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ORACLE PHOTOGRAPHIC CURVE PLOTTER AND DIGITAL-OUTPUT DEVICE

R. J. Klein
C. H. Schalbe

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
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ORACLE PHOTOGRAPHIC CURVE PLOTTER AND DIGITAL-OUTPUT DEVICE

R. J. Klein C. H. Schalbe

INTRODUCTION

The curve plotter serves as both an output device and as a monitor. As an output device, it can be used to obtain permanent records, in the form of photographs, of curves, data, or stored information all tabulated, labeled, and identified in accordance with the user's desires.

Photographs are taken automatically at a rate determined by the amount of information displayed and by the film-advance mechanism. A maximum of 200 photographs can be made before the camera has to be reloaded.

The monitor or slave scope can be used as a rapid visual check on problem progress, parameter selection, and validity of computations.

The curve plotter produces, simultaneously, displays on both cathode-ray tubes by brightening up discrete spots, whose coordinates are determined by information stored in its X and Y coordinate registers. This is true of both the curve tracing and the digital plotting facilities. The latter facility enables the trace to be stepped automatically over predetermined rectangles; the bright-ups occur within these rectangles in accordance with selected code words.

There are 1024 possible bright-up points in both the X and Y directions. However, the cathode-ray-tube resolution is such that only approximately 200 spots in any one row or column are discernible.

Trace width and intensity can be controlled to a limited extent by proper selection of spot spacing and by multiple plotting of individual spots.

GENERAL DESCRIPTION

The curve plotter, shown in Figs. 1–4, is housed entirely in one unit, except for some of the power supplies. The only independent supplies are those which provide voltages available from the Oracle; these are obtained from cabinets 2N and 3N.

The unit can be divided into the following general divisions: control system, register and deflection system, display system, and power supply system. The control system is composed of both electronic and mechanical devices. It integrates the curve plotter with the Oracle proper and enables selection of desired curve-plotter functions. In general, the control circuitry controls the deflection system, the cathode-ray-tube unblanking circuitry, and the camera control system and acts as an interlock between the Oracle and the curve plotter.

The X and Y coordinate registers consist of ten toggles each. Certain of these stages have a circuit added which provides them with a counting facility. All are tied to an analog-to-digital converter circuit, which is in the form of a current adder. The current from each toggle is weighted according to its significance, and the current adder circuits

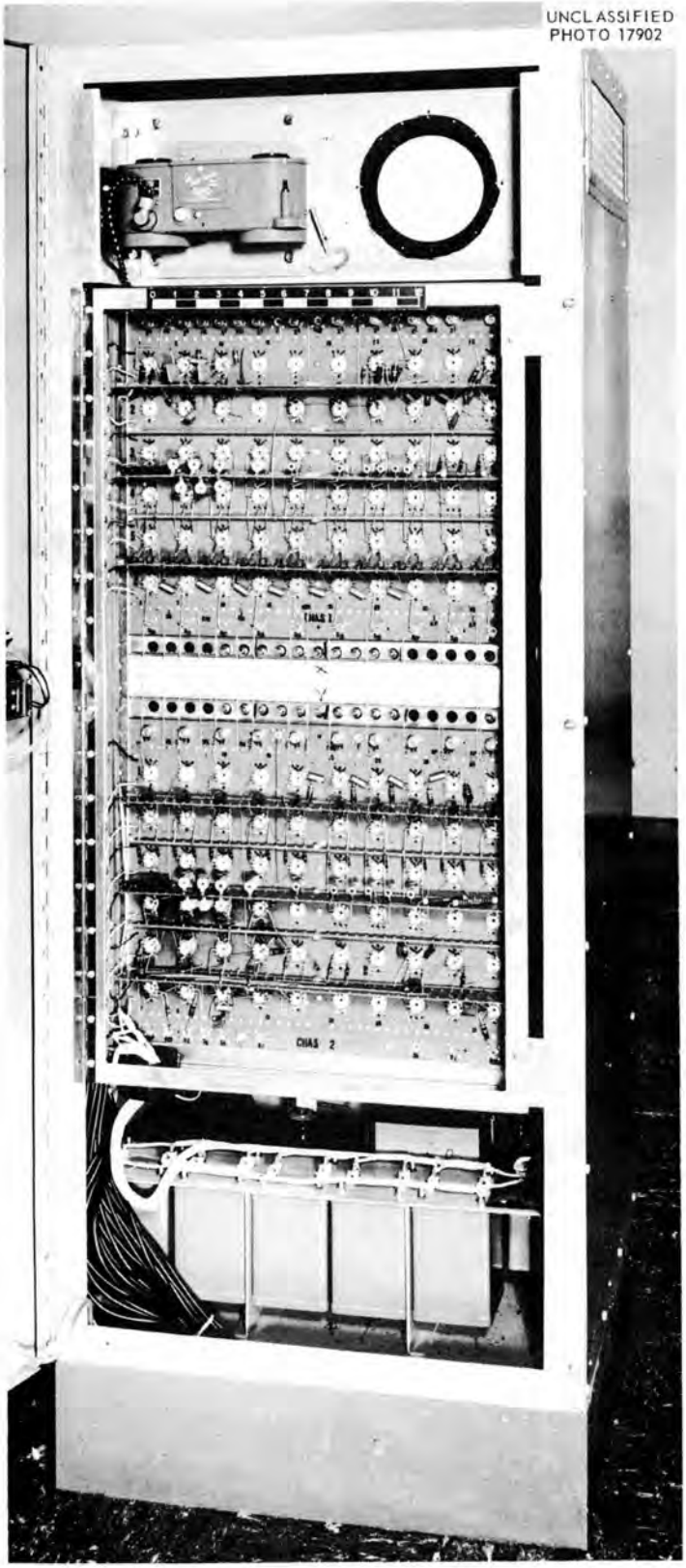

Fig. 1. Front View of Curve Plotter with Door Open.

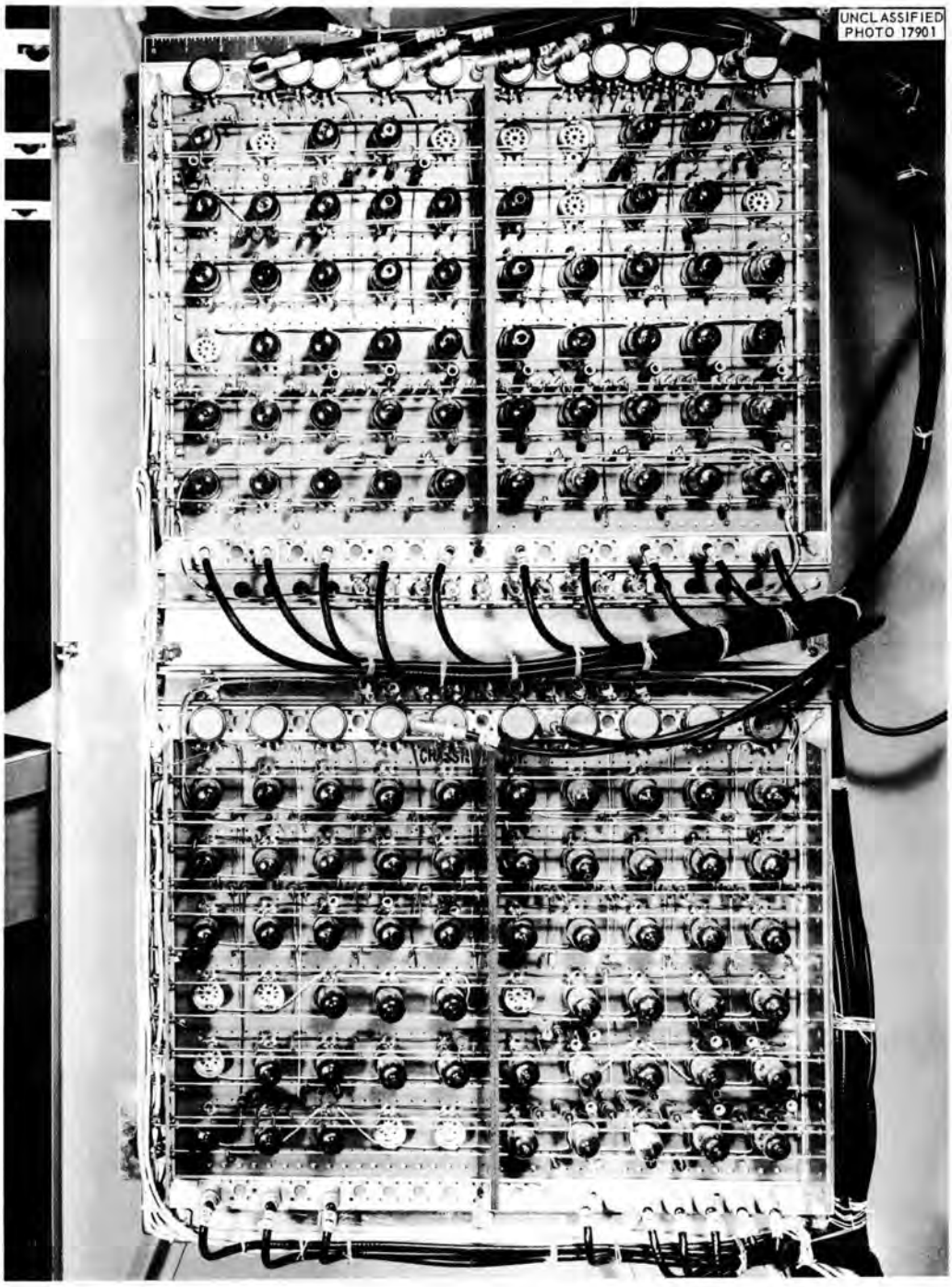

Fig. 2. Tube Side of Deflection Circuitry Chassis.

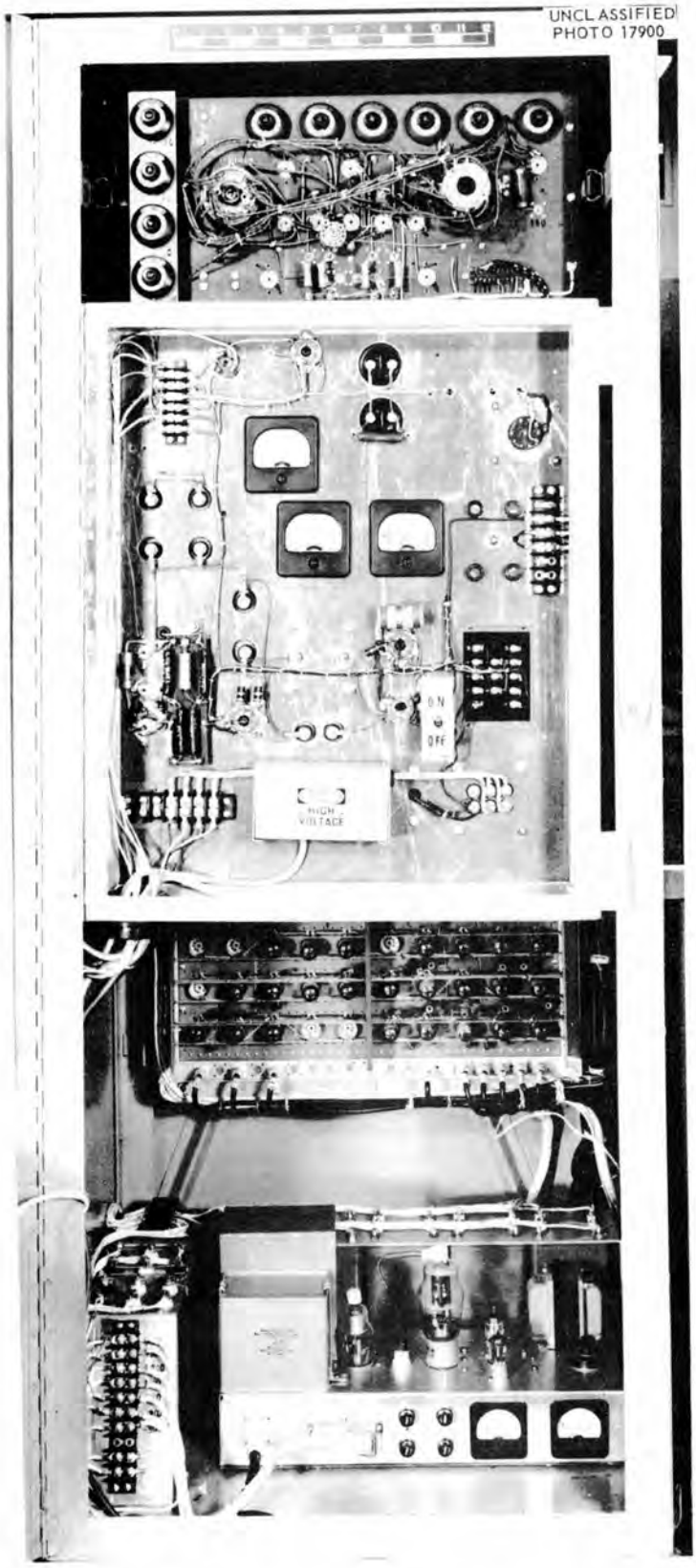

Fig. 3. Rear View of Curve Plotter with Door Open.

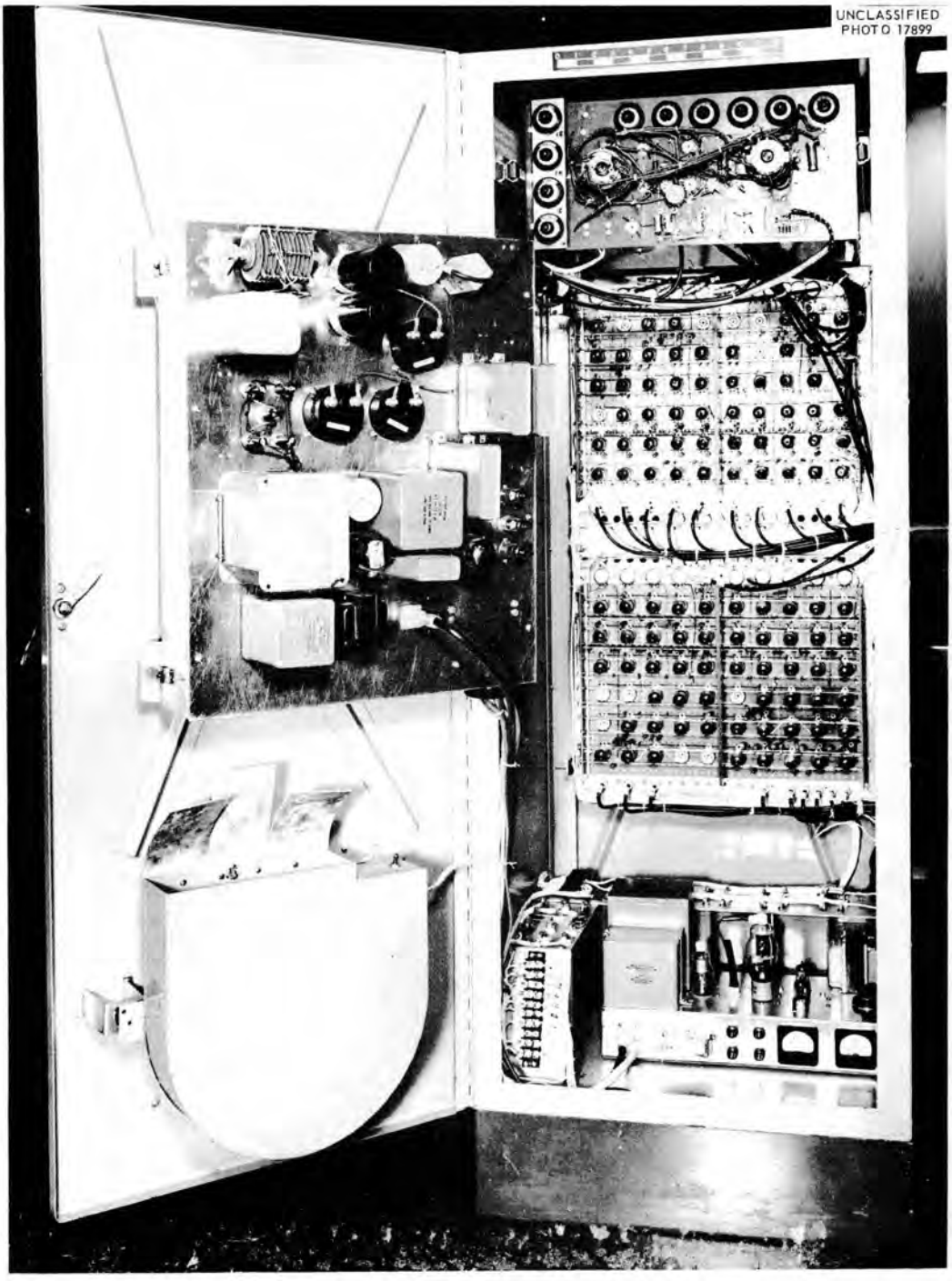

Fig. 4. Rear View of Curve Plotter, Showing Blower Mounting on Rear Door.

provide the cathode-ray-tube deflection voltages which position the electron beam so as to produce a bright spot on the tube face at the desired point.

The camera, a Shackman MK III Auto-camera, is mounted in front of a 3-in. cathode-ray tube. Its shutter is fixed in the open position and set at F 2.8. Film exposure is therefore determined by the length of time that the cathode-ray-tube electron beam is turned on. Kodak 35-mm Linograph Ortho film is used and must be loaded into special magazines or cassettes.

The film is advanced at the user's discretion by electromagnetic control of a spring-driven mechanism. Two hundred exposures are possible before reloading is necessary, but the spring must be rewound after each 100 exposures. An interlock circuit holds up the machine when the film magazine is empty or when the spring becomes unwound.

LOGICAL DESCRIPTION

Except for the film-advance order, each order associated with the curve plotter gates its own address into the appropriate coordinate register. The curve-plotter start signal initiates a group of pulses which control and sequence its operation. In the point-plotting function this consists of clearing the Y register and gating into it (C1 order), clearing the X register, gating into it, and, after a 5-μsec delay, turning the beam on (C2 order). Character-plotting operations (C3 orders) utilize the same procedures except that there is no beam bright-up following the X register gating. Instead, the control is prepared to step the beam over a small rectangle, and bright-up occurs in accordance with a code word previously inserted in the Oracle Q register.

After all curve-plotter orders, control is immediately returned to the Oracle, which continues to operate according to its program. Inherent delays in the system make it unnecessary to hold up successive curve-plotter orders to complete previous orders except in the case of a film advance (C8). When the latter is ordered, a new curve-plotter order cannot be initiated, and the computer waits until the film has stopped moving. The film advance requires approximately 250 msec.

In the character-plotting function the beam is forced by the control circuitry to sweep in 39 steps through a 5 $\times$ 8 rectangle for each character. The character plot order (C3) sets the X coordinate of the left side of each character, and the Oracle dynamic programmer then steps the beam. As the beam is stepped, the code word previously inserted in the Q register is shifted 39 times by a multiply order (38). After each shift the beam is turned on if the digit that went from Q_{38} to Q_{39} was a 1. The last shift of the multiply order resets the operation of the C3 order.

All the X coordinate toggles except X^0 and X^1 have both counting and information storage facilities; only Y^2, Y^3, and Y^4 have both. The other toggles are used only for information storage. Thus, in the point-plotting function all toggles are used and it is possible to brighten up any of the possible spot locations.

CHARACTER- AND POINT-PLOTTING PROCEDURE

In the character-plotting mode of operation, dot-move pulses are coupled to the counting toggles of the Y register (Y^2, Y^3, Y^4), and carry-out from Y^4 is coupled to the counting toggles of the X register (X^2–X^9). This arrangement causes both registers to step by four divisions at a time. A series of seven dot-move pulses therefore moves the beam vertically up over 28 possible spot locations; the eighth dot-move pulse returns the beam to its original Y coordinate but shifts it one step or four spot locations in the X direction. A series of 39 pulses then will cause the beam to sweep over a 5 × 8 rectangle (Fig. 5), leaving the beam at the original Y coordinate but shifted by 5 steps or 20 spot locations in the X direction.

An example of the above mode of plotting is given for K. The code word for K is

0100 0010 0010 0100 0001 1000 0111 1110 0000 0000 or 42241 87E00 .

To plot the letter K at location (152, 280) the following procedure would be followed.

A CI 280 would be executed directing the beam to line Y = 280. The code word for the letter K is placed in the Q register and then a C3 152 is executed. This will set the X coordinate at 152 and prepare the control for the character-plotting function. Execution of a multiply order (38) will then:

1. shift code word in Q 39 places to right,
2. shift beam each time Q is shifted,
3. turn beam on after each shift if digit that went from Q_{38} to Q_{39} was a 1.

A diagram of the plotting area on the cathode-ray-tube face is given in Fig. 6. To plot the point (X, Y) = (2C0, 340) a CI 340 is executed first. This moves the beam to the line Y = 340. Next, a C2 2C0 is executed. The beam moves along line Y = 340 until X = 2C0, where beam bright-up occurs. The plotting of one point in this manner requires approximately two add times. If a C2 12B were executed next, the point (12B, 340) would have been plotted, since the Y register would not have been changed.

Typical output photographs of digital data and curves are shown in Figs. 7 and 8.

CIRCUIT DESCRIPTION

In the following discussion only deviations from standard d-c coupled computer circuits will be described; however, a complete set of circuit diagrams is included.

Control Circuitry

The control is composed of the logical blocks in the top half of Fig. 9. The circuits for these blocks are shown in Figs. 10 and 11. The gating and driving circuits are conventional and follow the logic with the possible exception of the camera interlock relay. This relay is actuated by contacts within the camera which close when the film-advance solenoid is actuated and which reopen when the new frame of film has moved into place. A further delay is provided to ensure that the film is at complete rest before plotting is

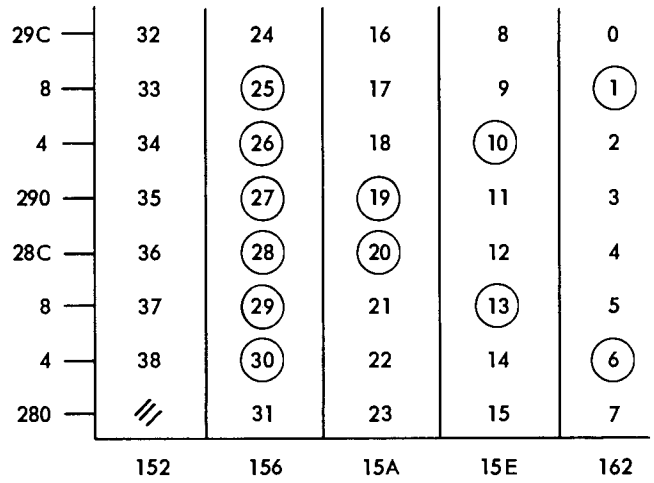

Fig. 5. Dot Pattern of a 5 × 8 Rectangle Demonstrating Character-Plotting Function.

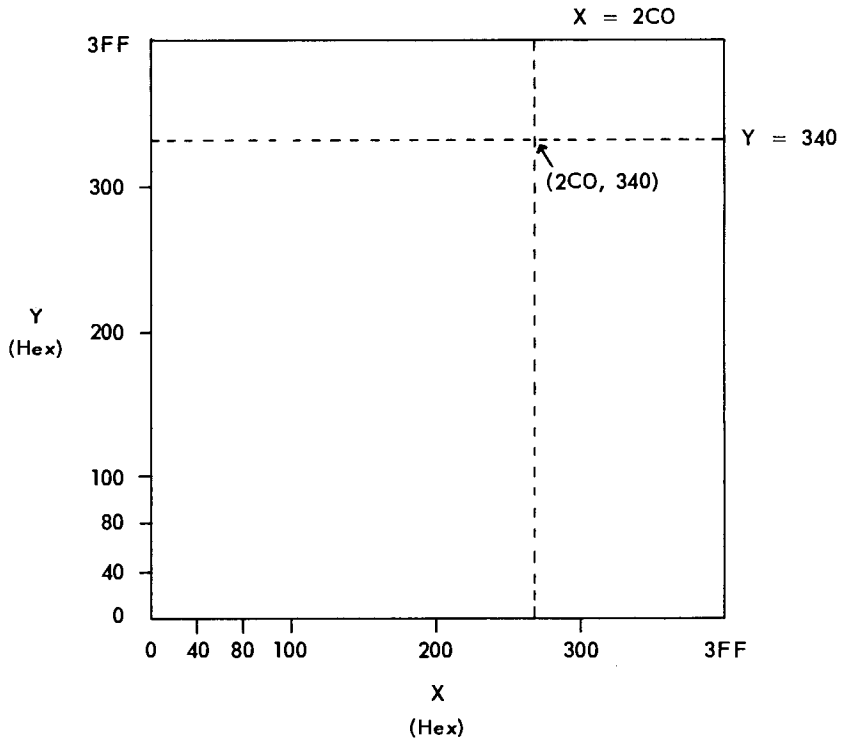

Fig. 6. Diagrom of Plotting Area on Cathode-Ray-Tube Face.

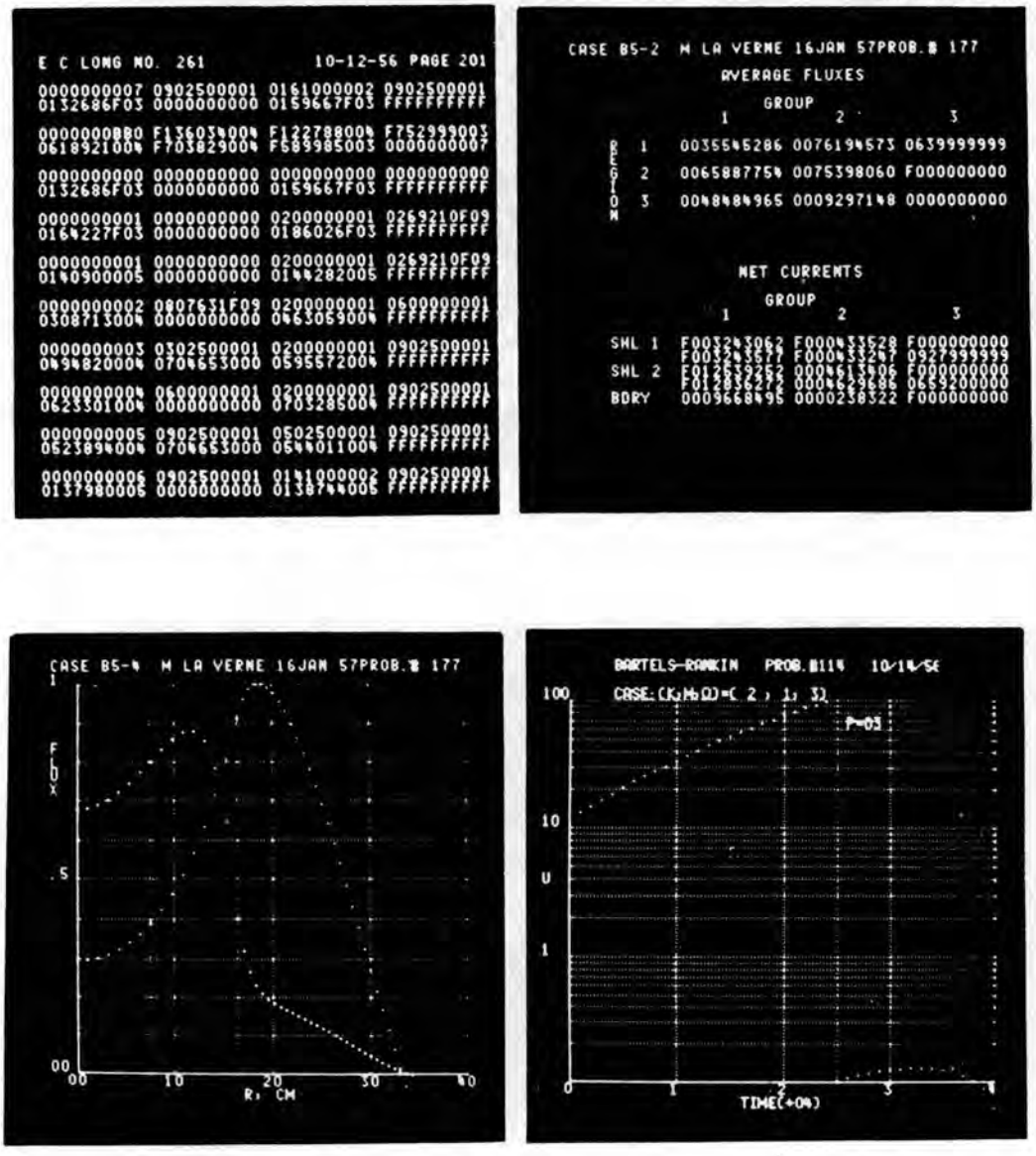

Fig. 7. Output Photographs of Digital Data and Curves.

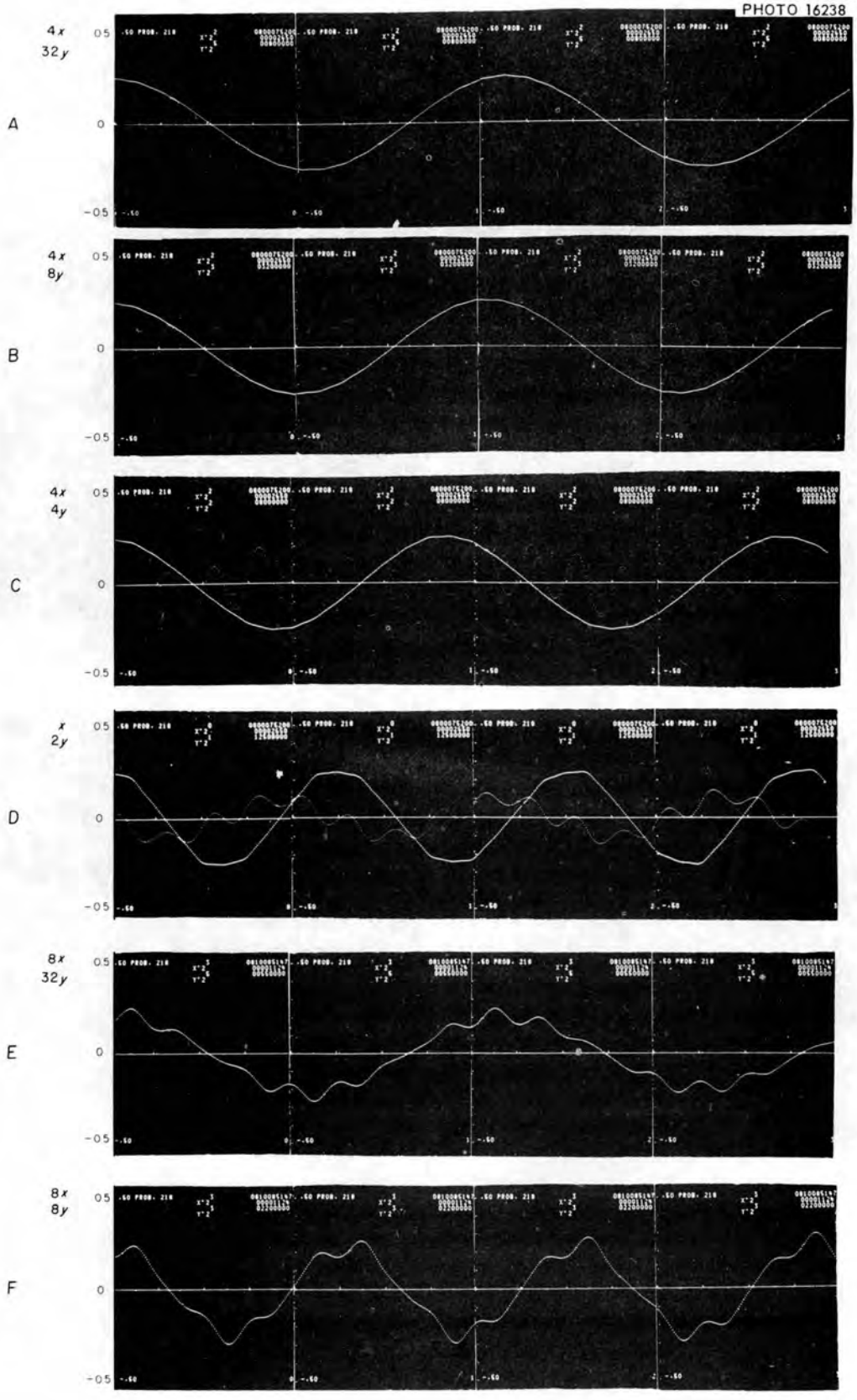

Fig. 8. Composite Photograph Made from 24 Output Photographs.

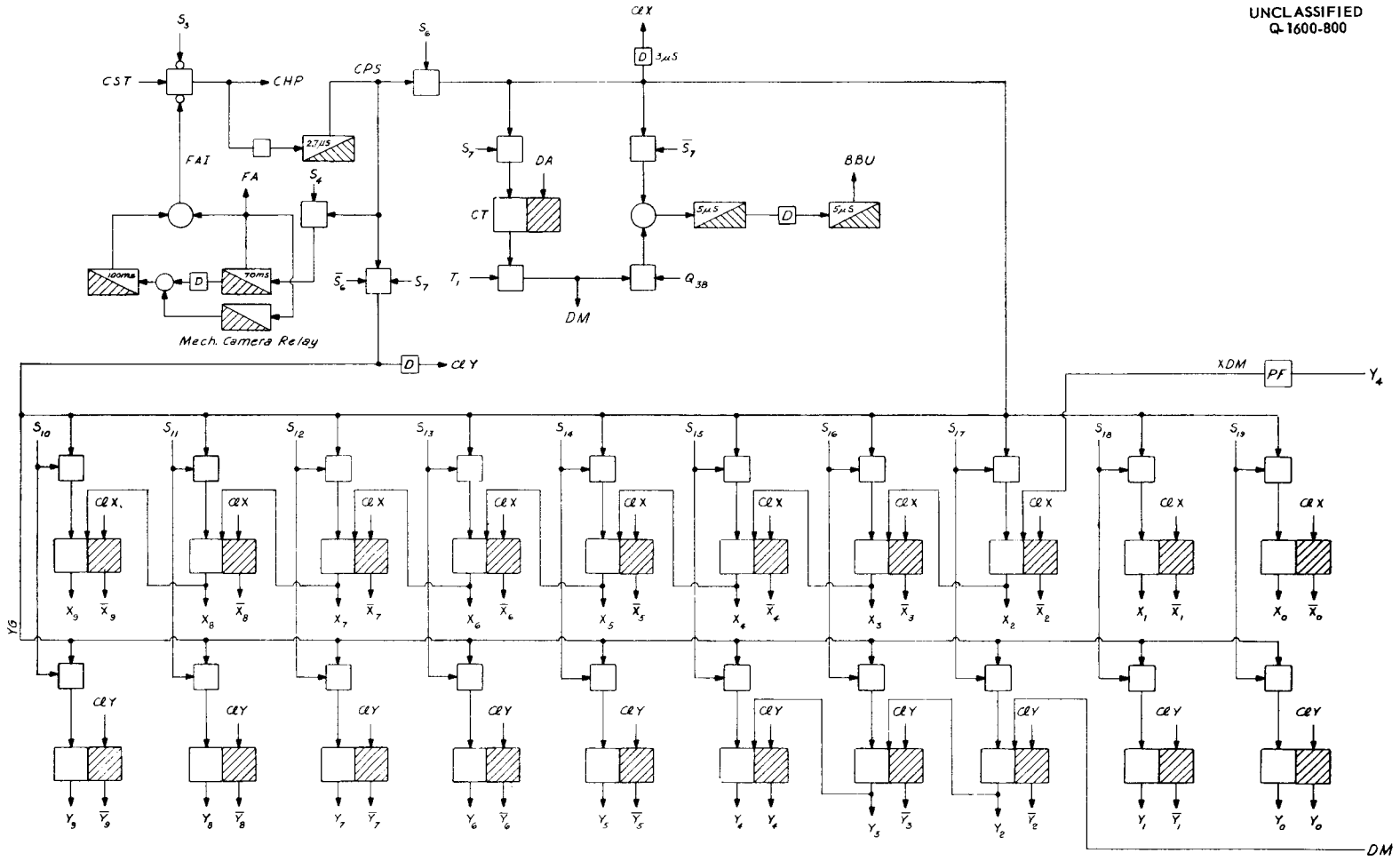

Fig. 9. Logical Diagram of Curve Plotter.

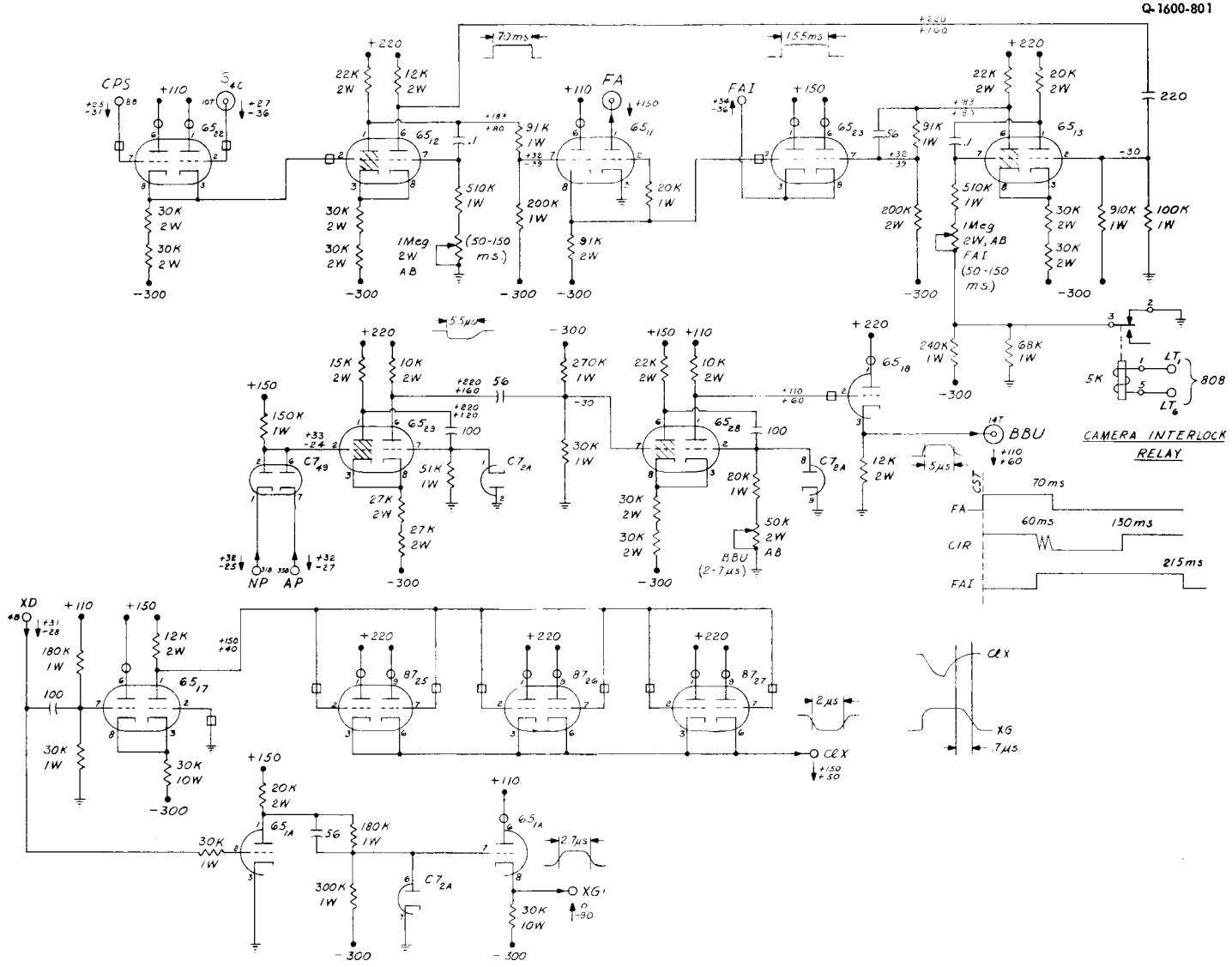

Fig. 10. Circuit Diagram of Curve Plotter – Chassis I.

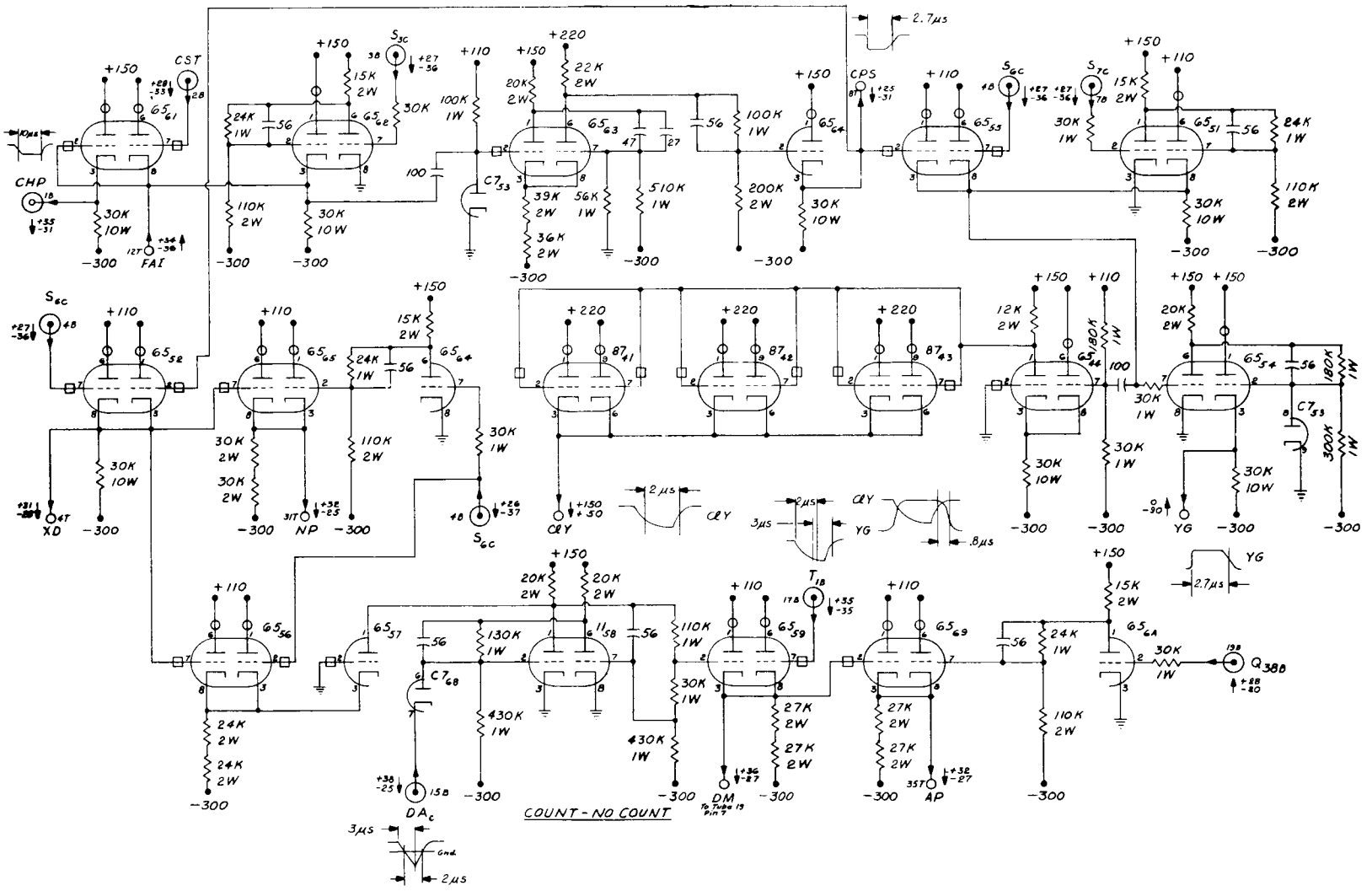

Fig. 11. Circuit Diagram of Curve Plotter – Chassis II.

begun on the new frame. If for some reason the new frame does not advance to its proper place, the internal contacts do not reopen and a warning light and buzzer are actuated. Timing diagrams of the control pulses for each of the orders concerning the curve plotter are shown in Figs. 12–16.

The functions of the tubes are given below:

Tube No.	Function
	Chassis I (Fig. 10)
22, 12, 11, 23, 13	Film-advance and interlock circuit
49, 29, 28, 18	Beam bright-up delay and driver for cathode-ray tubes
17, 25, 26, 27	Clear-pulse former and driver for X register
1A	X gate pulse former and driver
	Chassis II (Fig. 11)
61, 62, 63, 64	Starting gates and drivers and partial order decoding
55, 51	Partial order decoding for C1 orders
54	Y gate pulse former and driver
44, 43, 42, 41	Clear-pulse former and driver
52, 65, 64, 56	Partial order decoding for C2 and C3 orders
57, 58, 59, 69, 6A	Sequence control for plotting with C3 orders

Registers and Digital-to-Analog Converter Circuits

Both the X and Y coordinate registers are composed of d-c coupled toggles of standard design, with the possible exception of the coupling between the Y_2, Y_3, Y_4, and X_2–X_9 stages. This coupling allows the toggles to be used not only as temporary storage registers for holding the coordinate information during plotting, but also to generate part of the address, when desired, by counting shifting pulses from the arithmetic unit. The type of coupling used between stages may seem overly complicated at first glance. To be of value, this counting circuit must fulfill two conditions: the interstage carry must be completed fast enough to allow address generation and beam bright-up on each shift (about 10 to 14 μsec), and the toggle grids must swing from some negative voltage greater than –20 v up to ground and remain clamped at the ground level during plotting for proper operation of the digital-to-analog converter.

The digital-to-analog converter is a current-summing device in which each of the coordinate toggles operates a switch whose current is weighted according to the toggle's significance. The output of these switches is then summed in a common register to produce a deflection voltage proportional to the value of the number in the coordinate register.

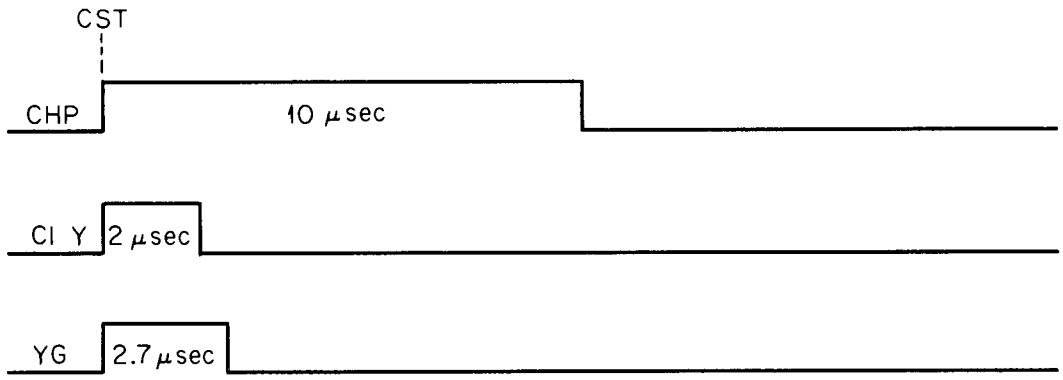

Fig. 12. Timing Diagram for C1 Order.

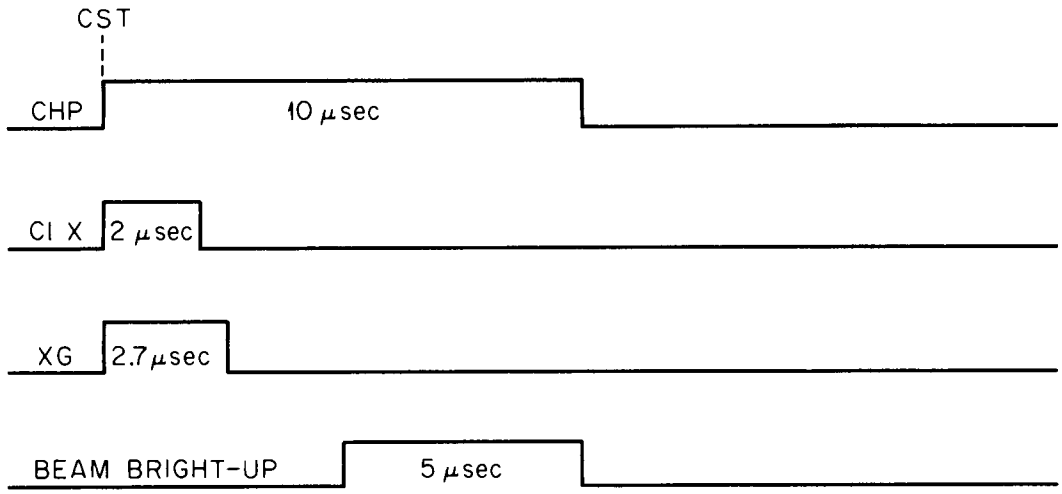

Fig. 13. Timing Diagram for C2 Order.

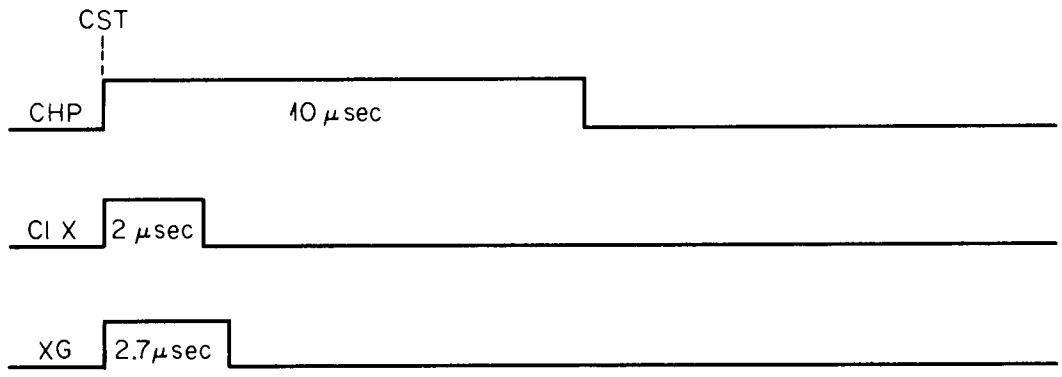

Fig. 14. Timing Diagram for C3 Order.

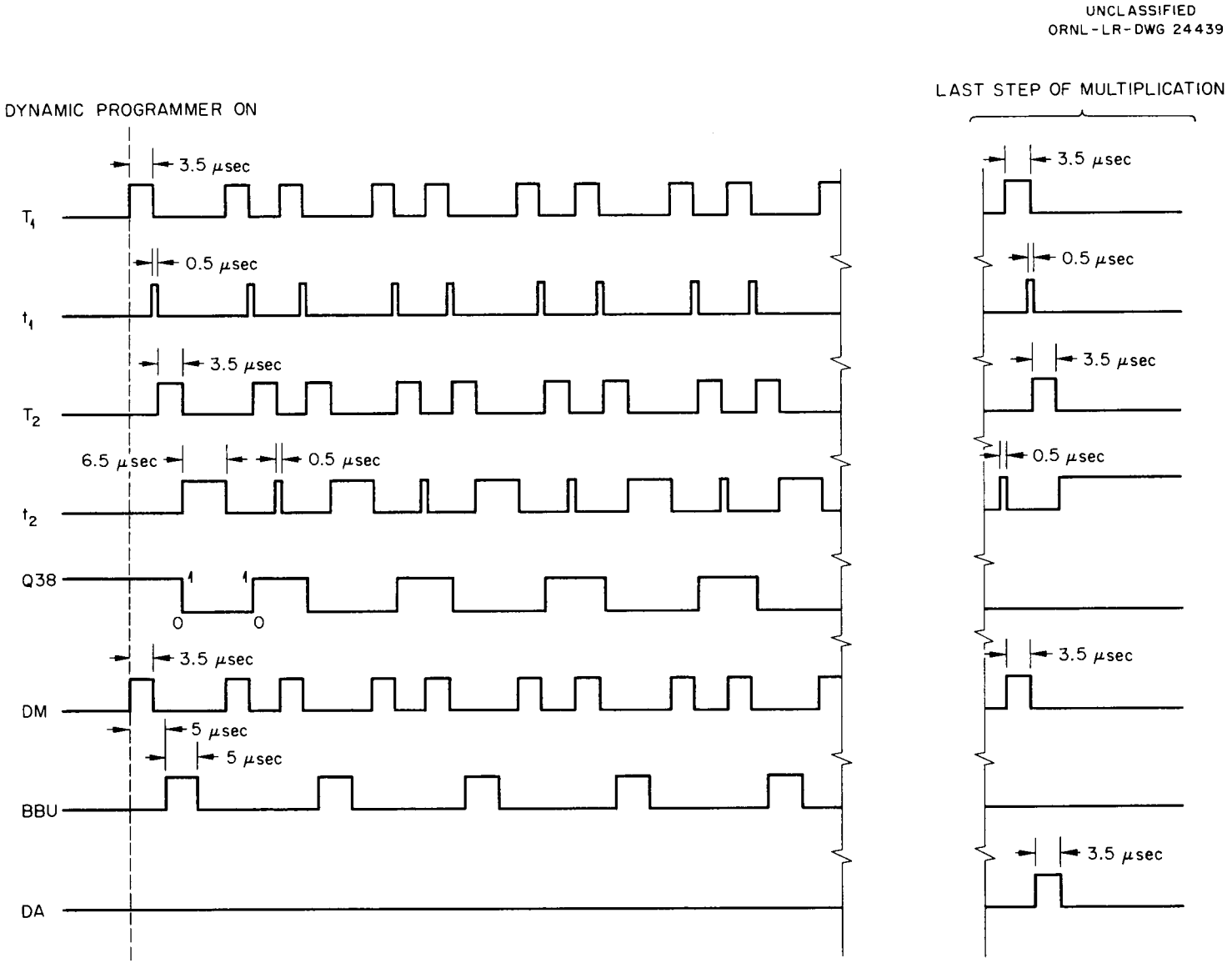

Fig. 15. Timing Diagram for 38[~] Order Following C3 Order for Q Code Word = 1010101010101010 ..... 10.

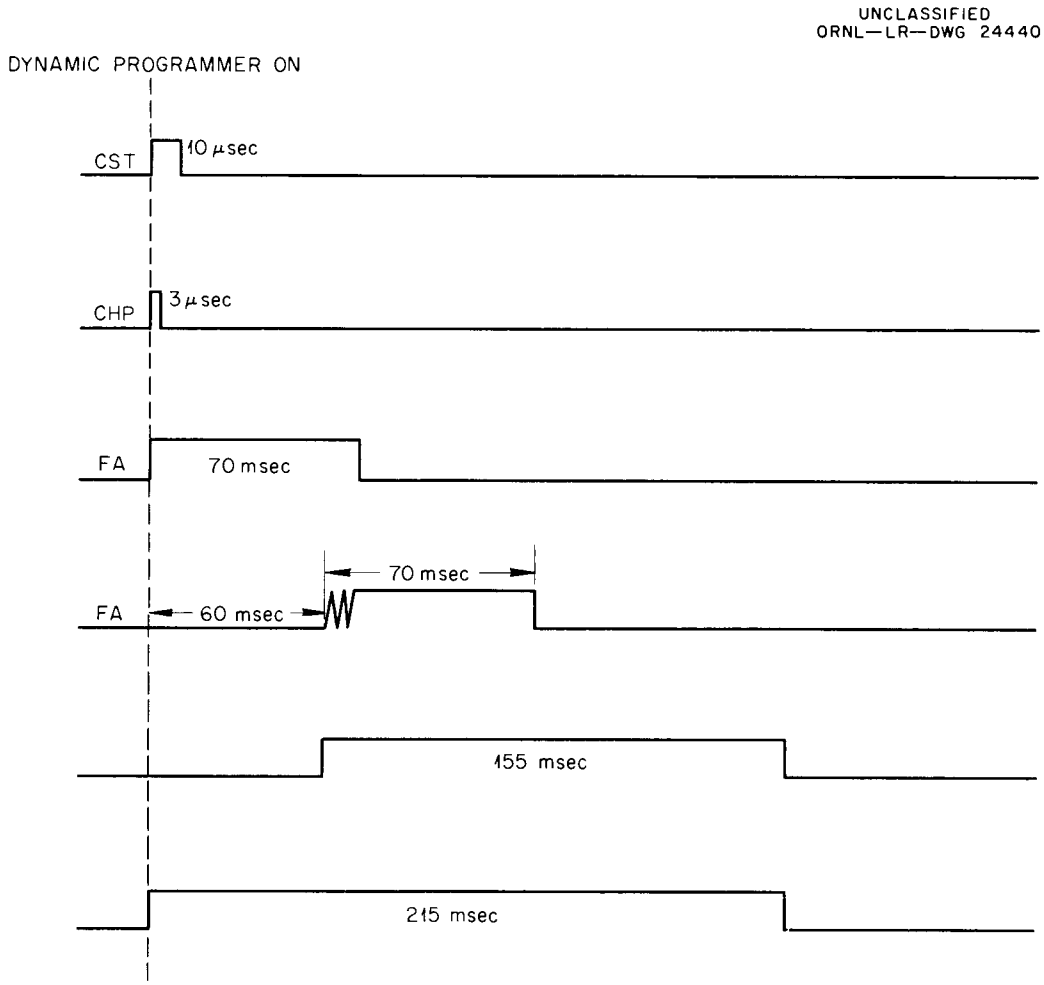

Fig. 16. Timing Diagram for C8[~] Film-Advance Order.

The tube functions are given below:

Tube No.	Function
	Chassis I (Figs. 17 and 18)
61 through 6A	Input gates to X register toggles and interstage drivers
51 through 5A	X register toggles
31 through 3A	Digital-to-analog converter, current-switching tubes for X address
41 through 48	X-register taggle clamps
	Chassis II (Figs. 19 and 20)
11 through 1A	Input gates to Y register toggles
21 through 2A	Y register toggles
31 through 3A	Digital-to-analog converter, current-switching tubes for Y address
46 through 48	Y-register toggle clamps
	Cathode-Ray-Tube Chassis (Fig. 21)
V_2	Digital-to-analog converter, current-summing tube for Y address
V_4	Digital-to-analog converter, current-summing tube for X address

Cathode-Ray-Tube Circuits

Both the plotting and monitor cathode-ray-tube circuits are of conventional design and require no explanation. A diode clamp is used on the beam bright-up pulse to ensure constant brightness, and cathode followers isolate the monitor tube capacity from the critical deflection voltages.

The tube functions are given below:

Tube No.	Function
	Cathode-Ray-Tube Chassis (Fig. 21)
V_3, V_5	Monitor tube deflection drives
V_1	Bright-up pulse clamp
6571	Plotting cathode-ray tube
6ABP7	Monitor cathode-ray tube

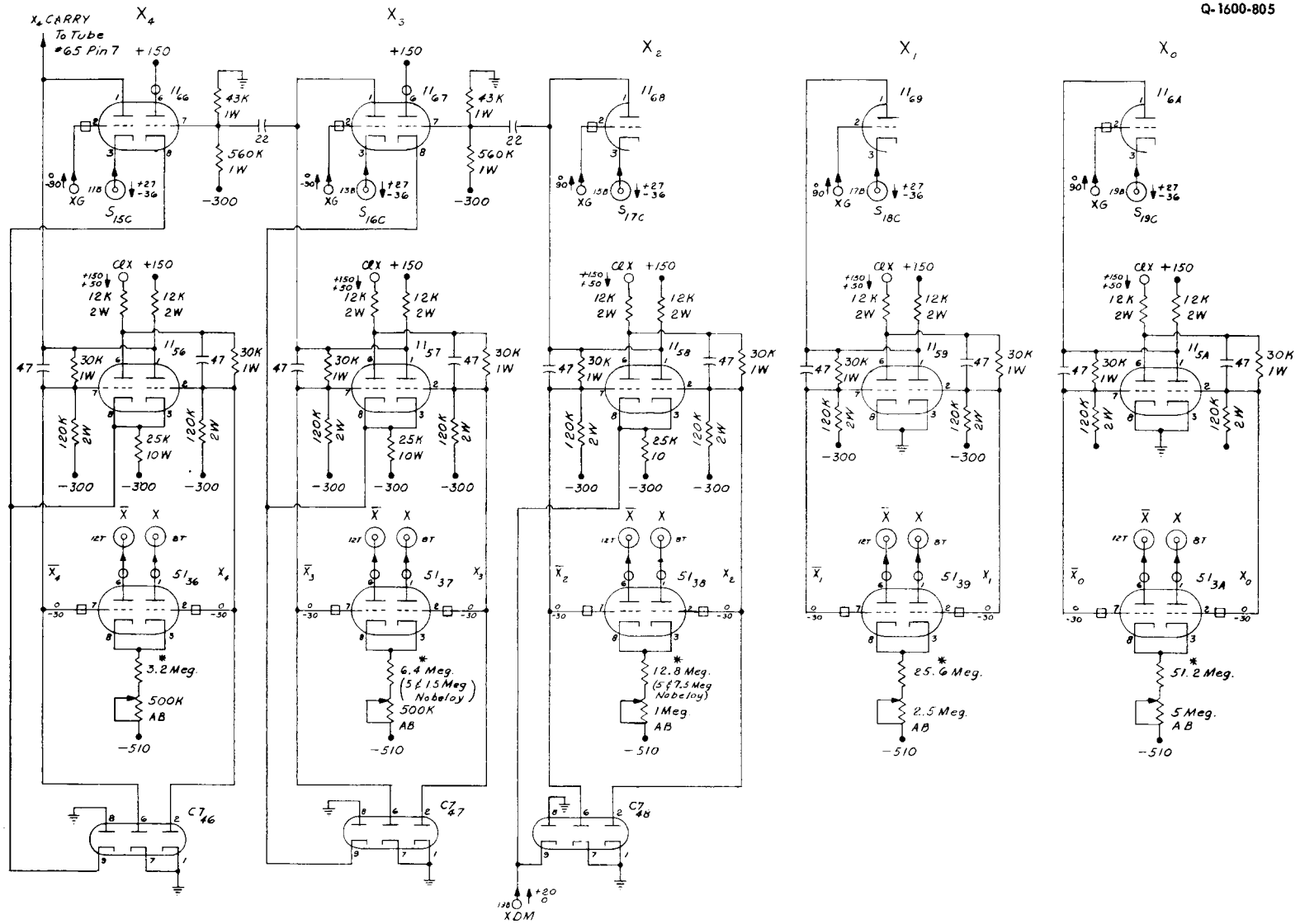

Fig. 17. Circuit Diagram for X Register, $X_0 - X_4$ Stages, Chassis I.

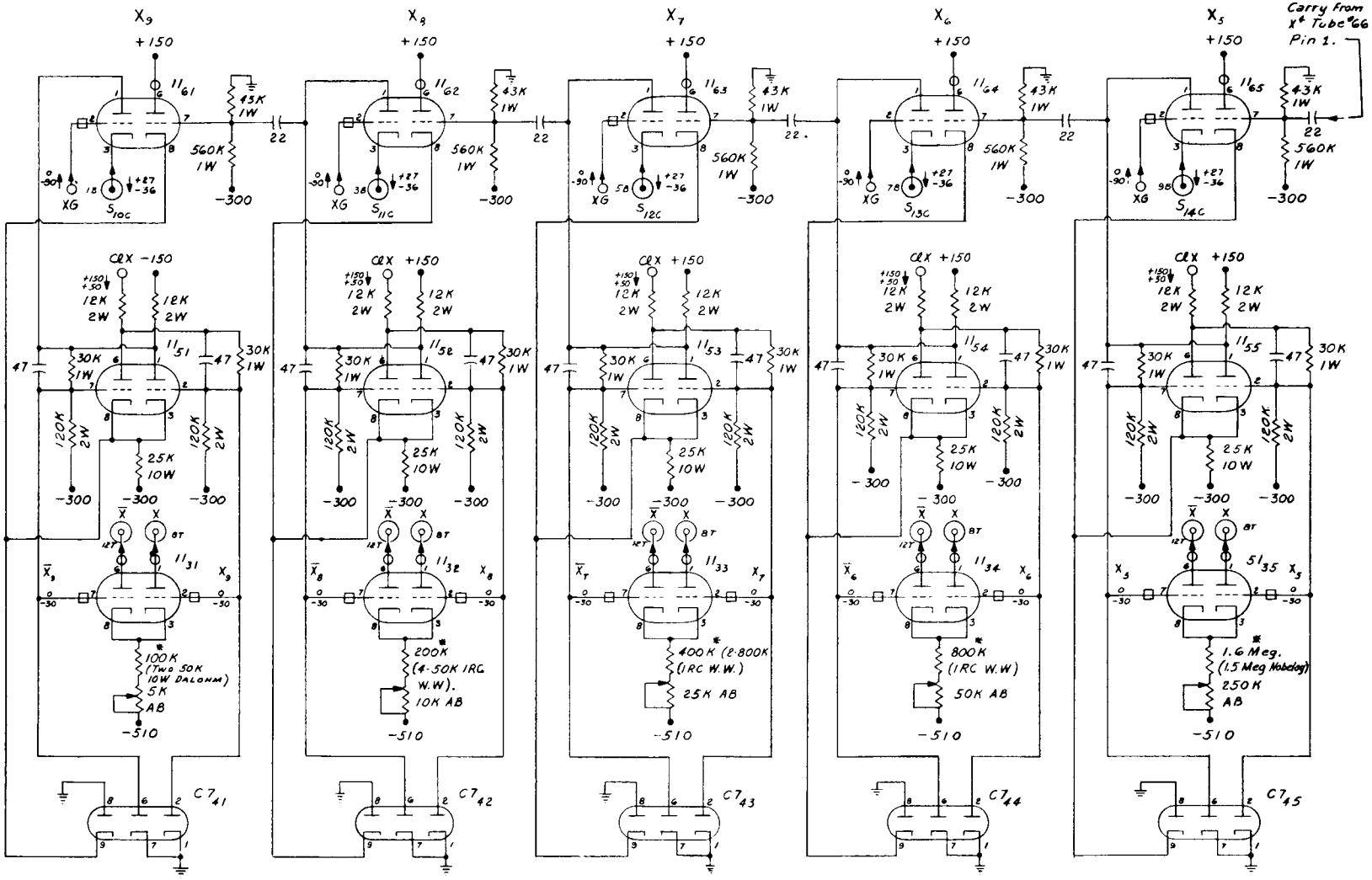

Fig. 18. Circuit Diagram for X Register, $X_5 - X_9$ Stages, Chassis I.

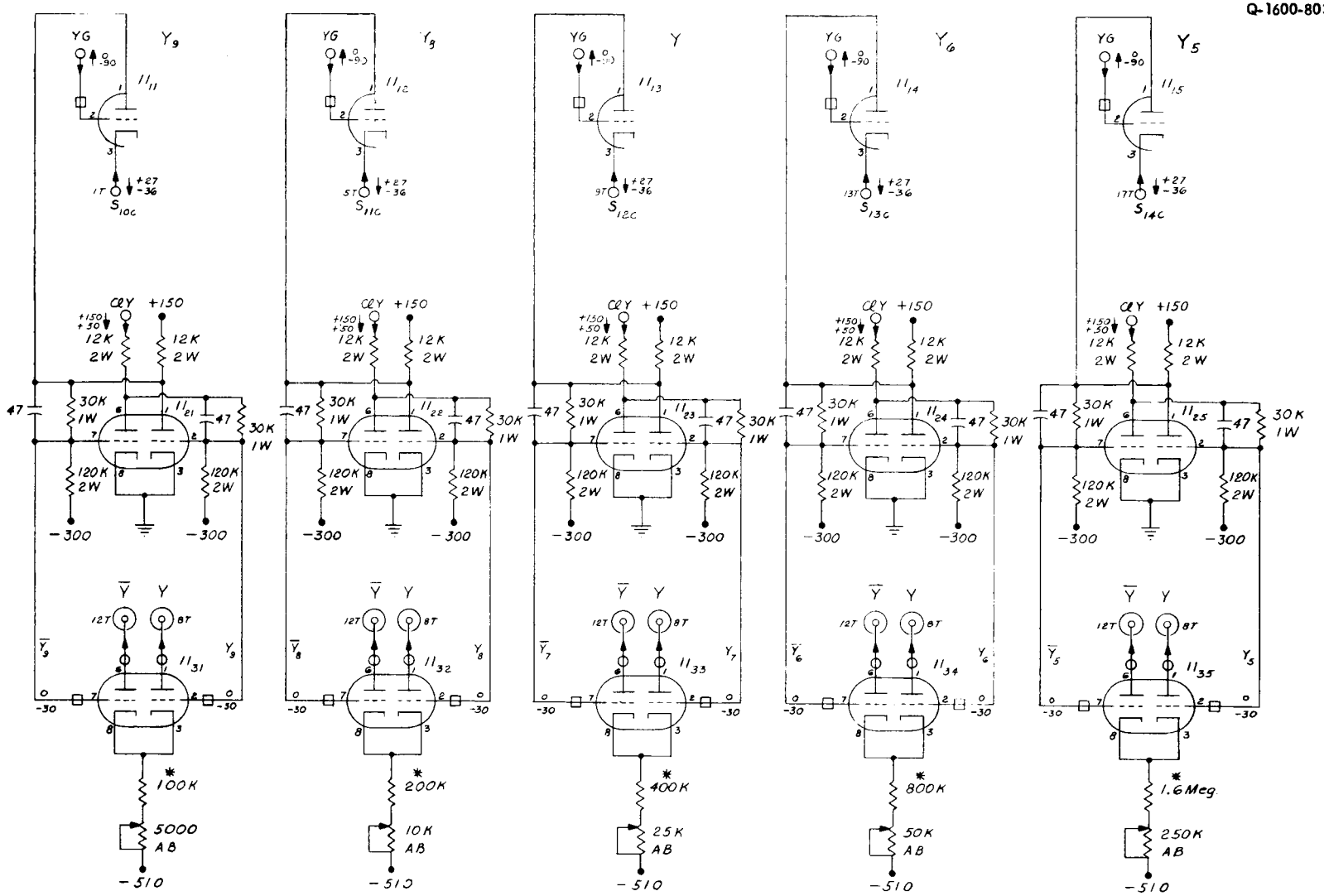

Fig. 19. Circuit Diagram for Y Register, Y_5–Y_9 Stages, Chassis II.

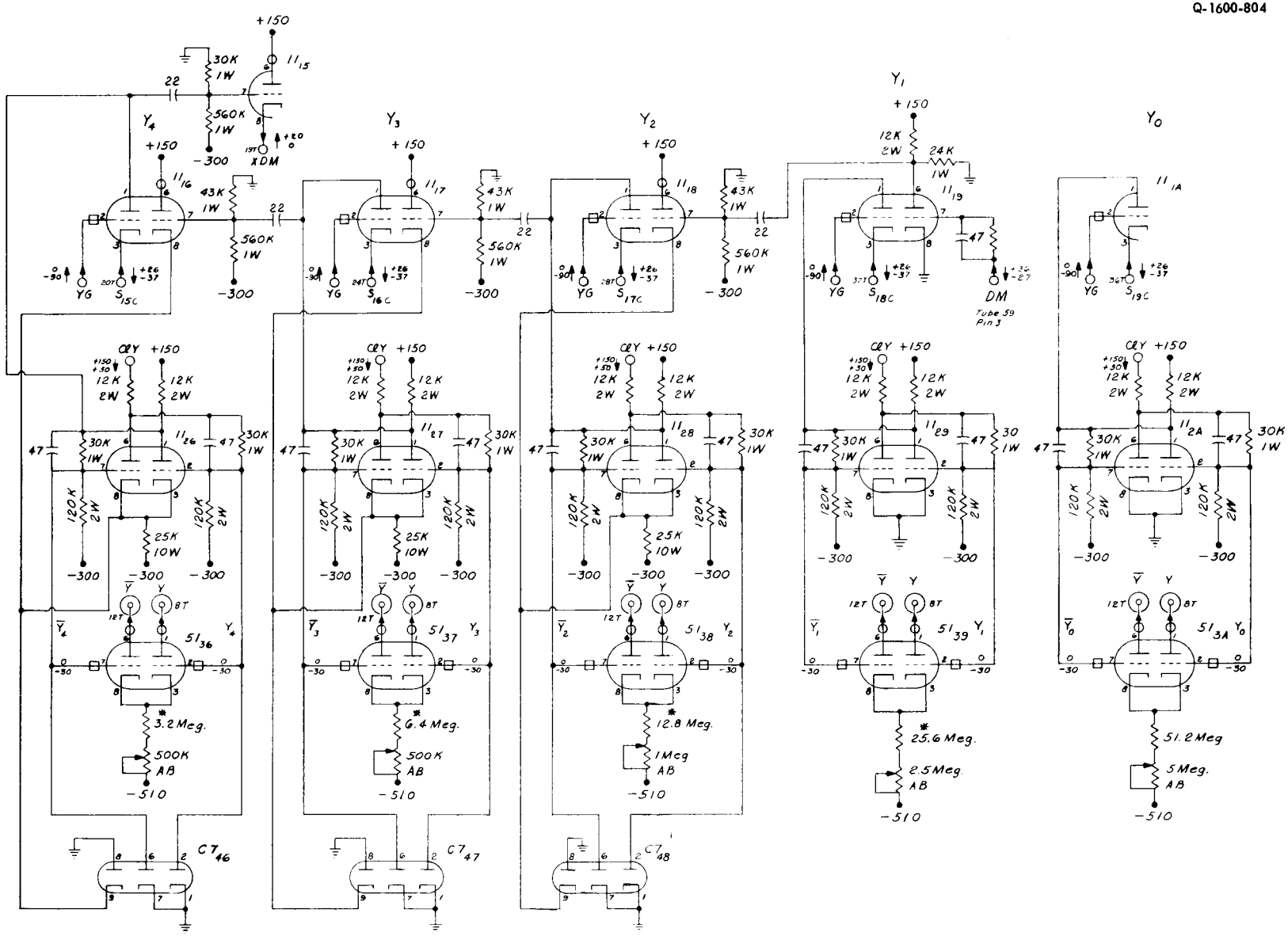

Fig. 20. Circuit Diagram for Y Register, Y_0–Y_4 Stages, Chassis II.

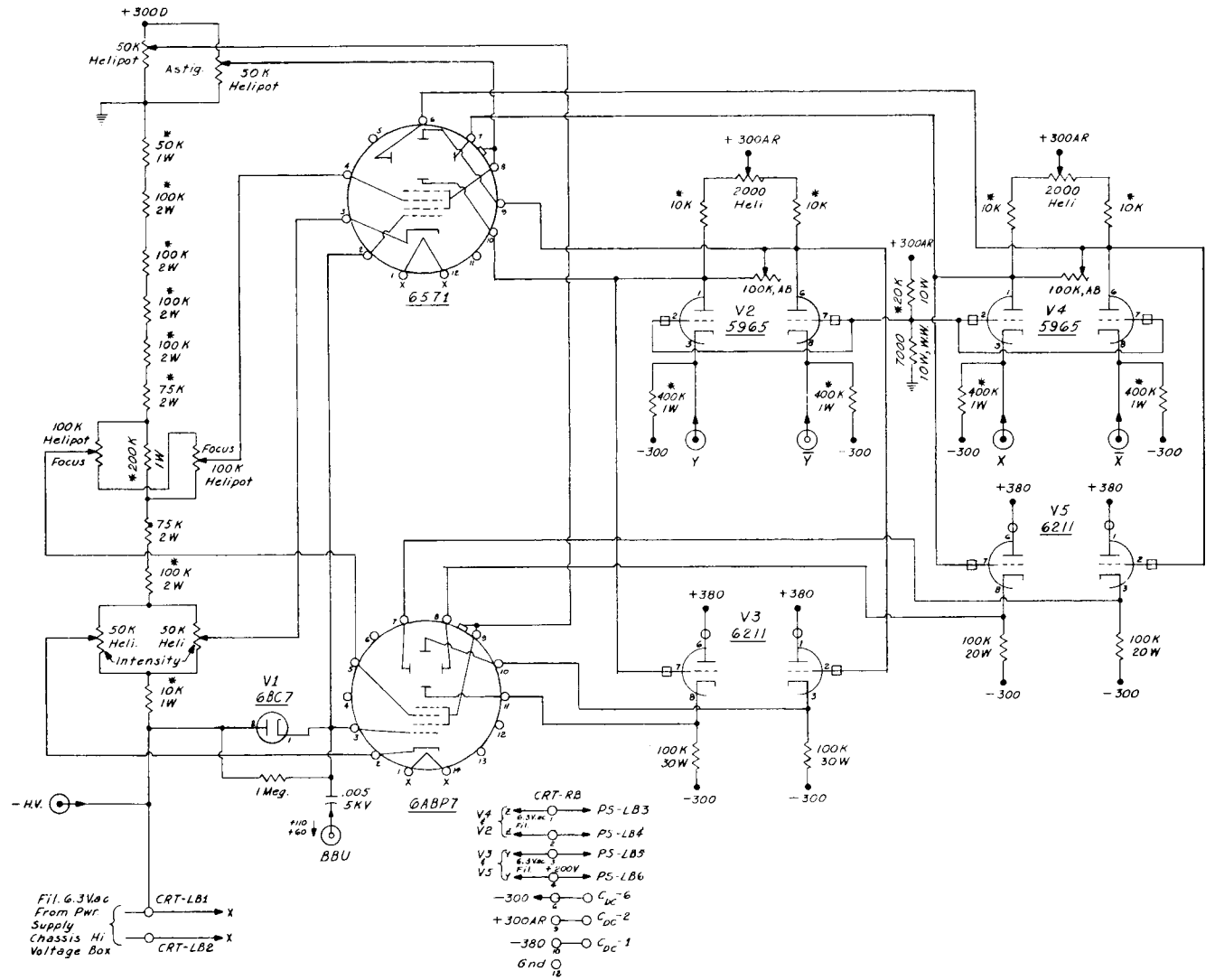

Fig. 21. Circuit Diagram for Cathode-Ray-Tube Chassis.

Power Supply Circuits

The three voltages required for curve-plotter operation which are not available from the main Oracle power supplies are −510 v, well regulated, for the digital-to-analog converter; −2720 v, also well regulated, for the cathode-ray tubes; and 24 v, for the camera film-advance solenoid and film frame counter. The −510-v supply is used as a reference in the −2720-v regulator so that the effect of changes in the −510-v supply will be partially corrected for in the plotting tube.

The tube functions are given below:

Tube No.	Function
Power Supply Chossis (Fig. 22)	
V_1	Rectifier for −510-v supply
V_2, V_3, V_4, V_5	Series regulator for −510-v supply
High-Voltage Supply Chassis (Fig. 23)	
V_1	Rectifier for −2720-v supply
V_2, V_3, V_4	Series regulator for −2720-v supply

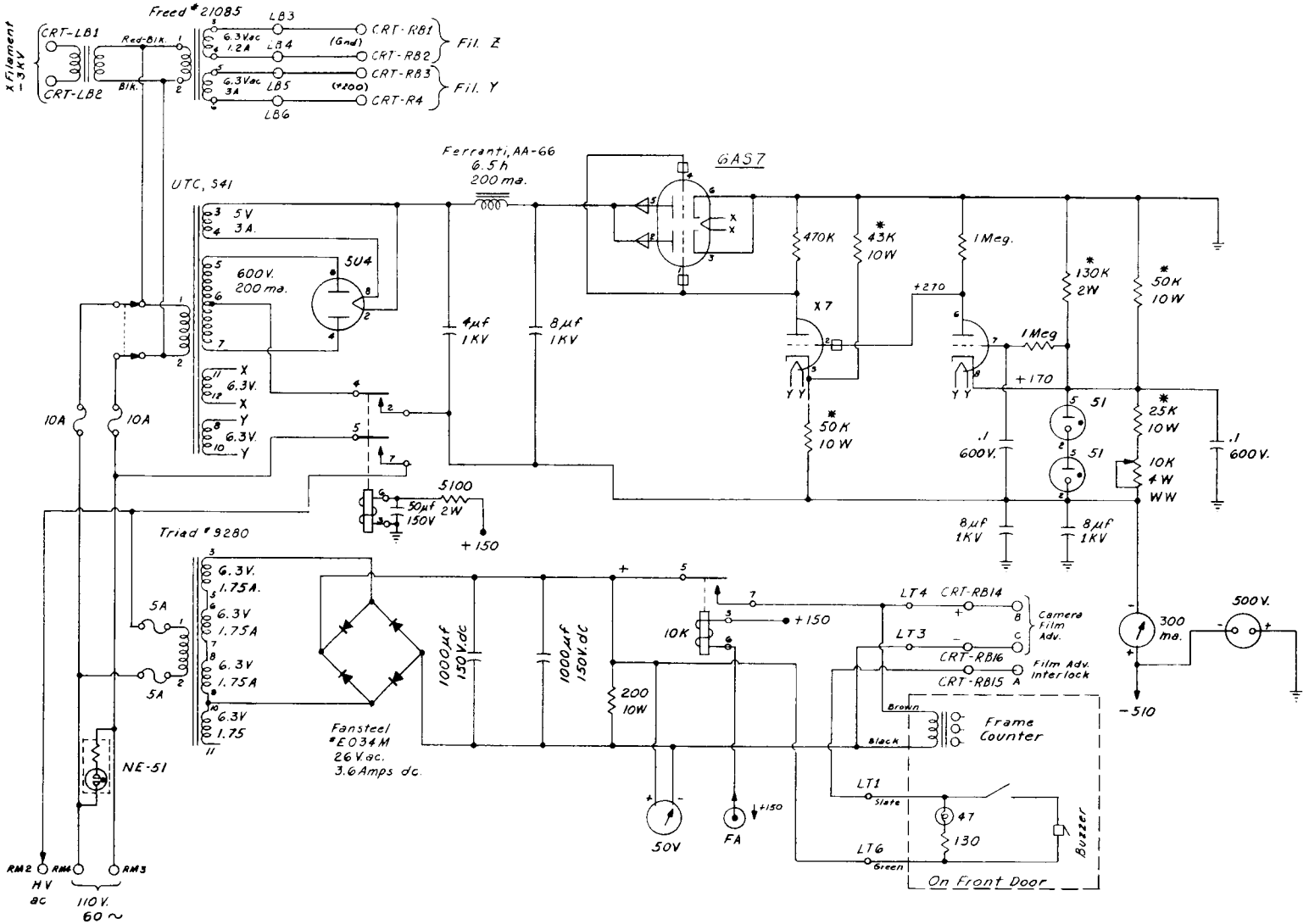

Fig. 22. Circuit Diagram for Power Supply Chassis.

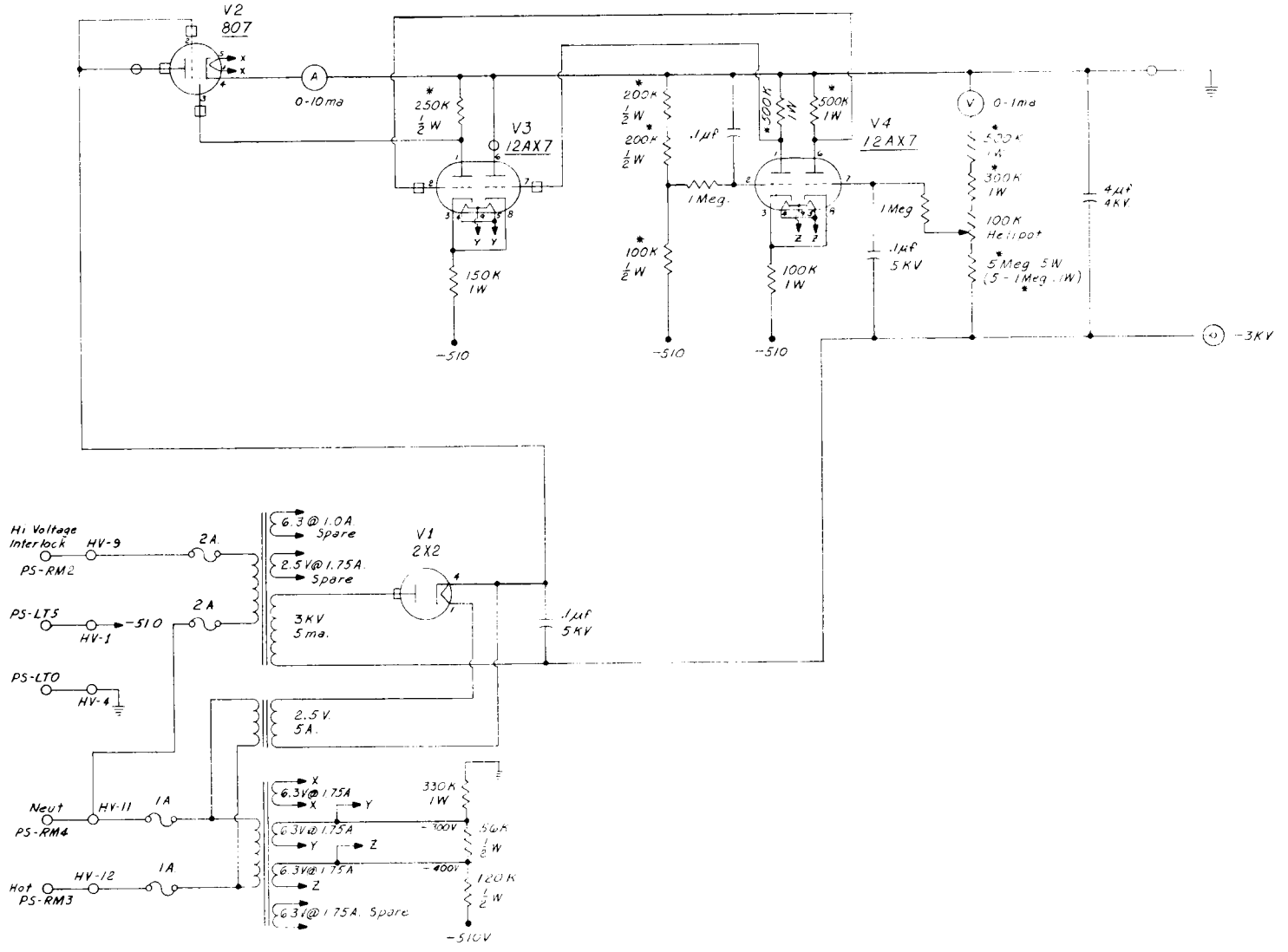

Fig. 23. Circuit Diagram for High-Voltage Power Supply Chassis.