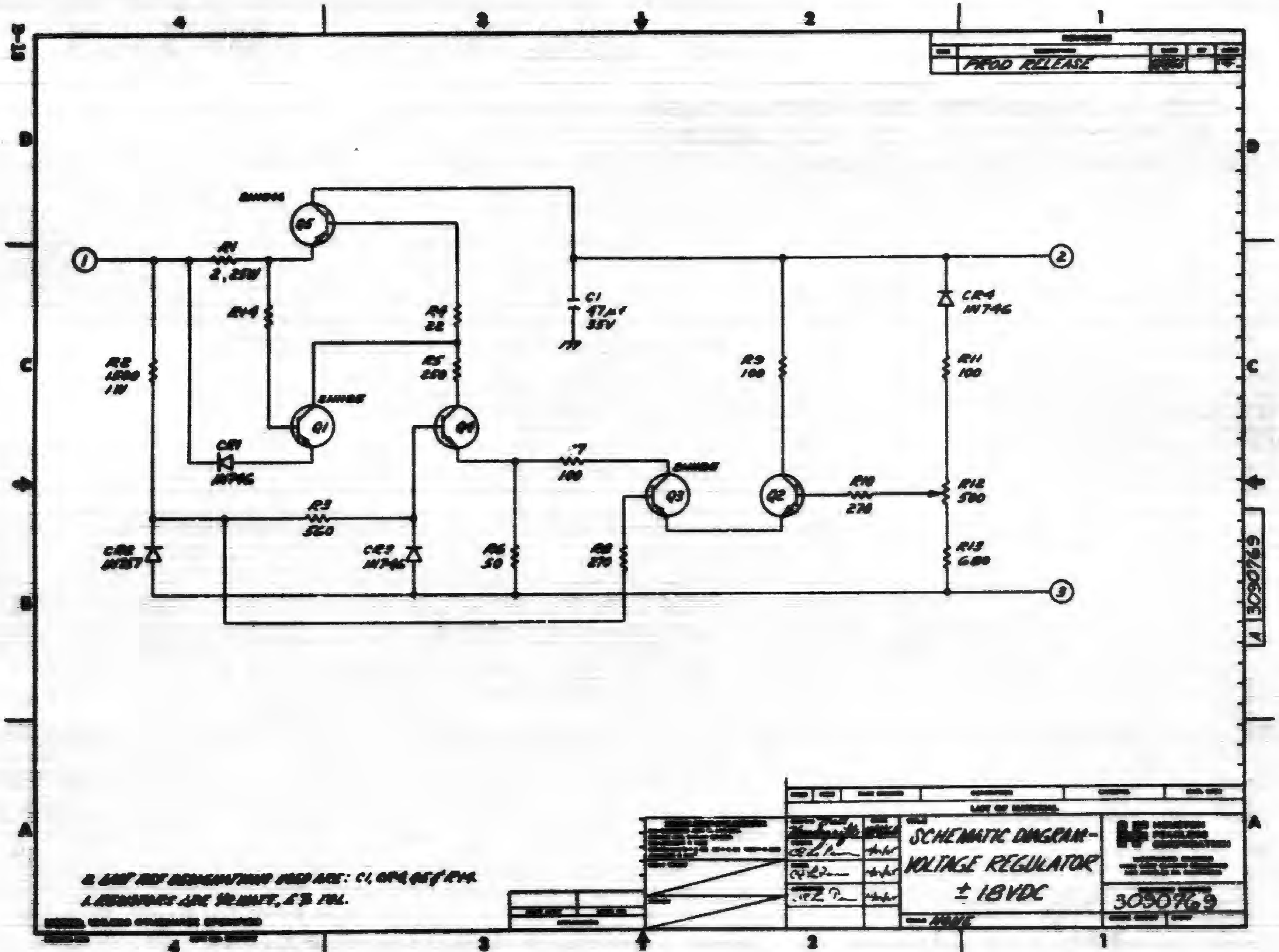
+18V. A
R1 1.5K
R2 150K
R4 82K
R6 150K
R8 10K
R10 150K
R12 10K
C1 2.2µf 35V
C2 1.2µf 35V
C5 1.2µf 35V
C4 2.2µf 35V
Q1 2N697
Q2 2N697
Q3 2N697
R3 10K
R5 390
C6
C3 .047µf 200V
R7 10K
R9 470
C7 100µf 6VDC
R11 10K
R13 1K
IN OUT
C
FL1
V1
V2
V3
PHOTOCELLS
V16
R26
BLK
RED
-18V A
COM. B
2. LAST REF. DESIGNATIONS USED ARE: C7, Q3, R16 & V3.
1. RESISTORS ARE 1/2 WATT, 5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED
A PROD. RELEASE
SCHEMATIC DIAGRAM-
PHOTO-CELL
AMPLIFIER
3090734
A 3090734
EN-77


A PROD RELEASE
MAIN ILLUMINATION LAMP
SHUTTER CLOSED SW
SHUTTER OPEN SW
SHUTTER SOLENOID
FILTER DRIVE MOTOR
SOLAR CELL
CCW LIMIT
CW LIMIT
TB1
TB2
TB3
1. ALL REF DESIGNATIONS SHALL BE PREFIXED WITH A8.
NOTES: UNLESS OTHERWISE SPECIFIED
EN-77
LIST OF MATERIAL
SCHEMATIC DIAGRAM-MAIN ILLUMINATION CHASSIS A8
HOUSTON FEARLESS CORPORATION
3090735
SCALE NONE
A 3090735

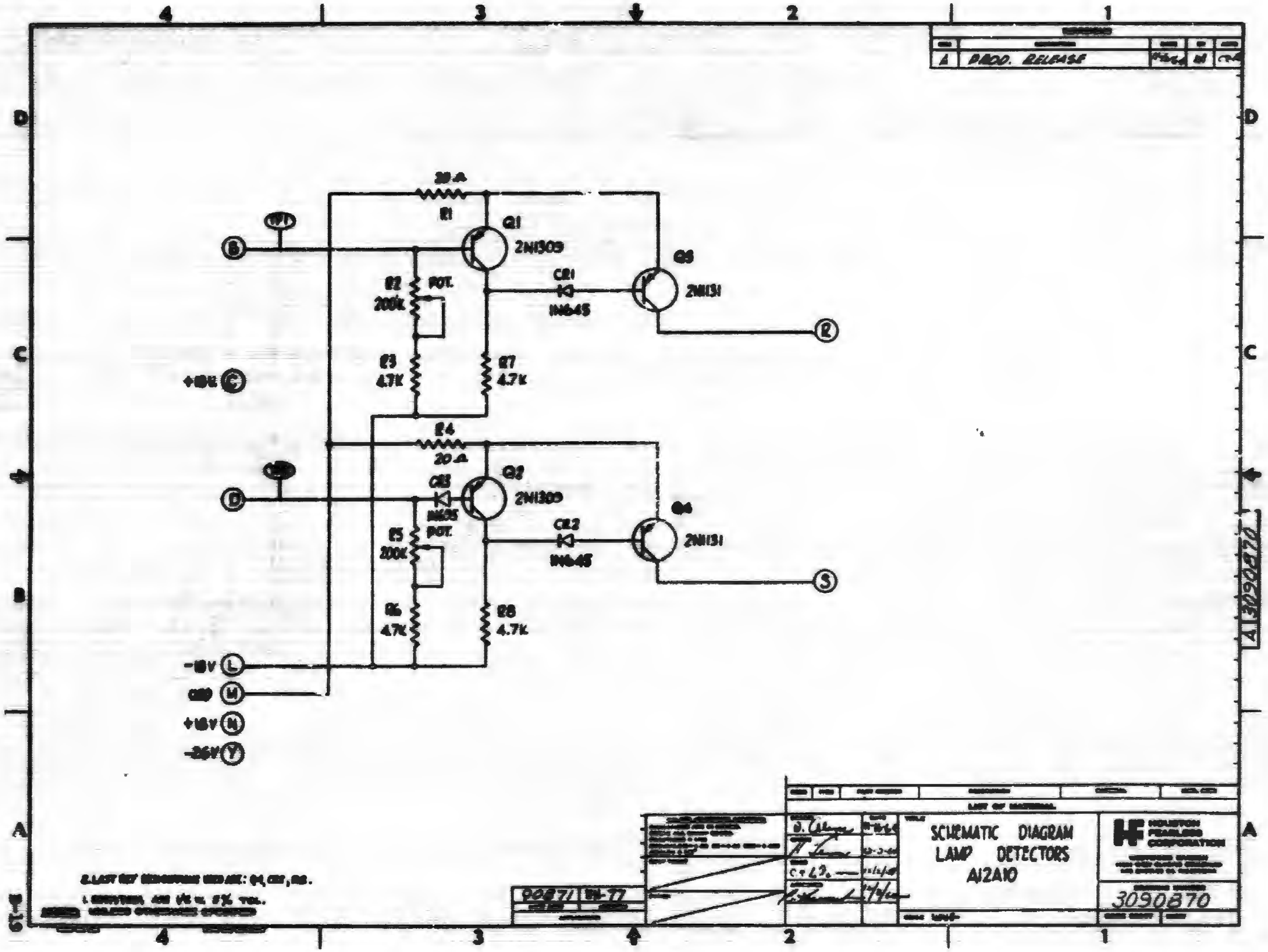

A PROD. RELEASE
25A
CB1
J1
5A CB2
15A CB3
5A CB4
1A CB5
7.5A CB6
K1
K2
TIME DELAY
91 16 AWG
92 16 AWG
93 16 AWG
94 16 AWG
95 16 AWG
96 16 AWG
9 16 AWG
97 18 AWG
90 18 AWG
98 18 AWG
MAIN ILLUMINATOR CHASSIS
AUXILIARY ILLUMINATOR CHASSIS
X TRANSPORT (SERVO AMP & TORQUE MOTORS) (V1-2, K1-11)
MENSURATION, LIGHT TABLE (K3-5)
D.C. POWER SUPPLIES
BLOWERS
ACC
POWER SWITCH INTERLOCK
J2
TB1
K1
PIN SOCKET LOCATION
SCHEMATIC DIAGRAM - MAIN POWER CHASSIS A6
HOUSTON FEARLESS CORPORATION
3090736
A 3090736



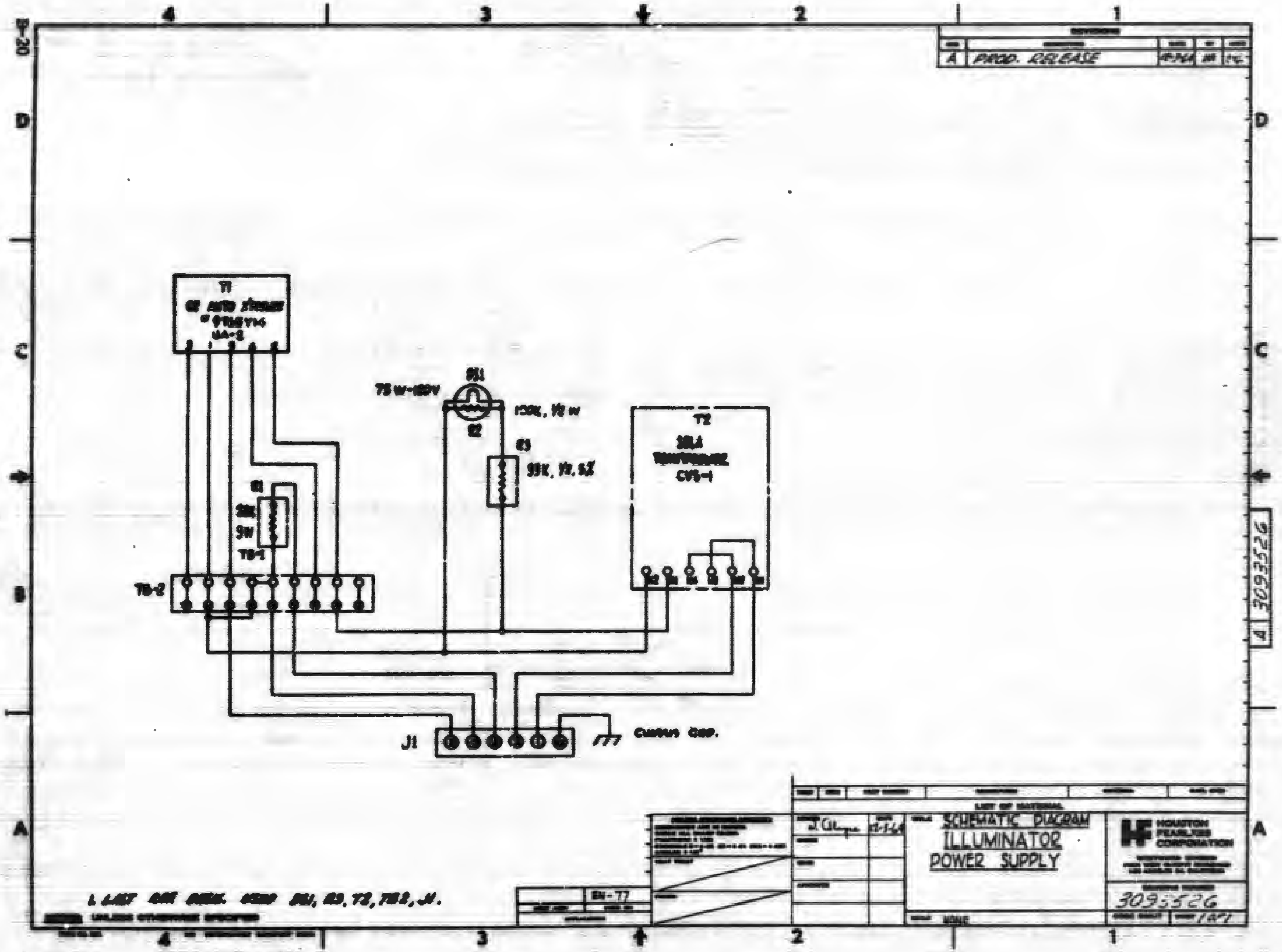
A PROD. RELEASE
T1
T2
TB1
TB2
IN252 CR1
C1 10000 uf 50V
IN252 CR3
CR2 IN252
CR4 IN252
IN252 CR5
C2 10000uf 50V
IN252 CR7
CR6 IN252
CR8 IN252
J1
6 5 8 3 1 7
1. LAST REF. DESIG. USED C2, CR8, J1, TB2, T2.
NOTES: UNLESS OTHERWISE SPECIFIED
SCHEMATIC DIAGRAM - POWER SUPPLY ± 18 V.D.C.
HOUSTON FEARLESS CORPORATION
3090748
A 3090748

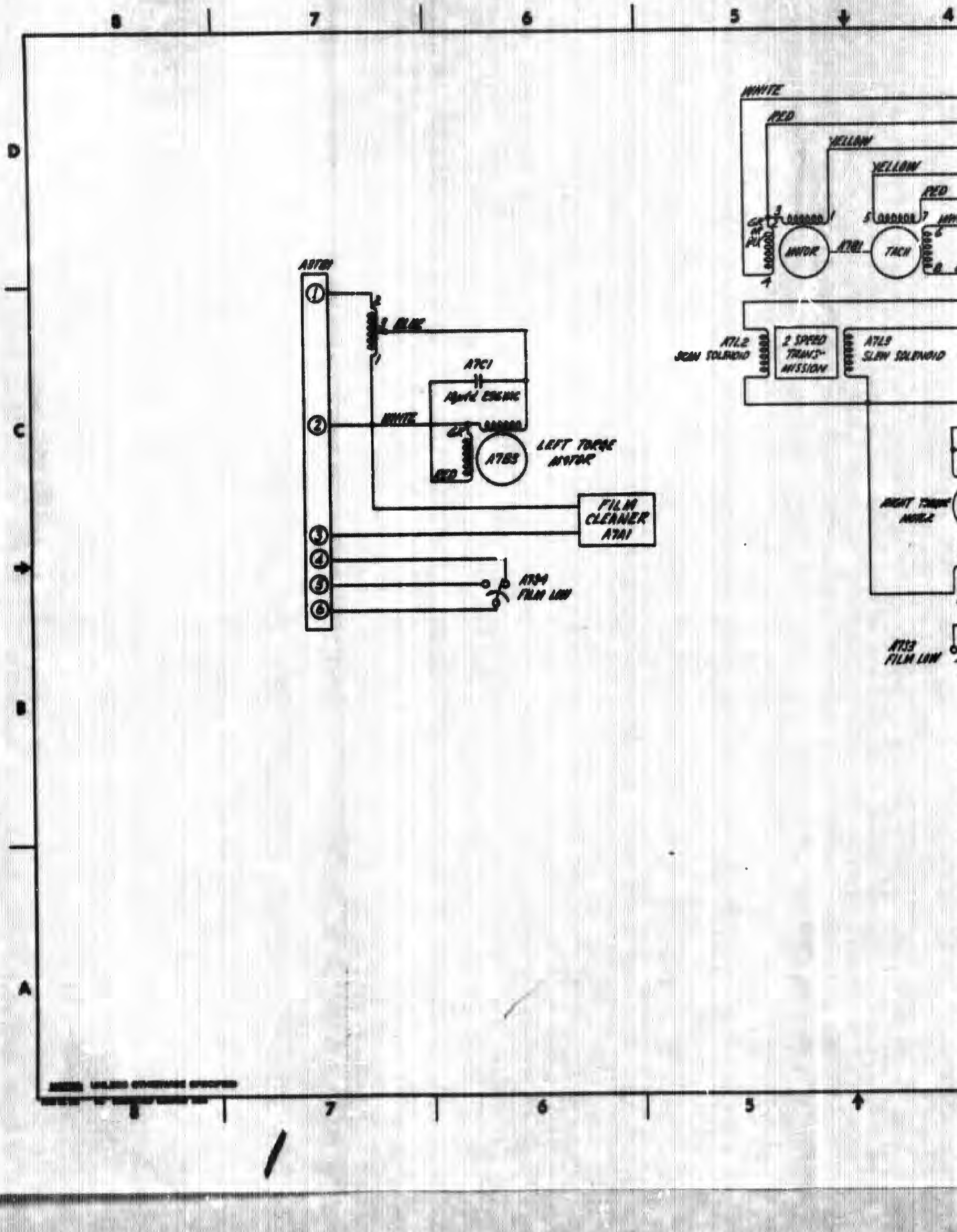


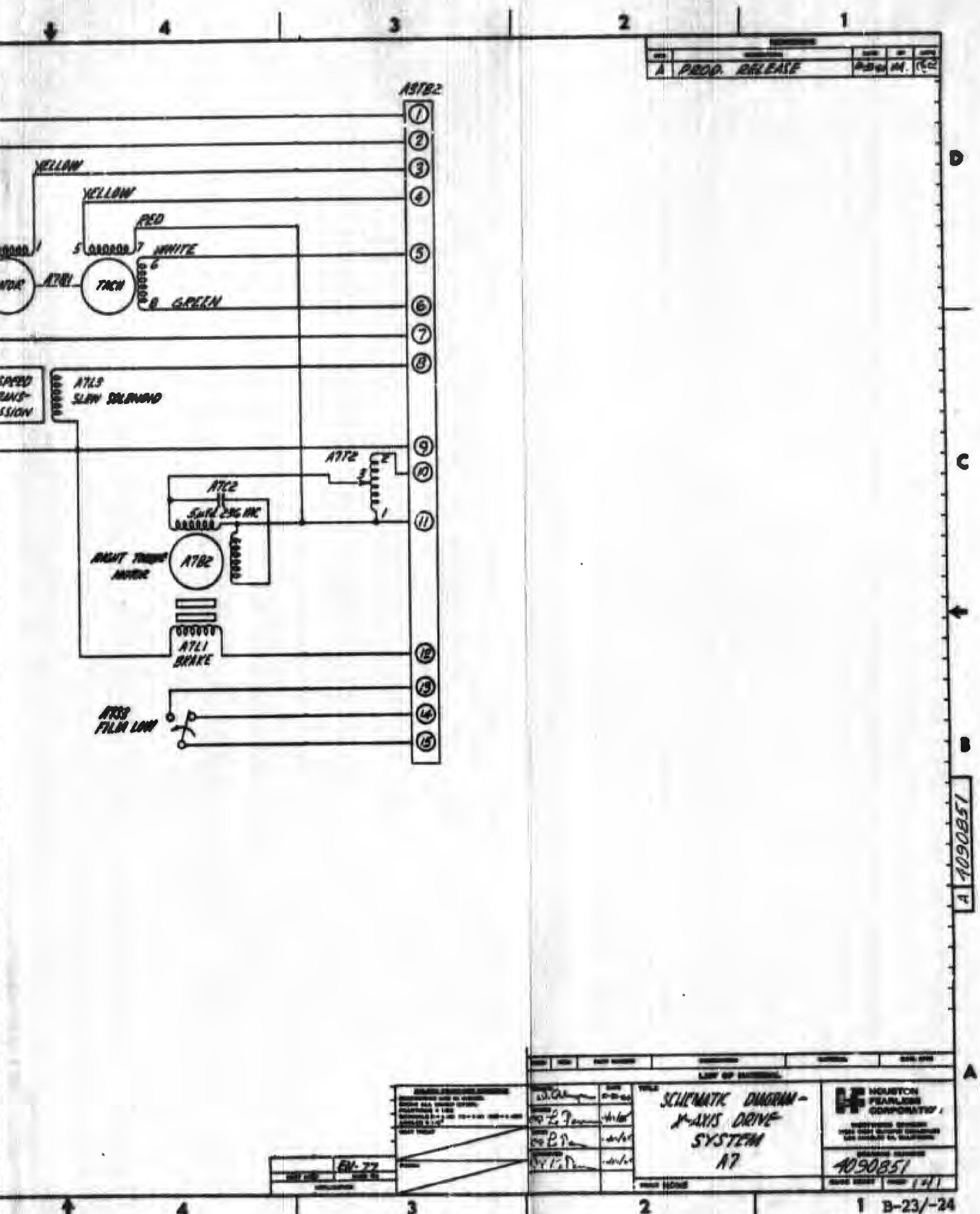
PROD RELEASE
SCHEMATIC DIAGRAM-
VOLTAGE REGULATOR
± 18VDC
3090769
A 3090769
R1
2, 25W
R14
R4
22
R5
250
C1
47µf
35V
R2
1500
1W
Q5
Q1
Q4
CR1
1N746
R3
560
CR3
1N746
CR2
R6
50
R7
100
R8
270
Q3
Q2
R9
100
R10
270
CR4
1N746
R11
100
R12
500
R13
680
2. LAST REF DESIGNATIONS USED ARE: C1, CR4, Q5 & R14.
1. RESISTORS ARE 1/2 WATT, ±5% TOL.
NOTES: UNLESS OTHERWISE SPECIFIED



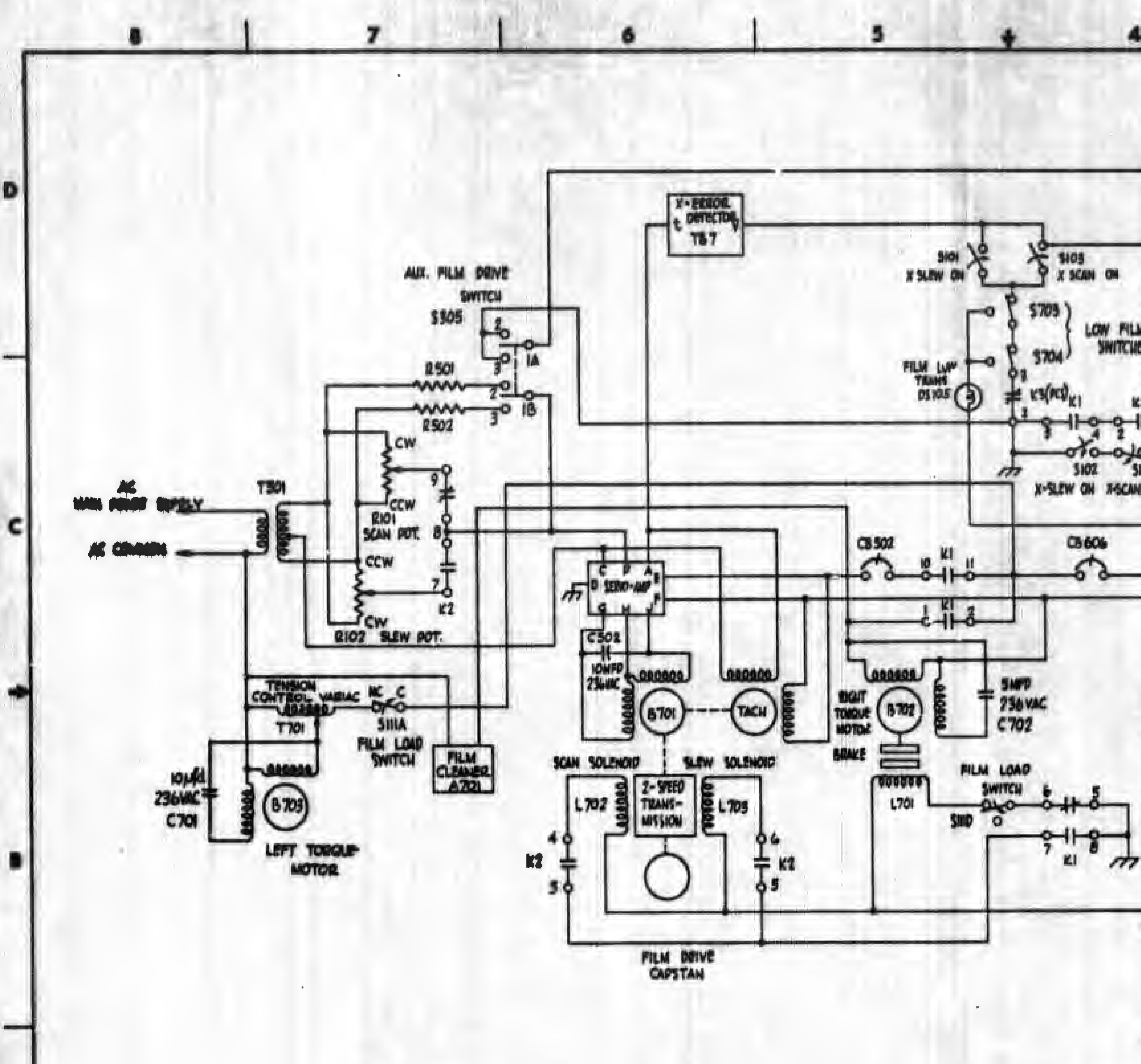
A PROD. RELEASE
R1
Q1
2N1309
R2
200K
POT.
CR1
1N645
Q3
2N131
R3
4.7K
R7
4.7K
R4
20
Q2
2N1309
CR3
POT.
R5
200K
CR2
1N645
Q4
2N131
R6
4.7K
R8
4.7K
-18V L
M
+18V N
-26V Y
+18V C
B
D
R
S
SCHEMATIC DIAGRAM
LAMP DETECTORS
A12A10
HOUSTON FEARLESS CORPORATION
3090870


A PROD. RELEASE
T1
T2
CVS-1
DS1
75 W-120V
R2
R3
R1
TB-1
TB-2
J1
SCHEMATIC DIAGRAM
ILLUMINATOR
POWER SUPPLY
3093526
EN-77
HOUSTON FEARLESS CORPORATION

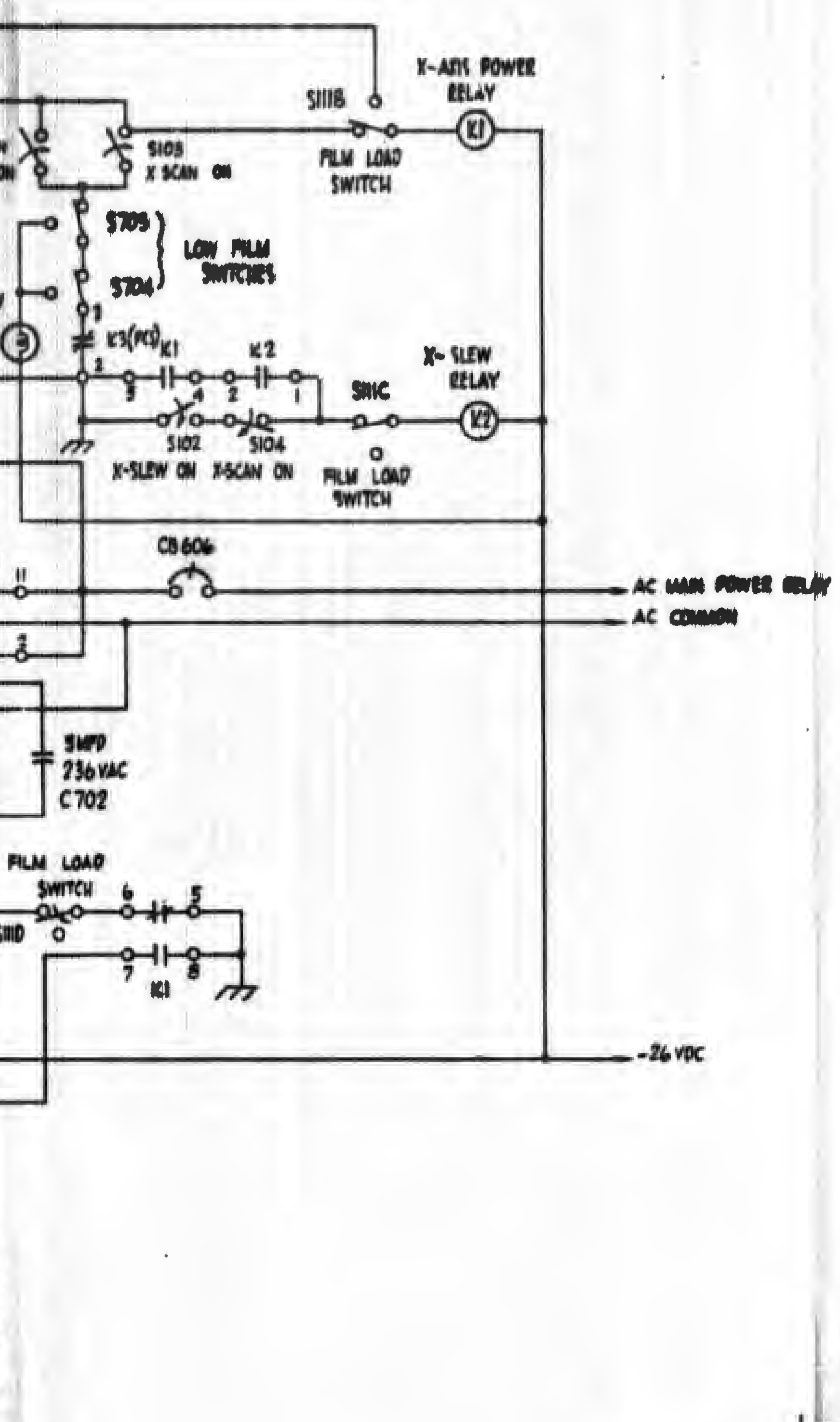
WHITE
RED
YELLOW
YELLOW
RED
MOTOR
TACH
2 SPEED TRANS-MISSION
SLEW SOLENOID
BLUE
WHITE
LEFT TORQUE MOTOR
RED
FILM CLEANER
FILM LOW
FILM LOW


A7TB2
YELLOW
YELLOW
RED
WHITE
TACH
A7B1
GREEN
A7L3
SLEW SOLENOID
A7T2
A7C2
RIGHT TORQUE MOTOR
A7B2
A7L1
BRAKE
A7S3
FILM LOW
A PROD. RELEASE
D
C
B
A
A 4090851
EN-77
SCHEMATIC DIAGRAM - X-AXIS DRIVE SYSTEM A7
HOUSTON FEARLESS CORPORATION
4090851
1 B-23/-24

2



3. TENSION CONTROLLED VARIAC, T701, IS DRIVEN BY A ROLLER SENSING FILM TENSION.
2. S103 & S104 OPERATE WHEN SCAN POT, R101, IS TURNED EITHER DIRECTION FROM ZERO.
1. S101 & S102 OPERATE WHEN SLEW POT, R102, IS TURNED EITHER DIRECTION FROM ZERO.



REV	DESCRIPTION	DATE	BY	APPD
A	PROD. RELEASE			

LIST OF MATERIAL

SYSTEM DIAGRAM
X-AXIS FILM DRIVE

HOUSTON FEARLESS CORPORATION

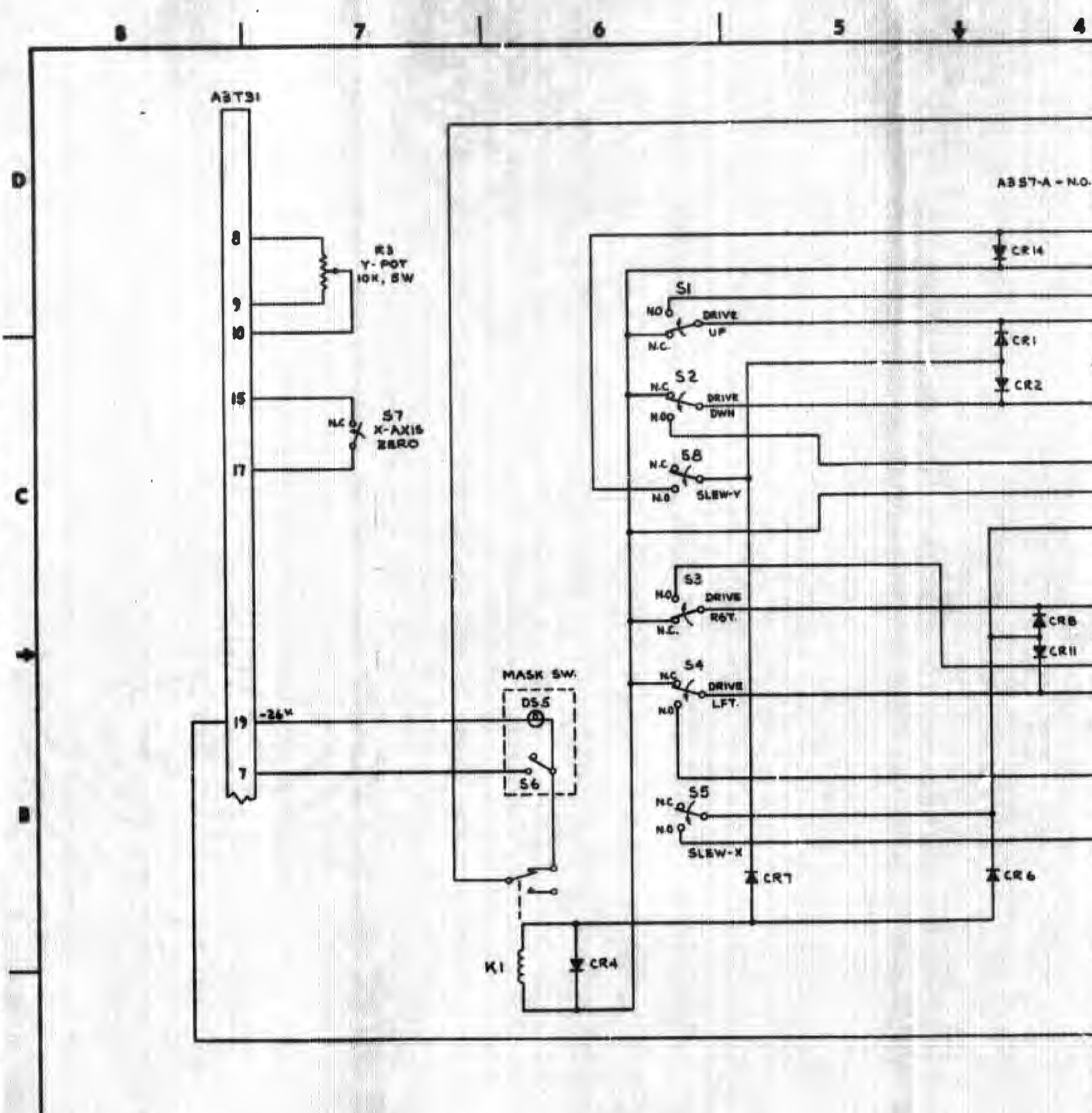
DRAWING NUMBER 4090852

SCALE NONE

EY-77

B-25/-26

2

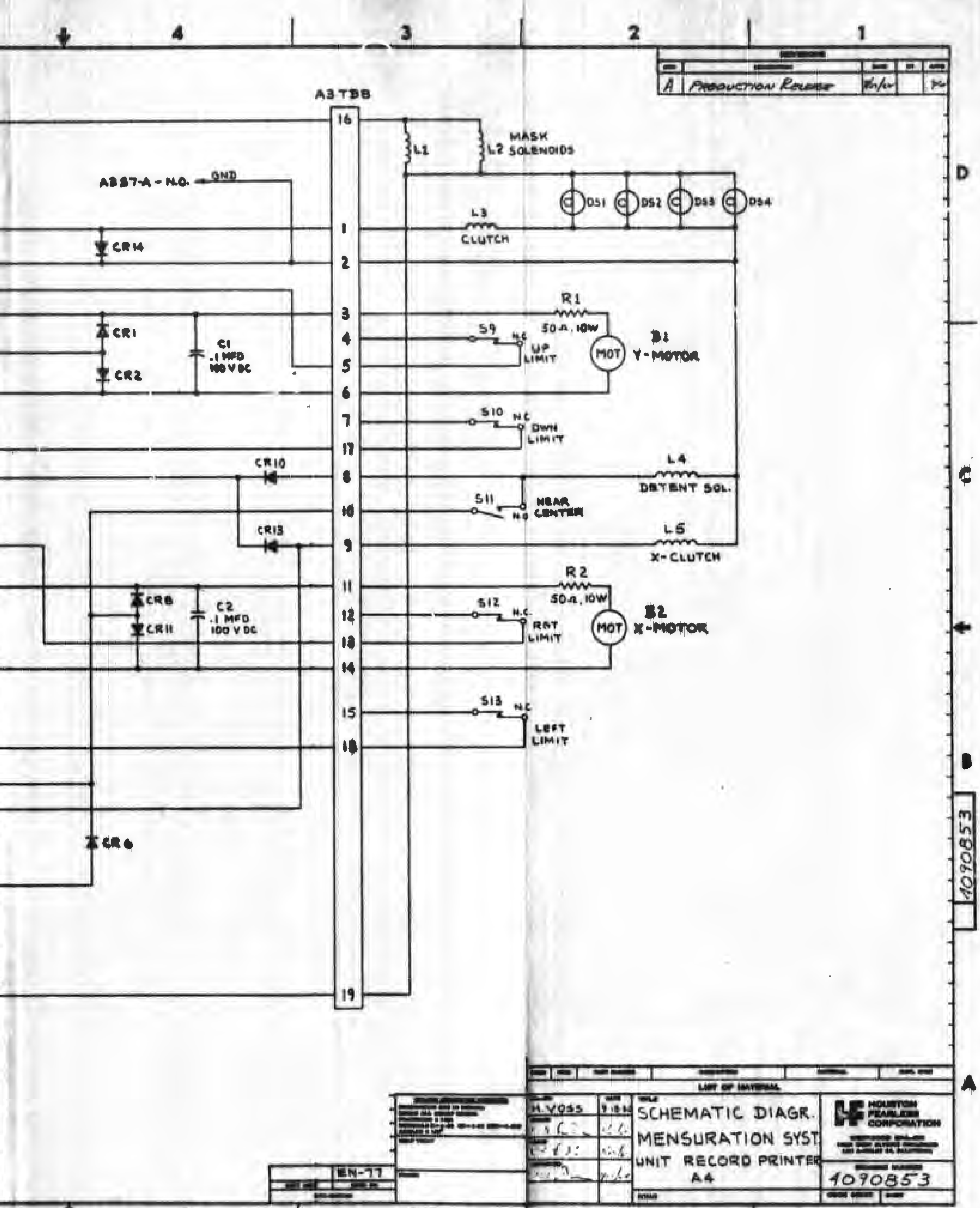


3) ALL DIODES, CAPACITORS AND RELAY K1 ARE ON A4A1 IN CONTROL TABLE.

2) S1, S2, S3, S4, S5, S6, / S8 ARE ON CONTROL TABLE
S1, S2, / S8 CONTAINED IN ONE SWITCH ASSY.
S3, S4, / S5 CONTAINED IN ONE SWITCH ASSY

1) ALL DIODES IN645.

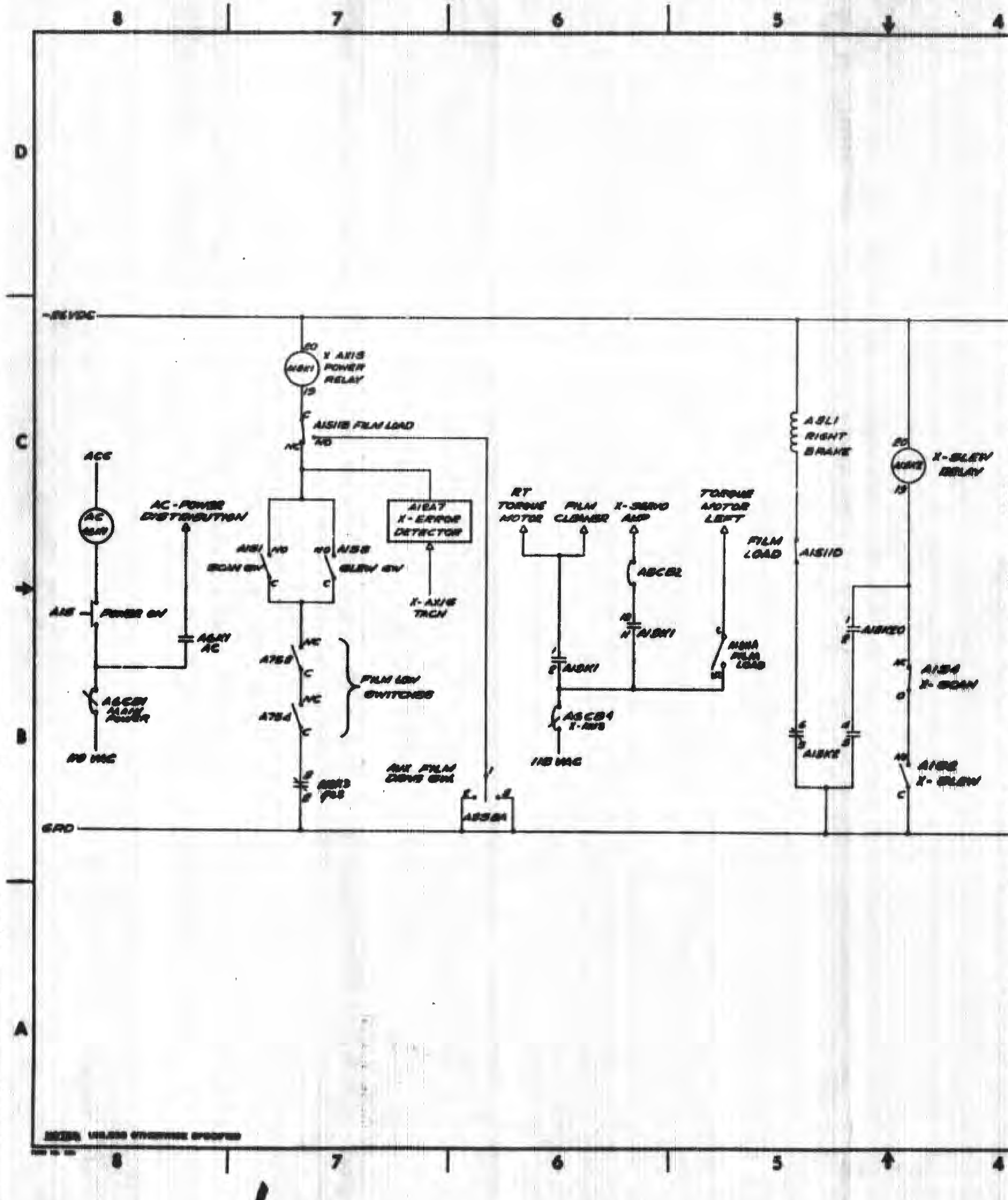
NOTES: UNLESS OTHERWISE SPECIFIED



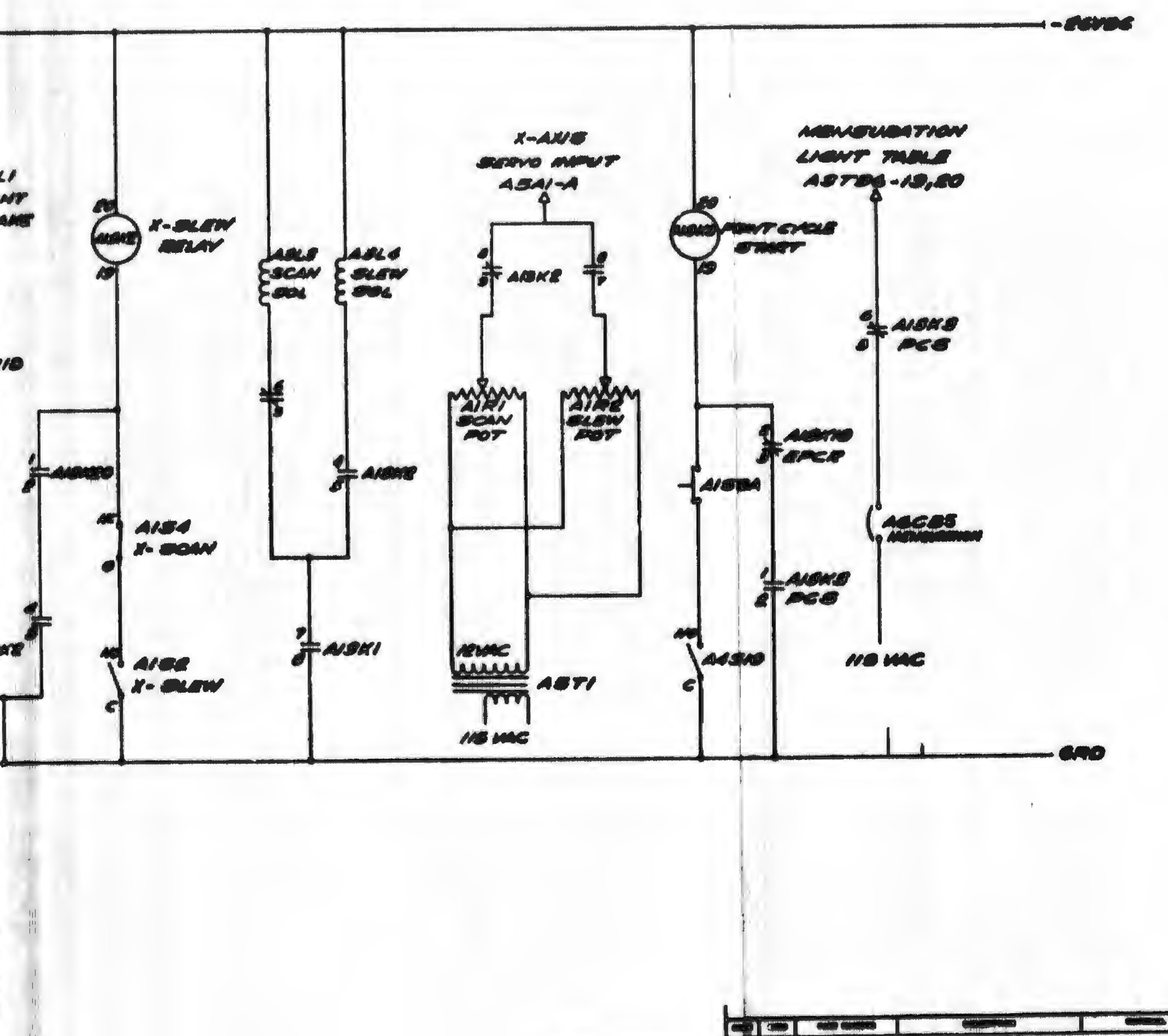
A PRODUCTION RELEASE
A3TB8
MASK SOLENOIDS
L1
L2
A3S7-A - N.O.
GND
DS1
DS2
DS3
DS4
L3 CLUTCH
CR14
CR1
CR2
C1 .1 MFD 100 VDC
R1 50Ω, 10W
S9 N.C. UP LIMIT
B1 Y-MOTOR
MOT
S10 N.C. DWN LIMIT
CR10
L4 DETENT SOL.
S11 N.O. NEAR CENTER
CR13
L5 X-CLUTCH
R2 50Ω, 10W
CR8
CR11
C2 .1 MFD 100 VDC
S12 N.C. RGT LIMIT
B2 X-MOTOR
S13 N.C. LEFT LIMIT
CR6
LIST OF MATERIAL
H. VOSS
SCHEMATIC DIAGR. MENSURATION SYST. UNIT RECORD PRINTER A4
HOUSTON FEARLESS CORPORATION
4090853
EN-77

B-27/-28

2



-26VDC
GRD
X AXIS POWER RELAY
A1S1B FILM LOAD
A1EA7 X-ERROR DETECTOR
X-AXIS TACH
AC-POWER DISTRIBUTION
SCAN SW
SLEW SW
POWER SW
FILM LOW SWITCHES
AUX FILM DRIVE SW
RT TORQUE MOTOR
FILM CLEANER
X-SERVO AMP
TORQUE MOTOR LEFT
FILM LOAD
A1S1D
RIGHT BRAKE
X-SLEW RELAY
X-SCAN
X-SLEW
115 VAC
NOTES: UNLESS OTHERWISE SPECIFIED

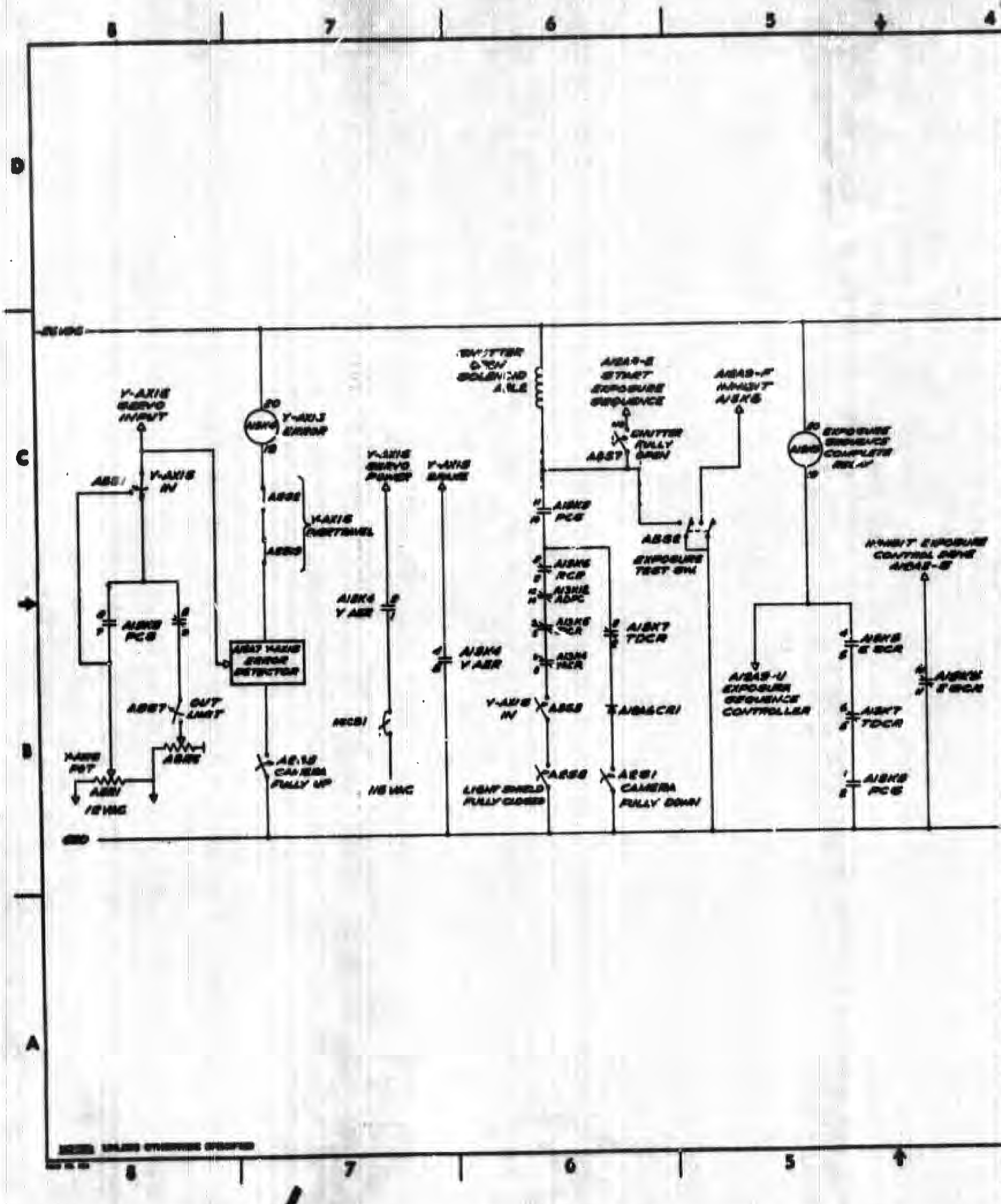


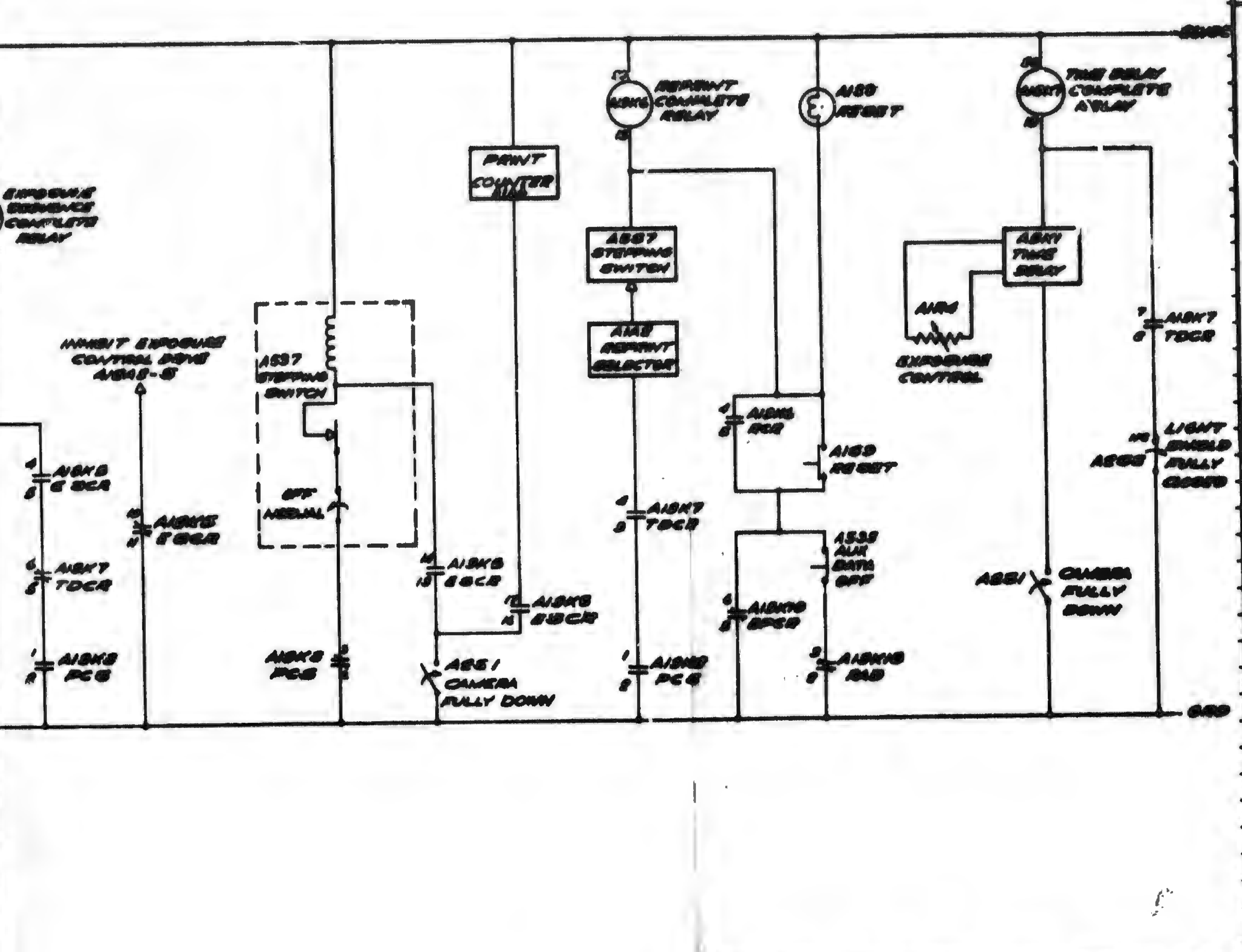
LOGIC DIAGRAM
UNIT RECORD PRINTER
EN 77

1093507

B-29/-30

2

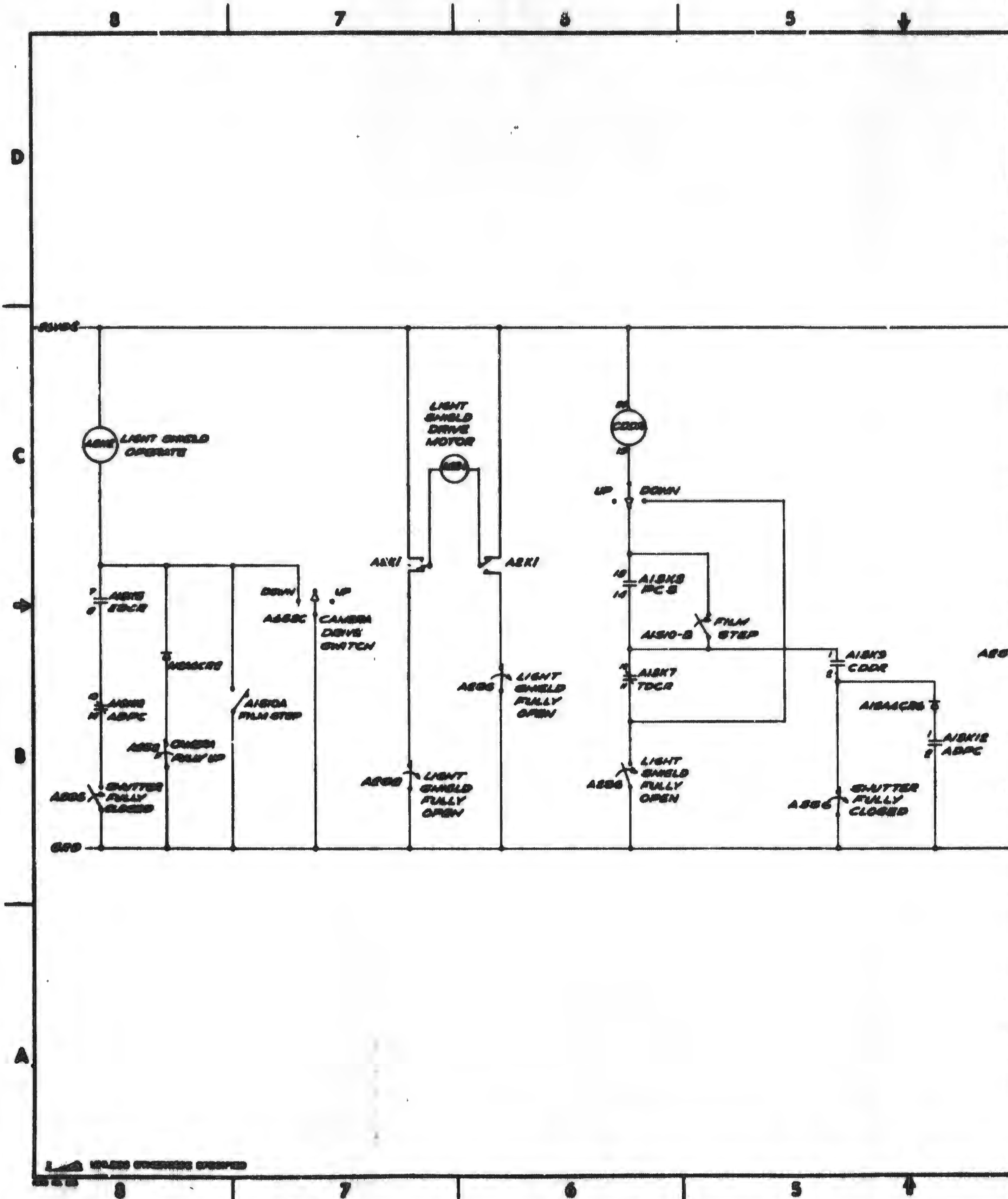

Y-AXIS SERVO INPUT
Y-AXIS IN
Y-AXIS ERROR
ERROR DETECTOR
OUT LIMIT
CAMERA FULLY UP
Y-AXIS SERVO POWER
Y-AXIS BRAKE
Y AER
115 VAC
LIGHT SHIELD FULLY CLOSED
CAMERA FULLY DOWN
START EXPOSURE SEQUENCE
SHUTTER FULLY OPEN
EXPOSURE TEST SW
EXPOSURE SEQUENCE COMPLETE RELAY
EXPOSURE SEQUENCE CONTROLLER
INHIBIT EXPOSURE CONTROL DRIVE
TDCR
PCS
RCP
GND



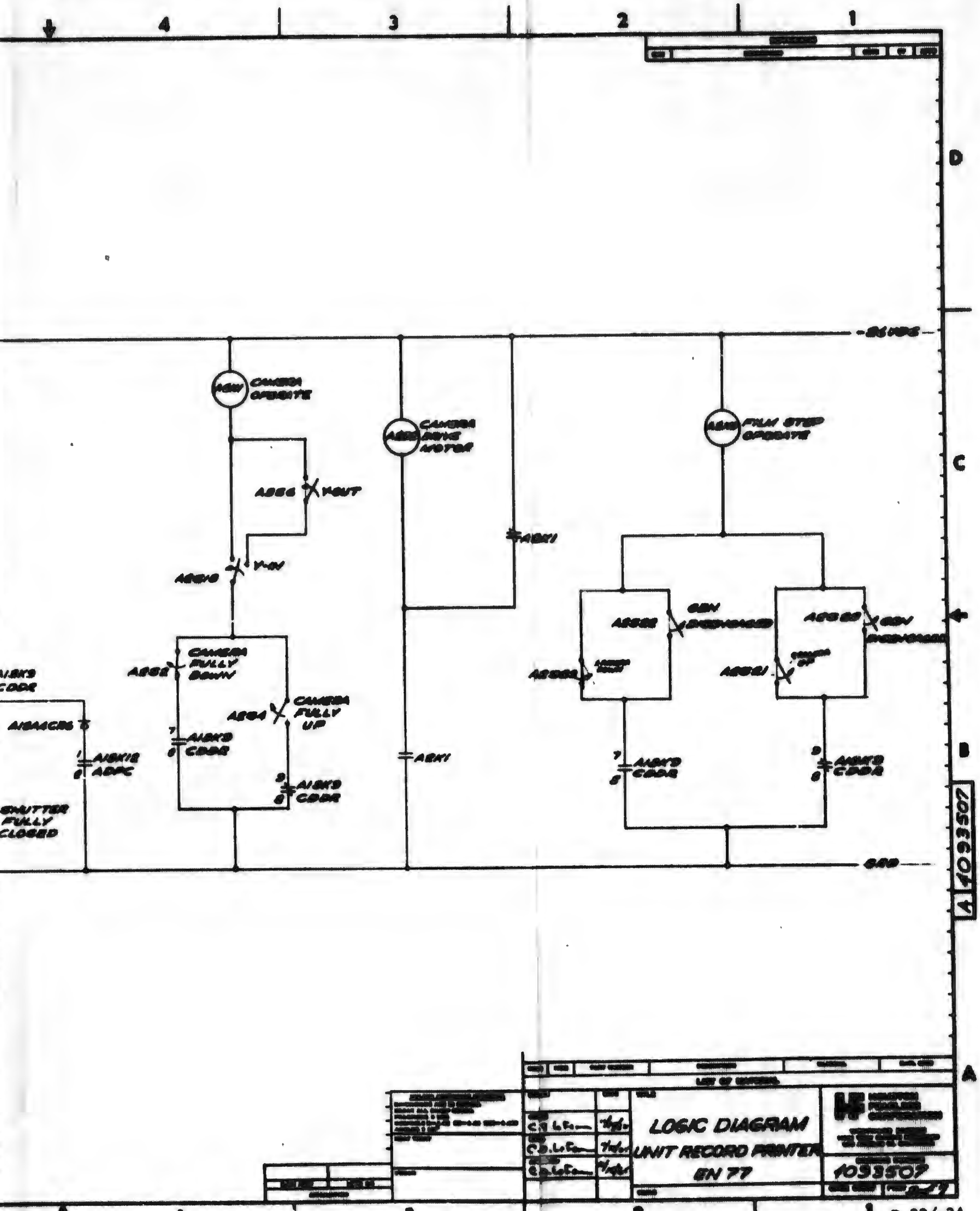
LOGIC DIAGRAM
UNIT RECORD PRINTER
EN77

4093507

2

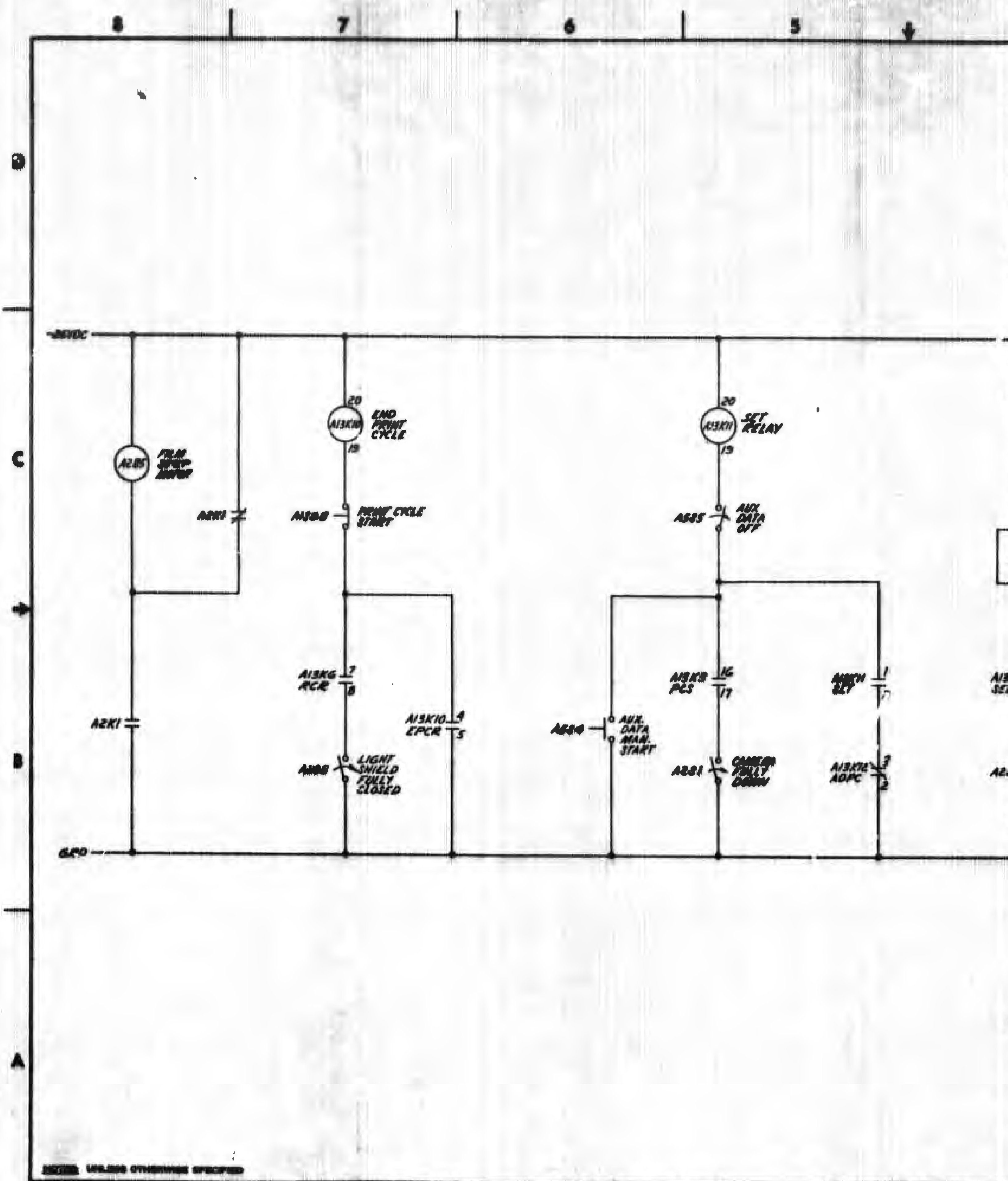


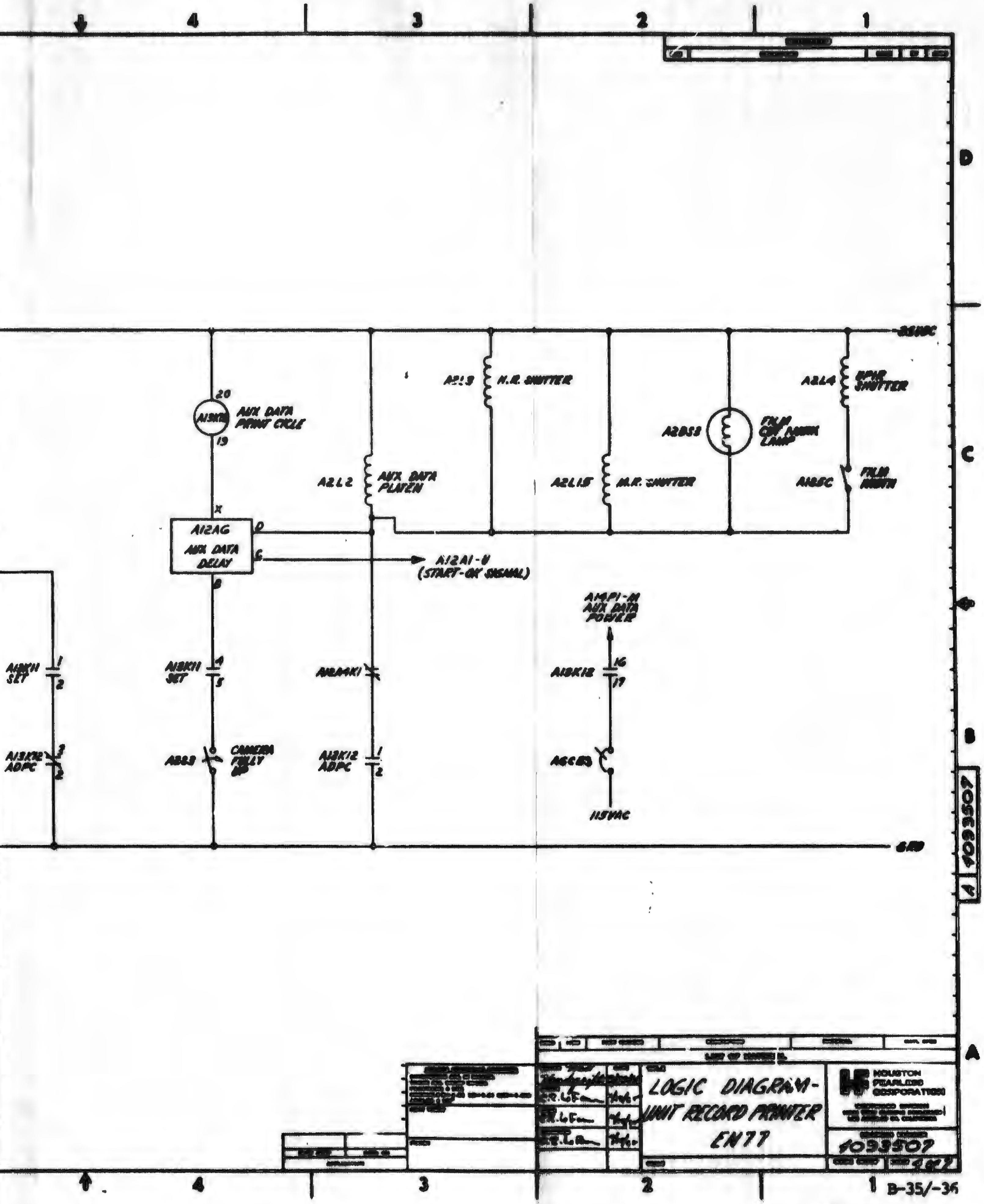
8
7
6
5
4
D
C
B
A
LIGHT SHIELD OPERATE
LIGHT SHIELD DRIVE MOTOR
CDDR
UP
DOWN
CAMERA DRIVE SWITCH
FILM STEP
TDCR
ADPC
LIGHT SHIELD FULLY OPEN
SHUTTER FULLY CLOSED
GRD



CAMERA OPERATE
CAMERA DRIVE MOTOR
FILM STEP OPERATE
-26VDC
Y-OUT
Y-IN
CAMERA FULLY DOWN
CAMERA FULLY UP
SHUTTER FULLY CLOSED
GND
LOGIC DIAGRAM
UNIT RECORD PRINTER
EN 77
1033507

B-33/-34

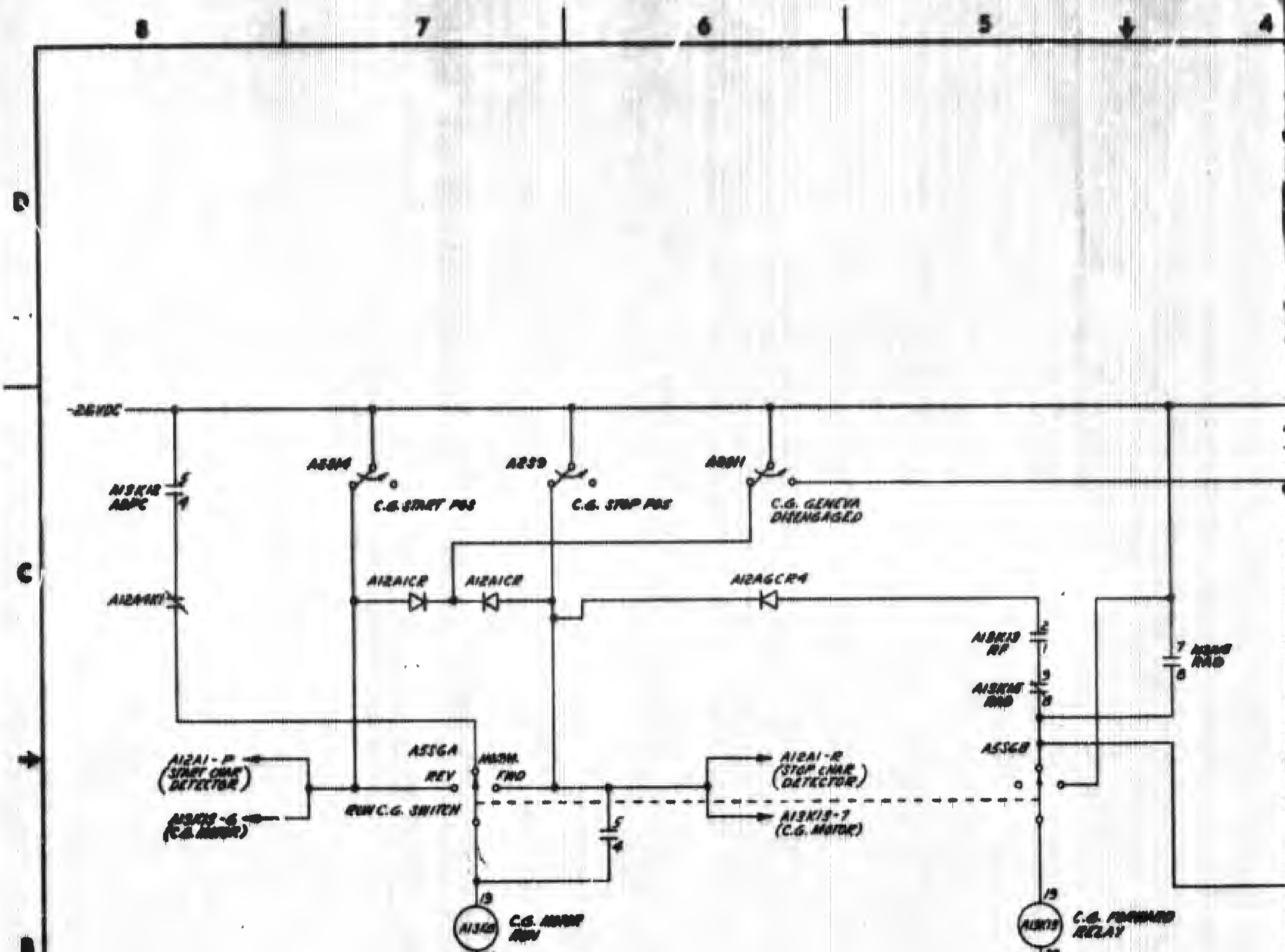

-28VDC
GND
A13K10
END PRINT CYCLE
A13K11
SET RELAY
A2K1
A13K6
ACR
A13K10
EPCR
LIGHT SHIELD FULLY CLOSED
PRINT CYCLE START
A5S5
AUX. DATA OFF
A13K3
PCS
A5S4
AUX. DATA MAN. START
A2S1
ADPC
UNLESS OTHERWISE SPECIFIED



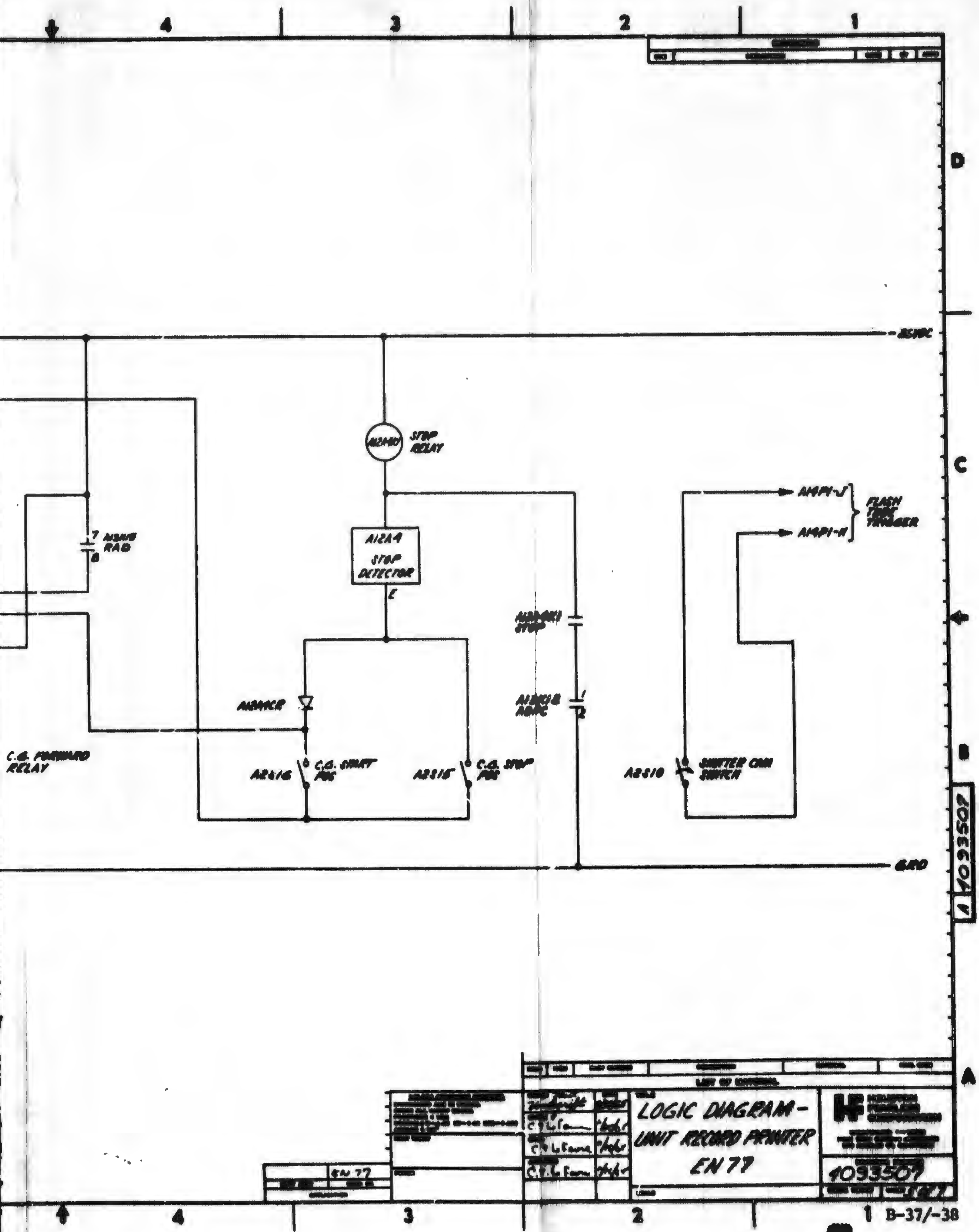
A13K10
AUX DATA PRINT CYCLE
A12AG
AUX DATA DELAY
A12A1-V
(START-OK SIGNAL)
A2L2
AUX DATA PLATEN
A2L3
H.R. SHUTTER
A2L15
M.R. SHUTTER
A2DS3
FILM OK MARK LAMP
A2L4
BPHR SHUTTER
A12SC
FILM MARK
A13K11
SET
A13K12
ADPC
A2S3
CAMERA FULLY UP
A1MP1-M
AUX DATA POWER
115VAC
GND
LOGIC DIAGRAM-UNIT RECORD PRINTER
EN77
HOUSTON FEARLESS CORPORATION
4093507

B-35/-36

2



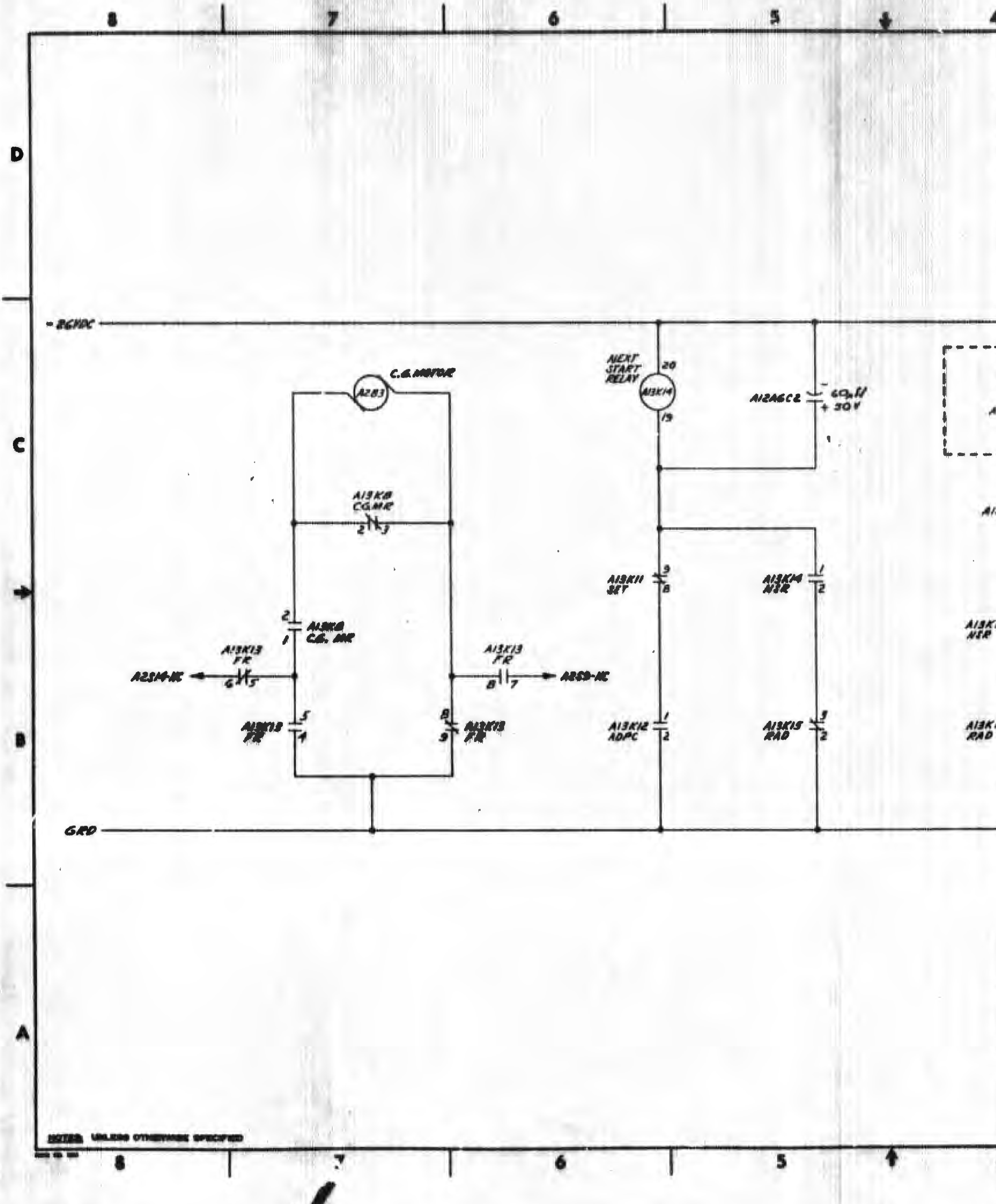
-28VDC
C.G. START POS
C.G. STOP POS
C.G. GENEVA DISENGAGED
A12A1CR4
A12A6CR4
A13K13 RF
A5S6A
REV
FWD
A5S6B
A12A1-P (START CHAR DETECTOR)
A12A1-R (STOP CHAR DETECTOR)
RUN C.G. SWITCH
A13K13-7 (C.G. MOTOR)
C.G. FORWARD RELAY
GND
NOTES: UNLESS OTHERWISE SPECIFIED

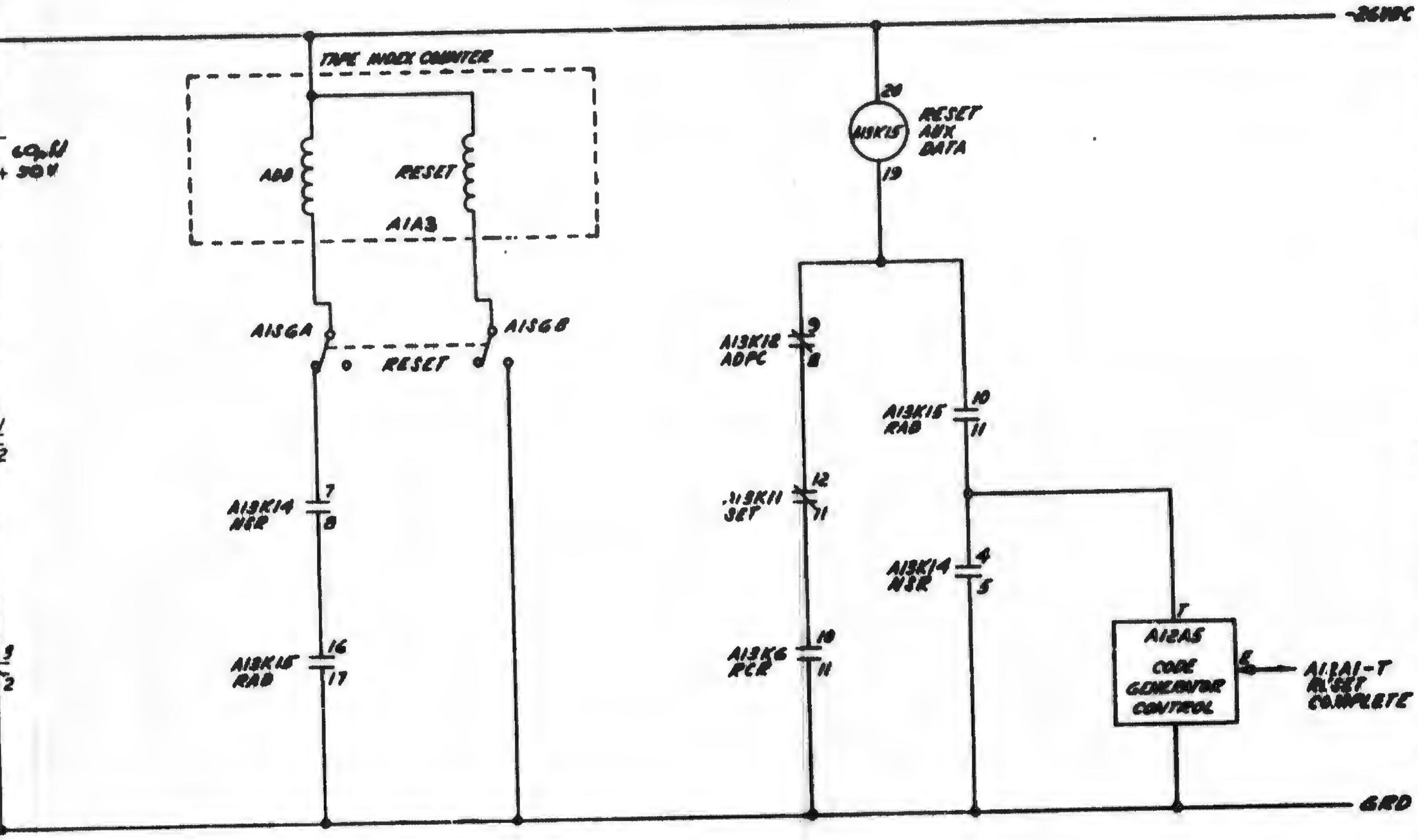


-25VDC
STOP RELAY
A12A4
STOP DETECTOR
E
C.G. FORWARD RELAY
A2S16
C.G. START POS
A2S15
C.G. STOP POS
A2S10
SHUTTER CAM SWITCH
A19P1-J
A19P1-H
FLASH TUBE TRIGGER
GRD
LOGIC DIAGRAM - UNIT RECORD PRINTER EN 77
1093507
EN 77

B-37/-38

2

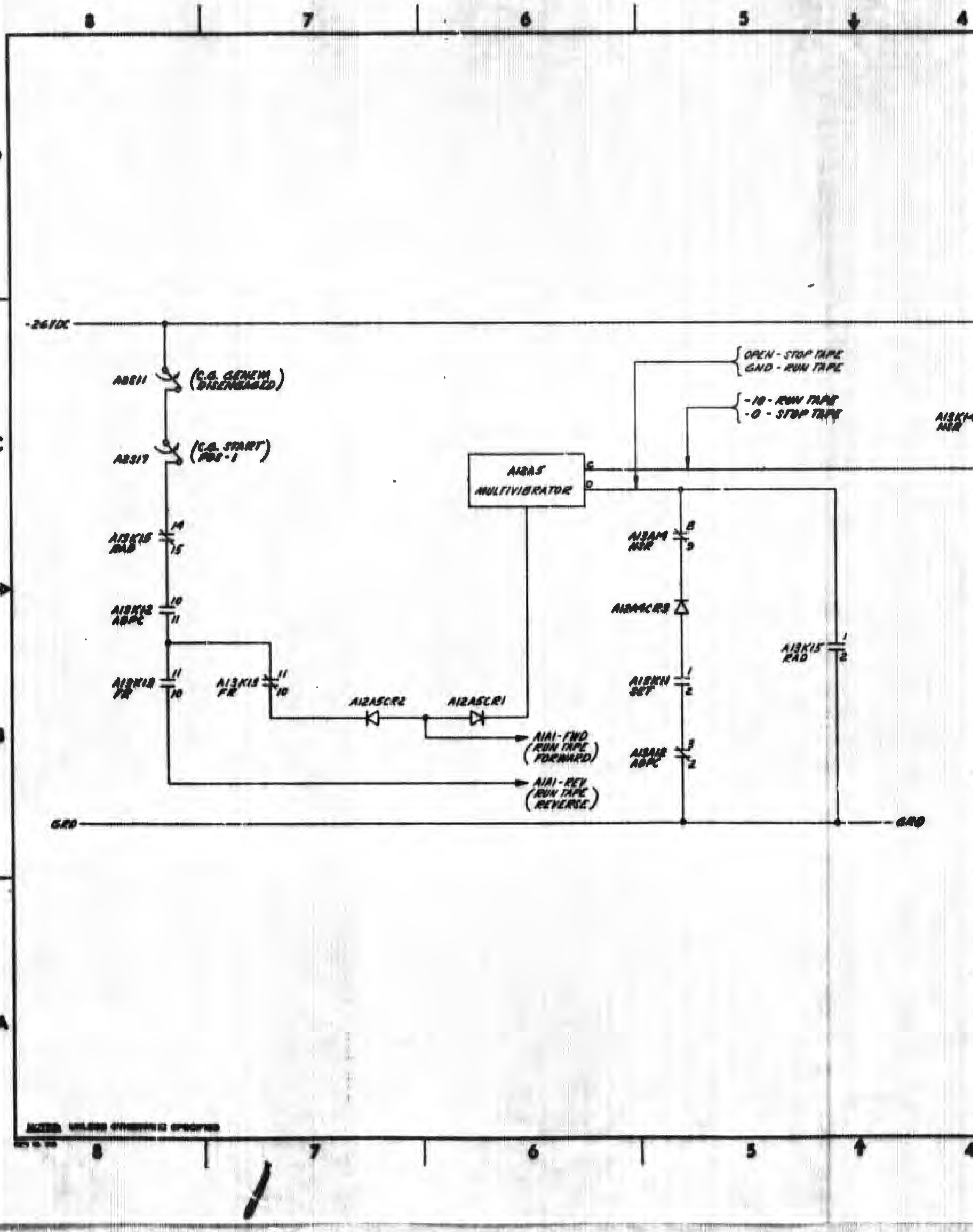

8
7
6
5
4
D
C
B
A
-26VDC
GRD
C.G. MOTOR
A2B3
A13K8
CGMR
A13K8
C.G. MR
A13K13
FR
A2S14-1C
A13K13
FR
A2S3-1C
NEXT
START
RELAY
A13K14
A12A6C2
60μf
30V
A13K11
SET
A13K14
NSR
A13K12
ADPC
A13K15
RAD
NOTES: UNLESS OTHERWISE SPECIFIED

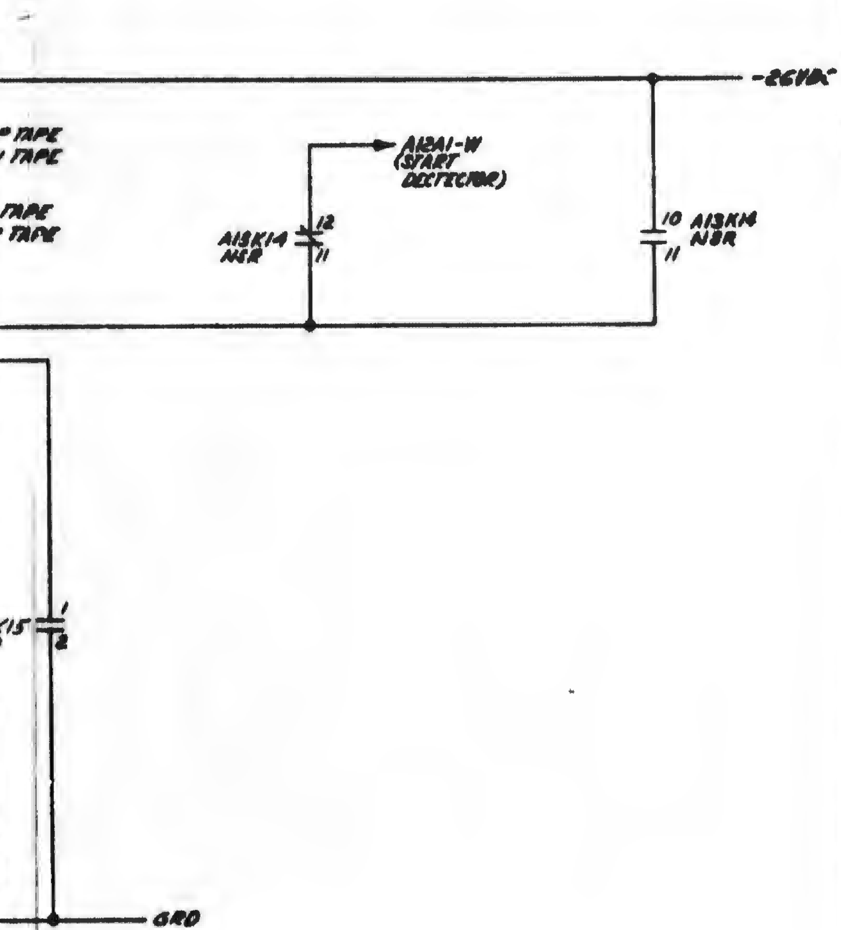


LOGIC DIAGRAM - UNIT RECORD PRINTER EN77

HOUSTON FEARLESS CORPORATION

4093507


-26VDC
(C.G. GENEVA DISENGAGED)
(C.G. START PBS-1)
A12A5
MULTIVIBRATOR
OPEN - STOP TAPE
GND - RUN TAPE
-10 - RUN TAPE
-0 - STOP TAPE
A12A5CR2
A12A5CR1
A1A1-FWD
(RUN TAPE FORWARD)
A1A1-REV
(RUN TAPE REVERSE)
GRD
GRD
NOTES: UNLESS OTHERWISE SPECIFIED



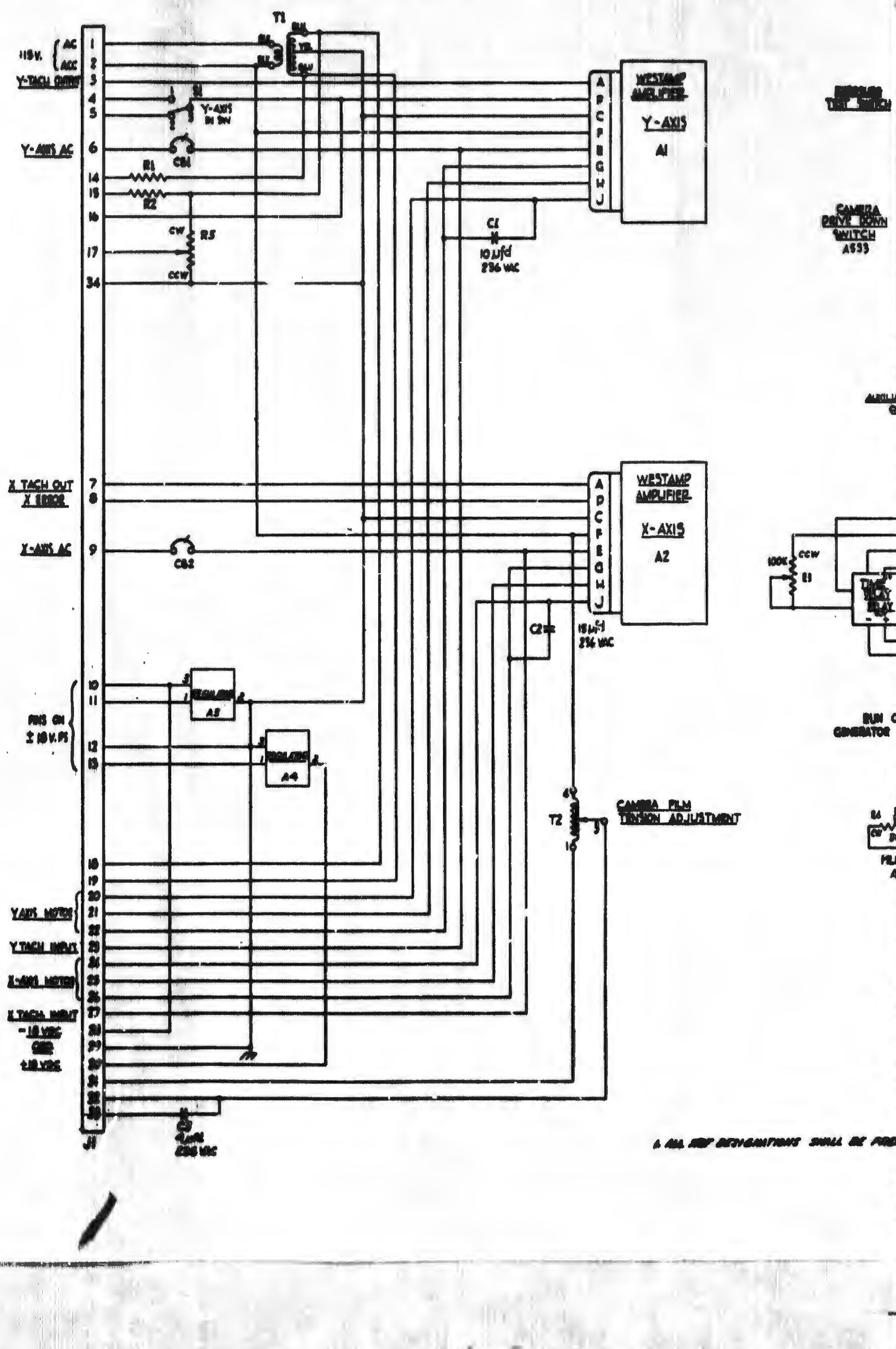
LOGIC DIAGRAM -
UNIT RECORD PRINTER
EN77

4093507

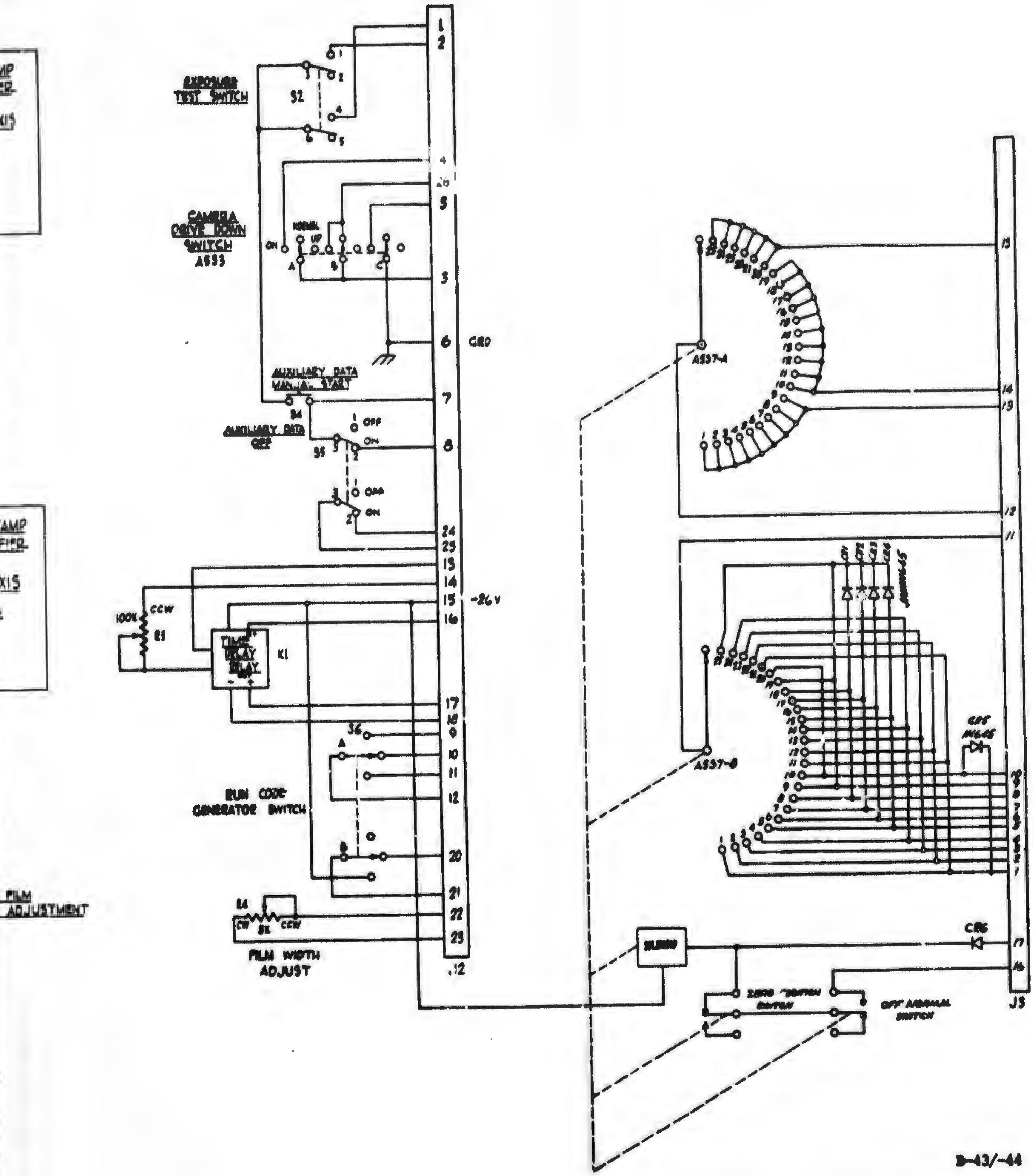
A 4093507

B-41/-42

2



115V.
AC
ACC
Y-TACH OUTPUT
Y-AXIS AC
T1
R1
R2
R5
CW
CCW
Y-AXIS
CB1
C1
10 µfd
236 VAC
WESTAMP
AMPLIFIER
Y-AXIS
A1
CAMERA
DRIVE DOWN
SWITCH
X TACH OUT
X ERROR
X-AXIS AC
CB2
WESTAMP
AMPLIFIER
X-AXIS
A2
C2
15 µfd
236 VAC
A3
A4
± 18 V. PS
CAMERA FILM
TENSION ADJUSTMENT
T2
Y AXIS MOTOR
Y TACH INPUT
X-AXIS MOTOR
X TACH INPUT
-18 VDC
GND
+18 VDC
J1
236 VAC
100K
CCW

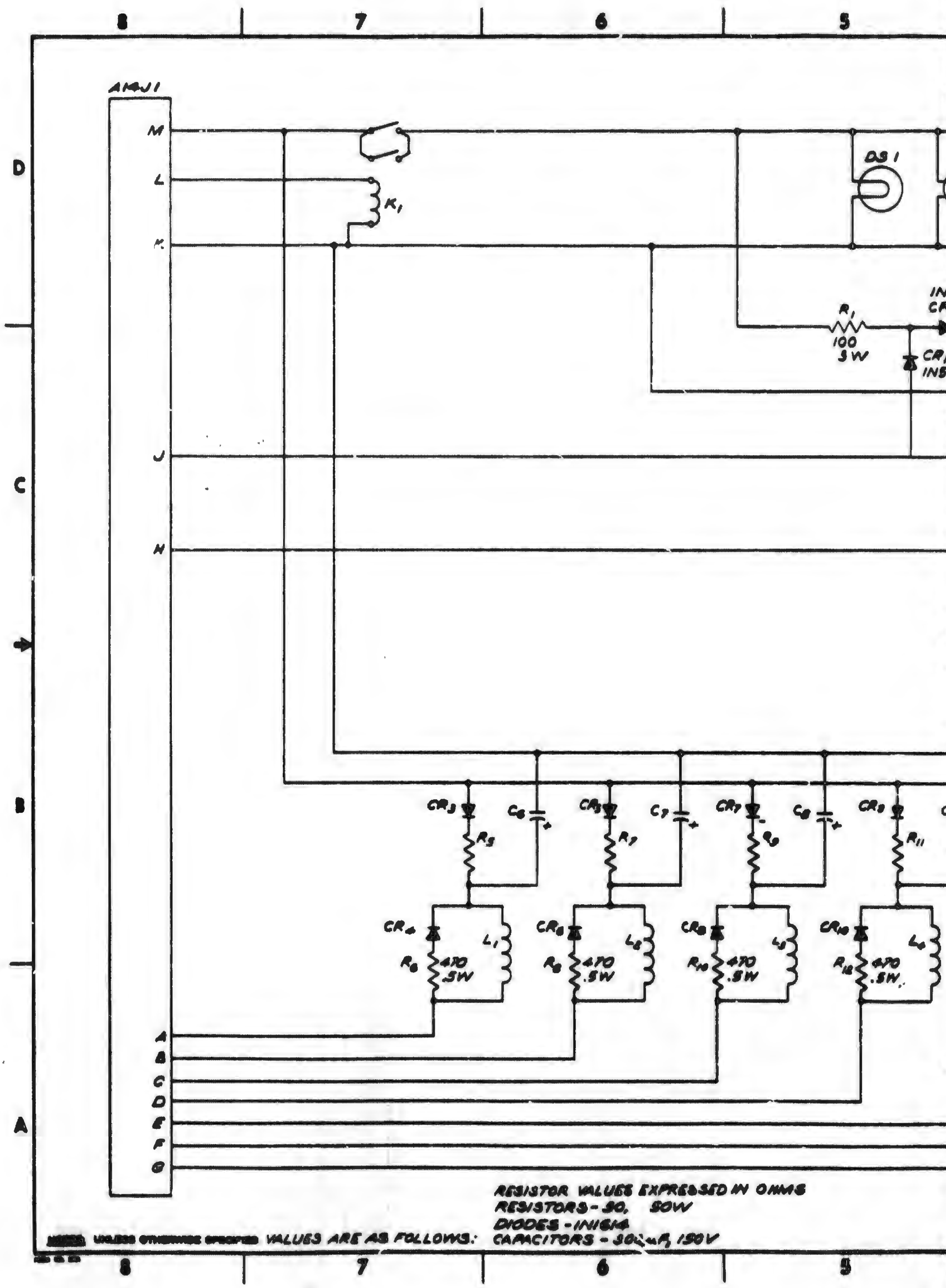


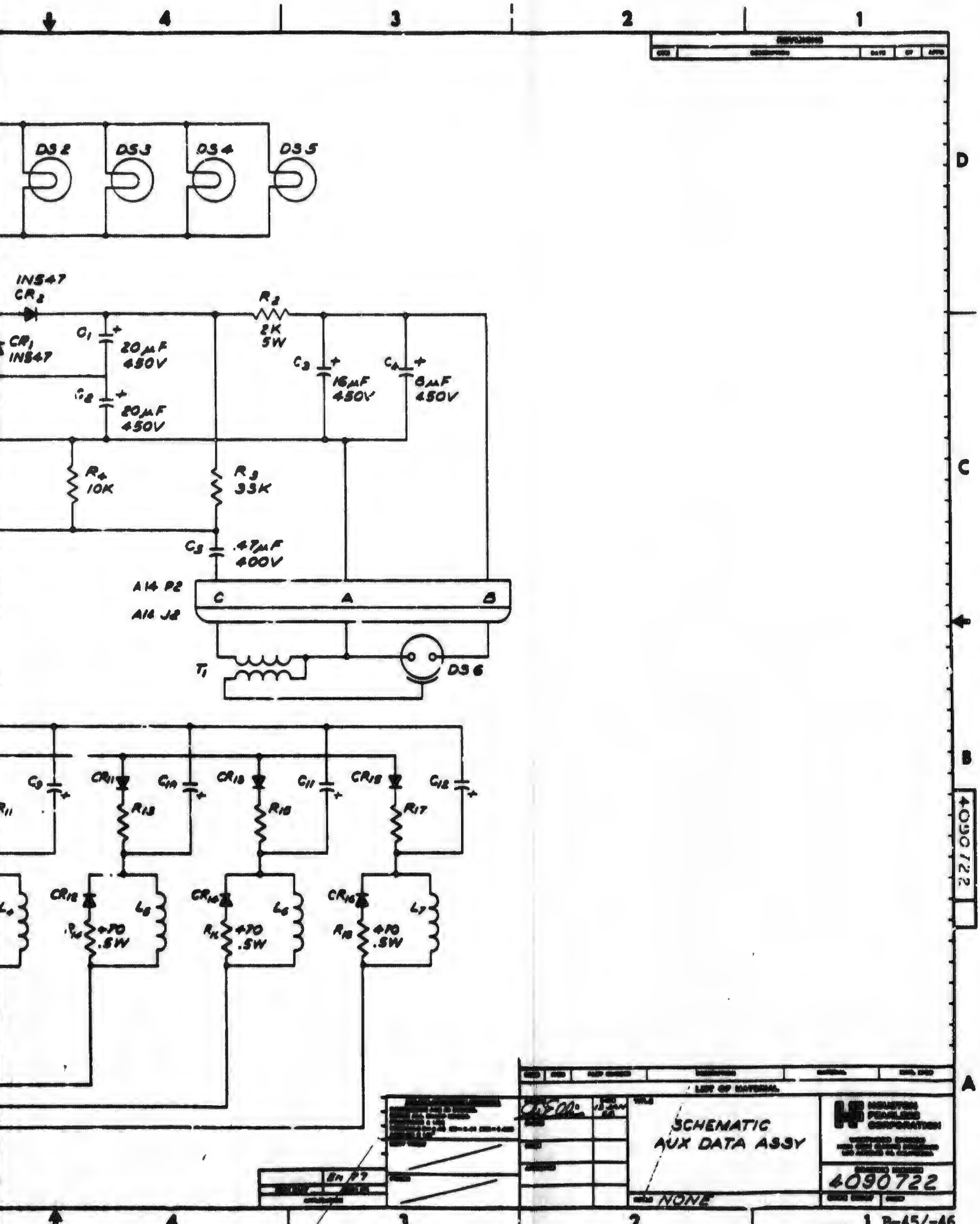
D-43/-44

ALL REF DESIGNATIONS SHALL BE PROVIDED BY AC

SCHEMATIC DIAGRAM - SYSTEM ELECTRONICS A5

2


A14J1
M
L
K
J
H
A
B
C
D
E
F
G
K1
DS1
R1
100
5W
CR3
CR5
CR7
CR9
C6
C7
C8
R5
R7
R9
R11
CR4
CR6
CR8
CR10
R6
R8
R10
R12
470
.5W
L1
L2
L3
L4
NOTES: UNLESS OTHERWISE SPECIFIED VALUES ARE AS FOLLOWS:
RESISTOR VALUES EXPRESSED IN OHMS
RESISTORS - 30, 30W
DIODES - 1N1614
CAPACITORS - 30 µF, 150V



DS2
DS3
DS4
DS5
IN547
CR2
CR1
IN547
C1
20μF
450V
C2
20μF
450V
R2
2K
5W
C3
16μF
450V
C4
8μF
450V
R4
10K
R3
33K
C5
.47μF
400V
A14 P2
A14 J2
C
A
B
T1
DS6
C9
C10
C11
C12
CR11
CR13
CR15
R13
R15
R17
CR12
CR14
CR16
470
.5W
L5
L6
L7
SCHEMATIC
AUX DATA ASSY
HOUSTON FEARLESS CORPORATION
4090722
NONE

1 B-45/-46

2

Unclassified

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13. ABSTRACT

The EN-77 Unit Record Printer was originally developed with capability for contact printing from input negatives and limited capability for mensuration on the input negatives and for recording auxiliary data. The output film consisted of exposed lengths of unperforated 70mm print film to be developed and cut into Tactical Target Record (TTR) chips.

The task covered by this report was to redesign and rework the unit record printer to give it substantially increased capability in the areas of mensuration and auxiliary data recording and to make it more reliable and more convenient in operation.

Section 1 of the report describes the final configuration of the reworked printer, illustrates all the major components and controls, and describes its capabilities. Section 2 presents the theory of operation of the printer as a whole and of each major functional subsystem and describes the automatically controlled sequence of operation in the printing cycle with each function referenced to the detailed logic diagram bound in Appendix B of the report. Section 3 discusses the changes that are required by contract to bring the printer to its new configuration and describes the methods proposed to achieve the performance goals. Section 4 describes the progress of the development, the problems that were uncovered, and the solutions that were incorporated in the final configuration. (Over)

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Photographic Intelligence Photographic Printers Photographic Recording Media						

Abstract

No. 13 (Cont'd)

Appendix A is a research report on initial studies of approaches to the problem of recording the machine and human-readable codes on the output film. Appendix B contains all the schematic diagrams of the printer.

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