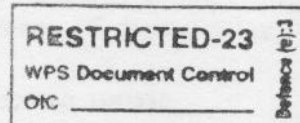




Application Notes

PANAPLEX™ NUMERIC PANEL DISPLAY THEORY OF OPERATION



INTRODUCTION

The PANAPLEX™ panel display is a cold-cathode, gas-discharge, multidigit display tube designed to fill the need for a low cost display for use in electronic calculators, test instruments and similar applications. The PANAPLEX panel is capable of displaying numeric and limited alpha information. It is available in models consisting of 8 to 16 character positions each with an array of 9 cathode segments per character. The PANAPLEX panel can be operated as either a 7 or 9-segment display. The nine-segment arrangement makes it possible for all numerals in the display to be equally centered (in a 7-segment display the numeral 1 must be off center to the right or left). The characters are formed by illuminating the appropriate combination of cathode segments. In addition, each digit position may have a decimal point cathode, a comma cathode or both (see Figure 1).

The PANAPLEX panel display is operated in a multiplexed mode in which the cathode drive and decoder circuitry is time shared by all the digits that are displayed. Some advantages of the PANAPLEX panel display are:



12 POSITION PANAPLEX™
NUMERIC PANEL DISPLAY

- . Low price
- . Minimum drive circuitry thru multiplexing
- . Streamlined, compact package
- . In-plane characters provide wide viewing angle
- . Centered numeral 1
- . High brightness with low power dissipation
- . Less than 2 connections per digit
- . High resistance to vibration and shock (there are no mechanical connections internal to the tube)
- . Life expectancy comparable to an ultra-long life NIXIE[®] tube.

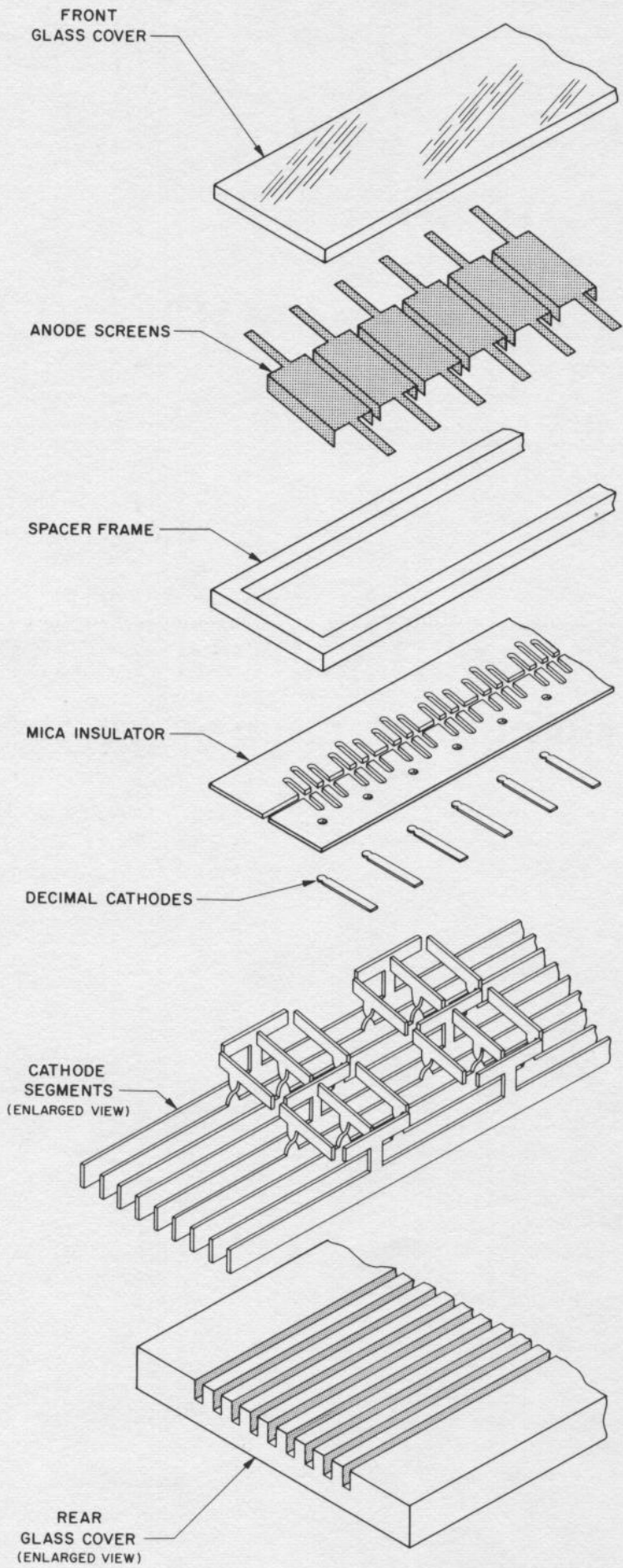


Figure 1 PANAPLEX™ PANEL DISPLAY CONSTRUCTION DRAWING



Figure 2 CHARACTER FORMAT

MECHANICAL CHARACTERISTICS

As illustrated in Figure 1 the PANAPLEX panel has a simple "sandwich" construction. A flat rear cover with ten grooves along its length provides a housing for the 9 etched metal cathode strips which are placed into the grooves and anchored at the ends of the glass plate. Each of these cathode strips forms a given cathode segment for all digit positions. These common cathode strips are brought out of the package to allow easy cathode connection. Since the segments are part of the etched cathode strips, no welded connections are required. When the cathode strips are in position the vertical segments are formed into the proper alignment as shown in Figure 1. Decimal cathodes are then positioned on the rear glass cover and a mica insulator is placed between the cathode segments and back glass to provide the necessary isolation. A frame is next placed around the periphery of the bottom glass plate to separate the cathode segments and the anode screens. The anode screens are then placed in position to cover the cathode segments in each

of the digit positions. These anode screens are also produced from a single etched piece of metal. Each screen has an integral tab to make connection to the outside of the package. The elimination of welded connections to the anodes and cathodes contributes to the high reliability of the tube. The assembly is then covered with a top glass plate, sealed around its edges, filled with a suitable neon mixture and sealed.

DEVICE CHARACTERISTICS

Operation

In the PANAPLEX panel display like cathode segments for all digit positions are common as shown in Figure 1. There are, therefore, 9 cathode segment connections to the display regardless of the number of digits the display accommodates. There is a separate anode connection for each digit. Decimal point and comma cathode connections may be separate or common.

Figure 3 indicates a block diagram of a typical nine segment 16 digit display system. The basic

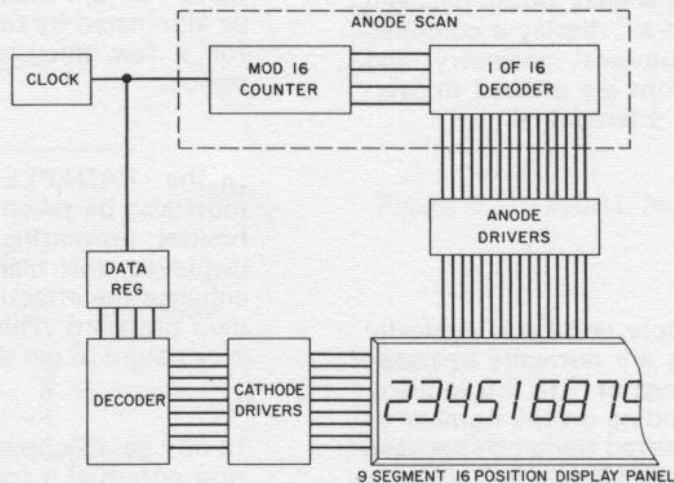


Figure 3 PANAPLEX™ PANEL DISPLAY, TYPICAL SYSTEM

electronics required to operate the display are the anode driver, the cathode decoder and drivers. The remainder of the display's circuitry will depend on the data source and the other electronics of the system. A typical circuit is shown in Figure 9.

The PANAPLEX display is designed to operate in a time-shared mode. In this mode of operation each digit is ionized individually in a sequential manner until all digits have been operated. The strobing can be either from left to right or right to left. The cycle is repeated at a sufficiently high rate, usually above 60 scans/second, to appear as a continuously energized multidigit display.¹

A cathode in any digit will glow when a voltage greater than the ionization voltage is applied between it and the anode for that digit. In the multiplexed mode of operation a digit position is selected by driving the anode for that digit with a positive voltage pulse at the same time the selected cathode segments are driven negative. This causes the potential between the anode and the selected cathodes to exceed the ionization voltage thus causing glow discharge to be visible around the selected cathode segments. Although like cathode segments for all digits are at the same low potential, no glow discharge is exhibited at other digit positions because the anodes are held at a potential less than the ionization voltage.

Gas discharge displays that contain more than one digit within a single envelope usually have critical isolation requirements between digits. Unless adjacent digits are sufficiently isolated, extraneous glow discharge may occur between them. In the PANAPLEX display a combination of the devices' physical geometry and circuit operating conditions are utilized to overcome such adjacent digit interactions.

Biasing

The required anode supply voltage is typically 200 volts. The cathodes are normally operated with a current in the range of 1 to 2.5 milliamperes per segment depending on the number of digit positions and the desired trade-offs between brightness and power dissipation.

It was previously noted that a cathode is illuminated with a voltage in excess of the ionization potential is applied between it and its anode. Similarly, anytime a potential in excess of this ionization potential exists between adjacent electrodes, the electrode at the lower potential, whether anode or cathode, will glow. To assure that the unselected digit positions do not exhibit ionization, the off anodes must be biased in the range of 90 to 100 volts. If an off anode is allowed to drop below the recommended bias of 90 volts it may begin to act as a cathode. This is particularly true for the anode adjacent to an energized digit position. This condition, if allowed to exist would cause a glow discharge to form around the anode screen, resulting in an objectionable visual effect. If an off anode is allowed to rise above 100 volts, it may cause ionization of the selected cathodes in an off digit position.

Like the anodes, the cathodes must also be returned to a bias voltage in the range of 90 to 120 volts. Within this range, off cathodes are at a potential high enough so that no glow is visible when the anode is turned on but low enough that they do not act as anodes.

In a multiplexed display it is desirable to use a short blanking interval each time a subsequent digit position is to be energized. This is necessary to prevent the wrong information from being displayed in the next count position. The rise and fall times of the cathode and anode waveforms and a possible small skew in the cathode and anode information timing may all be contributing factors to this undesirable effect. This effect can be eliminated by turning off all the anode drivers for a few microseconds during the transition period.

In the PANAPLEX panel these requirements must also be taken into consideration. However, besides preventing errors in the information displayed, this blanking interval is also used to enhance the effective isolation between adjacent digit positions. This isolation is enhanced by the very nature of gas discharge phenomena.

In any gas discharge device the sustaining ionization potential is considerably less than the initial

¹An application note entitled "Multiplexed Operation of NIXIE Tubes", Bulletin No. N101, further discusses the general considerations applicable to this mode of operation.

ionization potential. It follows, therefore, that if the anode strobe is immediately transferred from one anode to the next without a blanking interval the presence of the initial ionization potential at the adjacent anode may tend to sustain the ionization already present in the preceding digit position. Utilization of the blanking interval insures a decay below the sustaining ionization potential at the first digit position before energizing the subsequent digit position.

To achieve this isolation effect, in the PANAPLEX panel the anode and cathode drivers should be turned off for approximately 25 microseconds. Similar isolation can be achieved by turning off only the anode drivers for 100 microseconds.

The display should be turned on for at least 125 microseconds on any digit position to guarantee full ionization of the segments. Maximum time per digit is approximately 60 cycles/second (on and off time) for a 16 character tube.

Anode Drive Circuit

Figure 4 shows a typical anode drive circuit using a PNP transistor. Time constants R_1C_1 must be long enough to hold Q_1 on for as long as the anode is selected (from $100 \mu\text{s}$ to 1ms). Diode D_1 is common to all anode drivers. This diode helps to hold the transistor off and protects its base emitter junction when $B+$ is turned off.

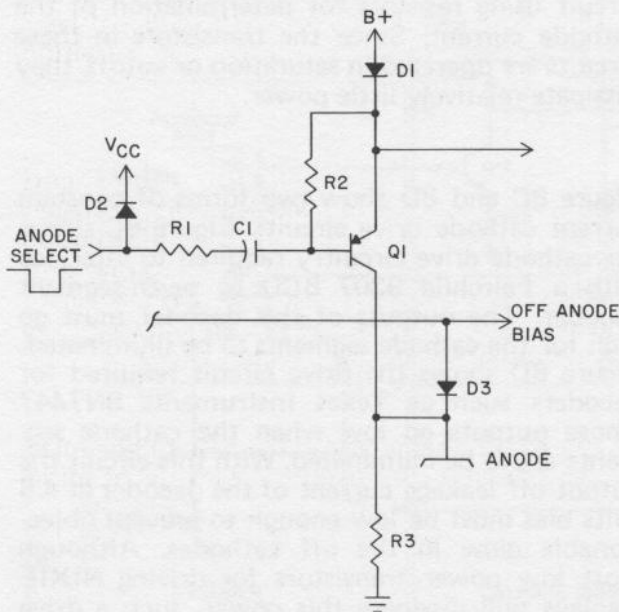


Figure 4 TYPICAL PNP ANODE DRIVER

Similarly diode D_2 protects the anode select logic from turn on transients as $B+$ is applied when C_1 is discharged, D_2 may effectively be present in integrated circuits with passive pullup output structures. R_3 pulls the anode down rapidly to its off voltage so that no extraneous glow will occur when the cathodes are changed to display the next digit. Diode D_3 clamps the anode to the off anode bias voltage to prevent the anode from acting as a cathode, the anode is on when transistor Q_1 is turned on when a negative strobe pulse is applied to R_1 .

Figure 5 illustrates an anode drive circuit using two NPN transistors. R_1 and R_2 form a voltage divider which holds the off anode at approximately 100 volts while Q_1 is turned on. Application of a logic "0" pulse to the base of Q_1 turns off Q_1 and Q_2 pulls the anode up. A disadvantage of this circuit is the large power dissipation in R_1 and R_2 for all the off anodes.

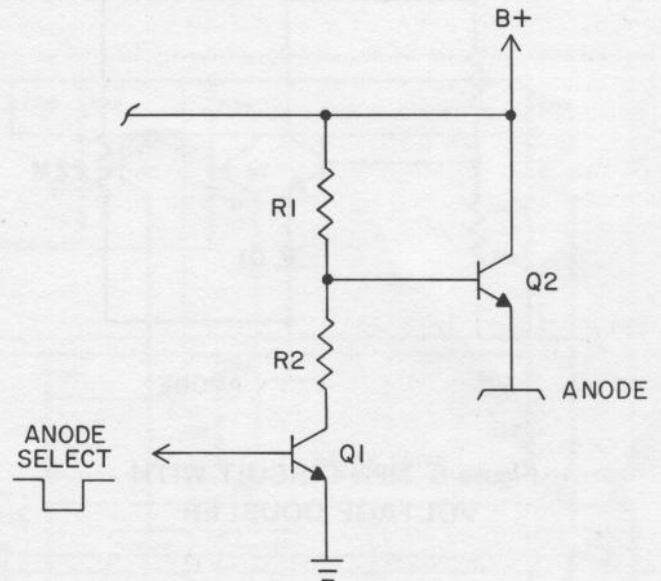


Figure 5 TYPICAL NPN ANODE DRIVER

Ionization Time

Because charged particles are available from adjacent ionized digits, the reionization time of intermediate digits in this multidigit display is less than the time required to ionize individually packaged readout tubes. The first digit to be scanned, however, cannot rely on particles from the previously ionized digit. For this reason some form of keep-alive circuits may be required on the first digit scanned. This is particularly true at

low scan rates where up to 16 ms may elapse before the digit is reionized. Reionization times can be reduced by increasing the anode voltage for the display to 200 volts.

In most applications the resistor R_{50} shown in Figure 9 will insure reionization. If the NPN circuit of Figure 6 is used, a diode D_1 should be inserted in series with the emitter as shown. Where the $B+$ is not sufficiently high to assure a constant current source for the $22M\Omega$ resistor doubler circuit can furnish the keep-alive potential $B++$ that is shown in Figure 6.

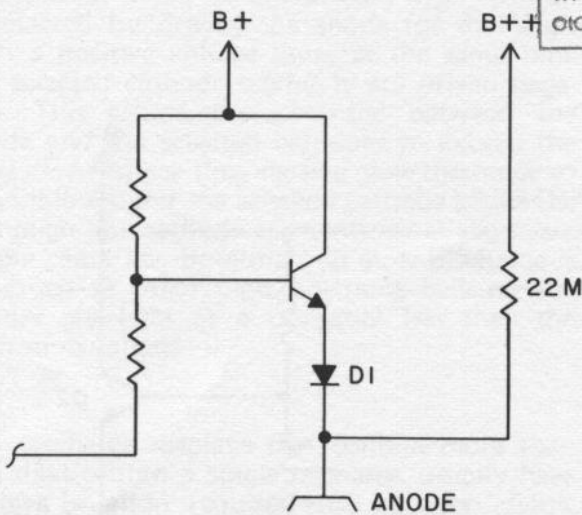


Figure 6 NPN CIRCUIT WITH VOLTAGE DOUBLER

Cathode Decoding

Figure 7 shows a nine-segment decoder logic built around a BCD to seven-segment decoder such as the Fairchild 9307 or Texas Instruments SN7447. The additional gates A1 and A2 convert a seven-segment decoder to a nine-segment format, so that a "1" is displayed by illuminating the segments h and i instead of b and c. Gates A3, A4 and A5 display a minus sign by illuminating segment g. Gate A6 displays a plus sign by illuminating segment g, h and i. Plus and minus sign data may be entered on separate parallel lines or by decoding unused BCD codes.

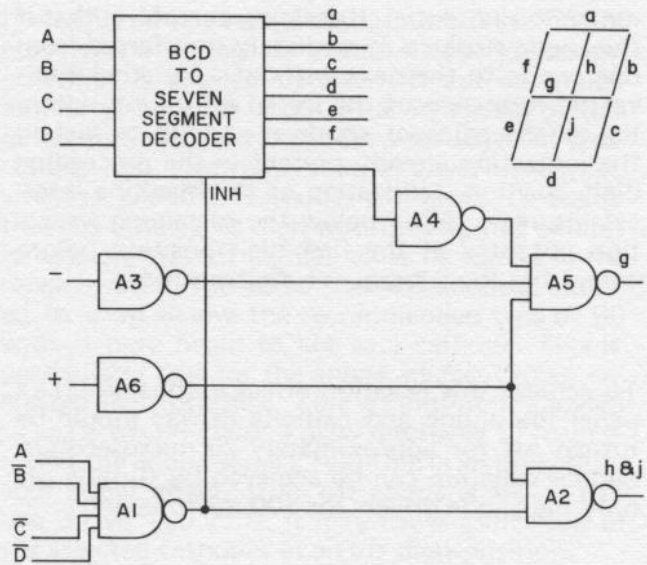


Figure 7 DECODER

Cathode Drive Circuits

In a NIXIE tube, the anode current is typically determined by a resistor or current source in the anode circuit. To insure uniform brightness in a segmented display, each segment should draw approximately equal current. Since the number of segments illuminated depends on the character being displayed, the anode current will vary.

Figure 8A and 8B show two variations of a drive circuit using resistors for determination of the cathode current. Since the transistors in these circuits are operated in saturation or cutoff, they dissipate relatively little power.

Figure 8C and 8D show two forms of constant current cathode drive circuits. Figure 8C shows the cathode drive circuitry required to interface with a Fairchild 9307 BCD to seven-segment decoder. The outputs of this decoder must go high for the cathode segments to be illuminated. Figure 8D shows the drive circuit required for decoders such as Texas Instruments SN7447 whose outputs go low when the cathode segments are to be illuminated. With this circuit the output off leakage current of the decoder at 4.5 volts bias must be low enough to prevent objectionable glow in the off cathodes. Although most low power transistors for driving NIXIE displays will dissipate this power, such a drive circuit is not easily incorporated in a low cost IC.

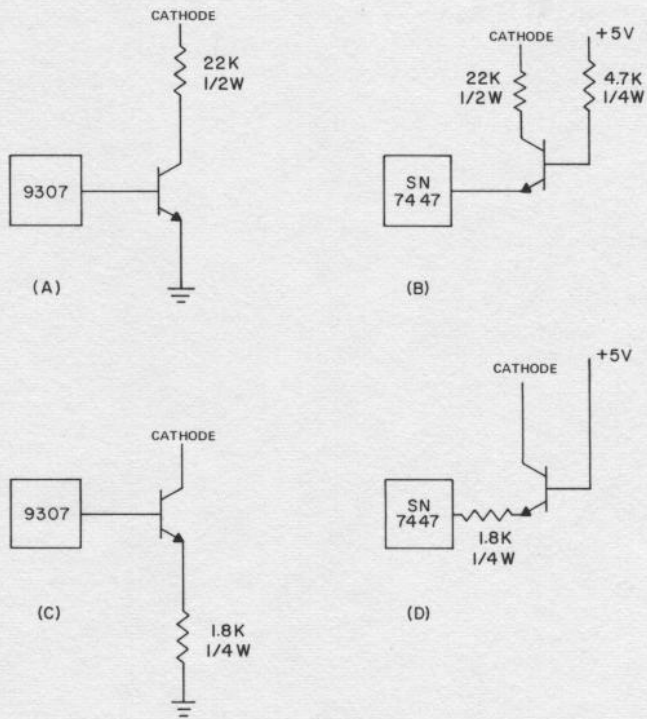


Figure 8 TYPICAL CATHODE DRIVERS

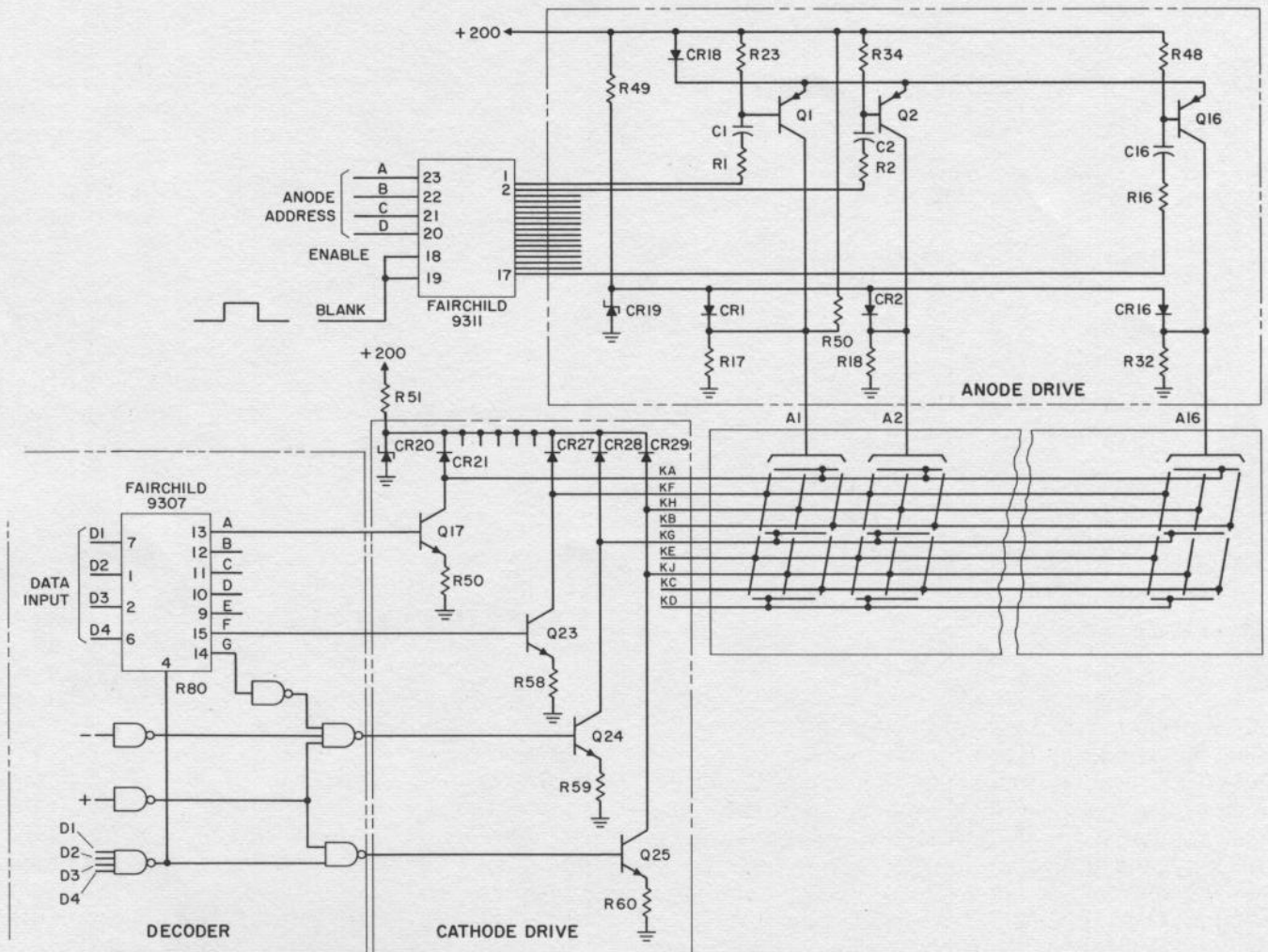


Figure 9 TYPICAL CIRCUIT

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