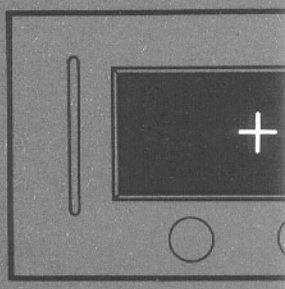
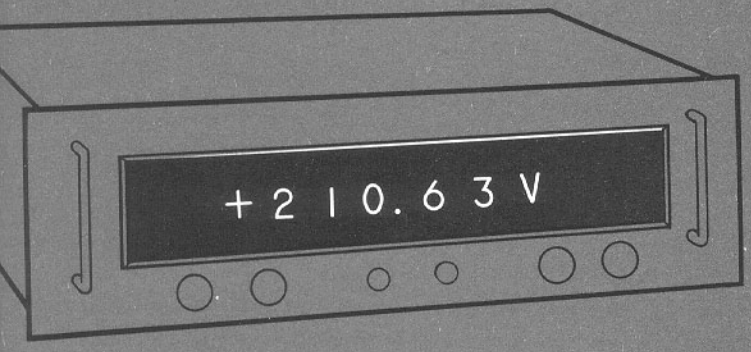
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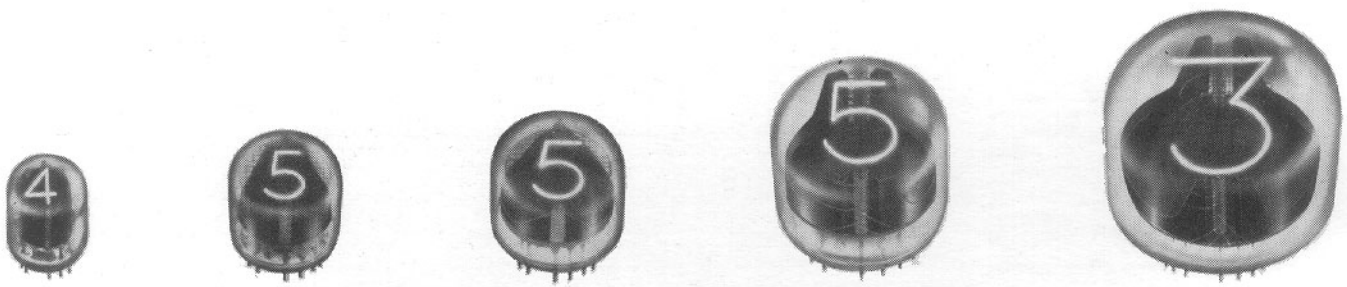
INDICATOR TUBES





CHARACTERISTICS AND CIRCUIT DESIGN DATA

ANOTHER ELECTRONIC CONTRIBUTION BY
Burroughs Corporation
ELECTRONIC COMPONENTS DIVISION
PLAINFIELD, NEW JERSEY


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NOTE: Data on Transistor Circuits contained on Pages 14 & 15 courtesy of Pacific Semiconductors, Inc.

INDUSTRY'S MOST POPULAR IN-LINE READOUT DEVICE

NIXIE®

INDICATOR TUBES

. . . . . INTRODUCTION

NIXIE tubes are all-electronic, gas filled, cold cathode indicators. They consist of a common anode and ten individual metallic cathodes, each of which is formed to the shape of numerals (0-9), alphabetical characters, or special symbols.

Their simplicity of operation makes NIXIE tubes ideal for the conversion of electro-mechanical or electronics signals directly to readable characters. Application of a negative voltage to the selected character with respect to the common anode makes the character the cathode of a simple gas discharge diode. Only the selected character is visible in the common viewing area because the visual glow discharge is considerably larger than its metallic source.

NIXIE tubes are unusually efficient electronic-to-visual converters since all of their electrical energy is converted into a neon glow of relatively narrow optical band width. The eye acts as a natural filter and distinguishes this glow in high ambient light.

Typical features which have established NIXIE tubes as the readout standard of the electronic industry are:

1. All-electronic design provides:
   a. Minimum power requirements
   b. High speed of operation
2. Smallest volume and lightest weight make simple and reliable packaging possible.
3. NIXIE tubes are lowest in cost — both to buy and operate.
4. Human engineered character design eliminates confusing segments or dot matrix patterns.
5. Best readability for characteristic size at any distance — any viewing angle.
6. Temperature, shock, and vibration characteristics qualify the tube for military use.
7. Simple decimal inputs eliminate decoding or segment selection circuitry.
8. NIXIE Tubes offer longest life and greatest reliability of any readout device.

This last feature, the combination of life and reliability, requires further explanation, since it is probably the most important reason for the NIXIE tube's outstanding popularity.

In September 1958, after two years of development and production of "regular" standard NIXIE tube types, a new series of tubes was announced. Called "Ultra Long Life" NIXIE tubes, these devices exhibited greatly increased life expectancy. On the basis of accelerated tests, a life of 20,000 hours per cathode or 200,000 hours for a complete 10 cathode tube was predicted. The 200,000 hour figure was based upon an assumption of uniform use of each of the characters within the tube.

To confirm these estimates, 50 Ultra Long Life Standard NIXIE tubes (Type 8037 (B5031) were placed on life test on September 9, 1958. Ten tubes were operated dynamically (sequential changing of cathodes at a 2 cps rate), while the remaining 40 tubes were subjected to "static" life (continuous display of the same character). This is the most severe life condition possible. (4 tubes displayed the numeral Zero, 4 tubes the numeral One, etc.) On December 8, 1958, a second group of 50 tubes joined the continuing life test and were operated in the same manner.

Progress of the life tests as of January 1, 1962, 29,200 hours later, indicates that of the first 50 tubes, 49 are still operating. One tube developed an intermittent open connection caused by a poor weld after 21,600 hours of continuous "static" operation. Examination of the cathode surface of the numeral which had been lighted showed it to be in excellent condition and capable of many more thousands of hours of use. The second group of 50 tubes have passed the 26,800 hour mark *without a single failure of any type.*

Based upon the results of tests to date, it is apparent that the original life predication of 20,000 hours (static) and 200,000 hours (dynamic) were conservative, since visual examination of the tubes undergoing test indicates that the individual cathode life will be on the order of 35,000 to 50,000 hours. Assuming that "dynamic" life under actual field operating conditions may provide a less than equal distribution of usage among the 10 characters of the tube, a realistic "dynamic" life can be predicated as being between 200,000 and 500,000 hours.

These figures indicate that Ultra Long Life NIXIE tubes can be expected to outlast the equipment in which they will be used.

This life and reliability, combined with the advantages of low cost, low power, best readability, small size and weight, high speed, rugged construction, and simplicity of operation offer the design engineer the ultimate in readout performance in a single device — the NIXIE Indicator Tube.

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ELECTRONIC COMPONENTS DIVISION
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GUIDE TO NIXIE TUBE SELECTION AND IDENTIFICATION

NIXIE tubes are available in 5 basic sizes, each of which is designed to meet a specific viewing distance requirement. The following tabulation is designed to serve as a guide to the selection of the proper tube size for your application.

TUBE GROUP	MINIATURE	STANDARD	SUPER	LARGE	JUMBO
					
NUMERAL SIZE HEIGHT	0.3″	0.6″	0.8″	1.375″	2.0″
MAXIMUM VIEWING DISTANCE*	11-14 feet	27-30 feet	37-38 feet	60-65 feet	90-100 feet
FOR DETAILED SPECIFICATIONS SEE	Page 6	Page 7	Page 7	Page 8	Page 8

*Under normal ambient lighting. Figures represent results of readability tests conducted under controlled conditions, with range of values resulting from variations in sight of viewers.

Within each tube group there are types which possess various combinations of electrical and mechanical features, e.g. Ultra Long Life, Regular Life, Low Voltage, Wide Viewing Angle (and combinations thereof). Complete specifications on the various types which are available within a particular tube group will be found on the pages noted above. For ease of identification, Ultra Long Life types are printed in *blue*.

Tube identification by type number: Each NIXIE tube, when originally produced, is assigned a type number which consists of 4-5 digits preceded by the letter B, e. g. B4081, B5031, B6091, B7094, B8091, B50117, etc. As these tubes are registered with the Electronic Industries Association, EIA numbers are assigned. As examples, the original B5031 Standard Nixie tube has become the type 8037, and the Miniature Type B4032 has become the 7977. Wherever possible in this catalog both numbers are shown for ease of identification.

ELECTRICAL DATA

	B4081 Wide Viewing Angle	*7977 (B4032) Long Life*	*7009 Regular*	*B4021 Low Voltage*
Absolute Ratings Ionization Voltage (Maximum)	170 Vdc	170 Vdc	170 Vdc	120 Vdc
Supply Voltage (Minimum) See (Note 2)	170 Vdc	170 Vdc	170 Vdc	120 Vdc
Cathode Current (Peak) See (Note 1)	2.0 ma	1.5 ma	2.0 ma	2.0 ma
Test Conditions (See Basic Circuit, Fig. 1)				
Supply Voltage	170 Vdc	170 Vdc	170 Vdc	120 Vdc
Series Resistor	68 K	15 K	68 K	20 K
Cathode Current: (Minimum) (Maximum)	0.7 ma 1.4 ma	0.7 ma 1.4 ma	0.7 ma 1.2 ma	0.7 ma 1.4 ma
Recommended Operating Conditions (DC) (See Basic Circuit, Fig. 1)				
Supply Voltage (E)	170V | 250V | 300V	170V | 250V | 300V	170V | 250V | 300V	120V
Series Resistor (R)	68K | 150K | 200K	15K | 91K | 150K	68K | 150K | 200K	20K

Note 1. Due to life considerations only long life NIXIE tubes are recommended for pulsed operation.

Note 2. The minimum supply voltage should be as stated for each tube type. However, the use of the highest voltage available, with the appropriate series resistor to maintain cathode current within the specified limits, is recommended.

MECHANICAL DATA

	All Types
Outline Drawing *	Figures 2 or 3
Sockets	Page 22
Wiring Plugs	Not Applicable
Pin Straighteners	Page 22
Pin Connections	Figure 4

*All Miniature Type NIXIE tubes are available in both Short and Long Lead versions. Short Lead versions are shown in figure 2 and 3. The Long Lead tubes have 1.400" leads and are designed for direct solder connection to circuit boards. The tubes can be ordered by applying the suffix L to the regular tube type number (Ex: 7977L, B4021L, 7009L, B4081L.)

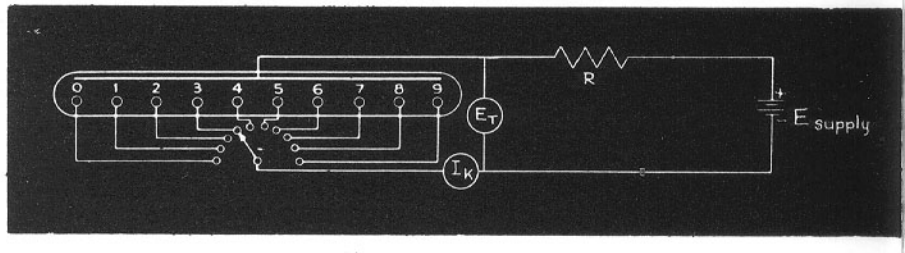


Fig. 1 — Basic Circuit

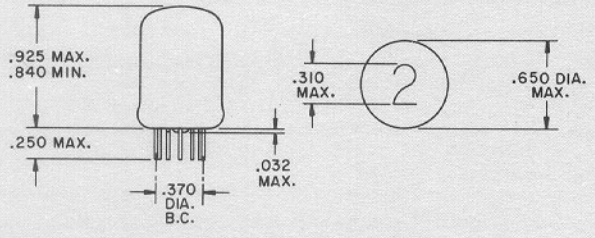


Fig. 2 — Outline Drawing for all Miniature Tubes except Type 7977

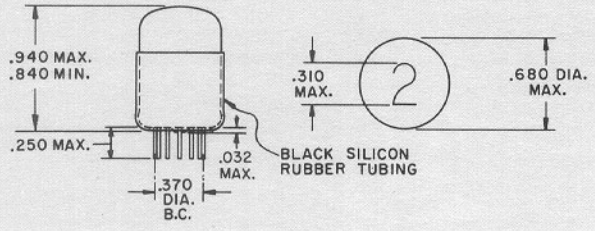
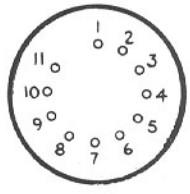


Fig. 3 — Outline Drawing for Type 7977 Tubes

PIN CONNECTIONS



BOTTOM VIEW

For Proper viewing — Pins 1 and 7 should be vertically aligned with Pin 7 on top

PIN NO	CHARACTER
1 —	Numeral 1
2 —	Numeral 2
3 —	Numeral 3
4 —	Numeral 4
5 —	Numeral 5
6 —	Numeral 6
7 —	Numeral 7
8 —	Numeral 8
9 —	Numeral 9
10 —	Numeral 10
11 —	Anode

Fig. 4 — Pin Connections for Miniature Tubes

ENVIRONMENTAL DATA

Contact Applications Department for specific data on individual tube types — *See Page 20 for general information*

STANDARD AND SUPER TUBES

ELECTRICAL DATA

	STANDARD									SUPER								
	6844A Regular			*8037 (B5031) Long Life*			*B5092 Long Life Wide Angle*			*7153 Regular*			*B6033 Long Life*			*B6091 Long Life Wide Angle*		
Absolute Ratings Ionization Voltage (Maximum)	170 Vdc			170 Vdc			170 Vdc			250 Vdc			170 Vdc			170 Vdc		
Supply Voltage (Minimum) See (Note 2)	170 Vdc			170 Vdc			170 Vdc			250 Vdc			170 Vdc			170 Vdc		
Cathode Current (Peak) See (Note 1)	4.0 ma			3.5 ma			3.5 ma			5.0 ma			4.5 ma			4.5 ma		
Test Conditions (See Basic Circuit, Fig. 1)																		
Supply Voltage	170 Vdc			170 Vdc			170 Vdc			250 Vdc			170 Vdc			170 Vdc		
Series Resistor	15 K			10 K			10 K			43 K			6.8K			6.8 K		
Cathode Current: (Minimum) (Maximum)	1.5 ma 3.0 ma			1.5 ma 3.0 ma			1.5 ma 3.0 ma			2.0 ma 3.0 ma			1.5 ma 4.0 ma			1.5 ma 4.0 ma		
Recommended Operating Conditions (DC) (See Basic Circuit, Fig. 1)																		
Supply Voltage (E)	170V	250V	300V	170V	250V	300V	170V	250V	300V	170V	250V	300V	170V	250V	300V	170V	250V	300V
Series Resistor (R)	15K	56K	82K	10K	56K	82K	10K	56K	82K	12K	43K	62K	6.8K	39 K	56K	6.8K	39K	56K

Note 1. Due to life considerations only long life NIXIE tubes are recommended for pulsed operation.

Note 2. The minimum supply voltage should be as stated for each tube type. However, the use of the highest voltage available, with the appropriate series resistor to maintain cathode current within the specified limits, is recommended.

MECHANICAL DATA

	STANDARD			SUPER		
	6844A Regular	*8037 (B5031) Long Life*	*B5092 Long Life Wide Angle*	*7153 Regular*	*B6033 Long Life*	*B6091 Long Life Wide Angle*
Outline Drawing	Figure 5	Figure 5	Figure 6	Figure 7	Figure 7	Figure 7
Sockets	Page 23	Page 23	Page 23	Page 23	Page 23	Page 23
Wiring Plugs	Page 23	Page 23	Page 23	Page 23	Page 23	Page 23
Pin Straighteners	Page 23	Page 23	Page 23	Page 23	Page 23	Page 23
Pin Connections	Figure 8	Figure 8	Figure 8	Figure 8	Figure 8	Figure 8

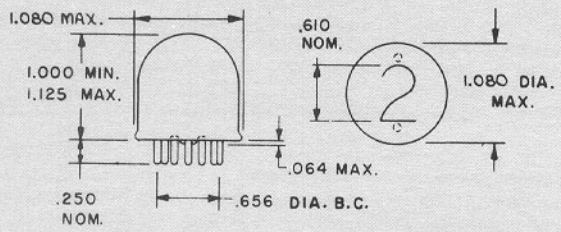


Fig. 5 — Outline Drawing for 6844A and B5031 Standard Type Tubes

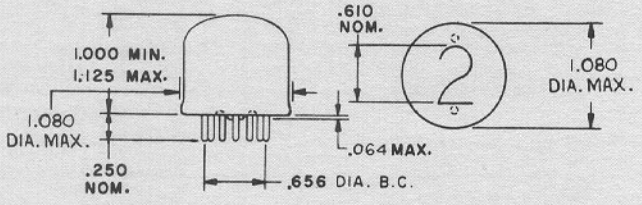


Fig. 6 — Outline Drawing for B5092 Type Tube

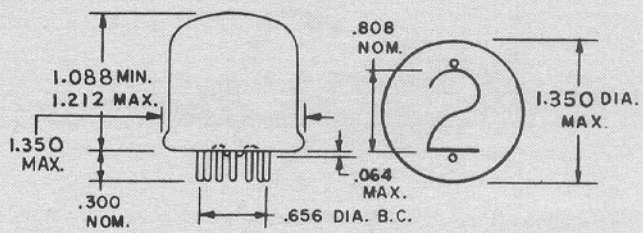
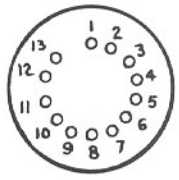


Fig. 7 — Outline Drawing for all Super Tube Types

PIN CONNECTIONS



BOTTOM VIEW

For Proper viewing — Pins 1 and 8 should be vertically aligned with Pin 8 on top

PIN NO	CHARACTER
1 —	Internal Connection
2 —	Anode
3 —	Numeral 0
4 —	Numeral 9
5 —	Numeral 8
6 —	Numeral 7
7 —	Numeral 6
8 —	Internal Connection
9 —	Numeral 5
10 —	Numeral 4
11 —	Numeral 3
12 —	Numeral 2
13 —	Numeral 1

Fig. 8 — Pin Connections

ENVIRONMENTAL DATA

Contact Applications Department for specific data on individual tube types — *See Page 20 for general information*

LARGE AND JUMBO TUBES

ELECTRICAL DATA

	LARGE			JUMBO
	B8091 Long Life Wide Angle			*B7094 Long Life Wide Angle*
Absolute Ratings Ionization Voltage (Maximum)	170 Vdc			300 Vdc
Supply Voltage (Minimum) See (Note 2)	170 Vdc			300 Vdc
Cathode Current (Peak) See (Note 1)	6.5 ma			7.5 ma
Test Conditions (See Basic Circuit, Fig. 1)				
Supply Voltage	170 Vdc			300 Vdc
Series Resistor	5.6K			27 K
Cathode Current: (Minimum) (Maximum)	3.0 ma 6.0 ma			4.0 ma 7.0 ma
Recommended Operating Conditions (DC) (See Basic Circuit, Fig. 1)				
Supply Voltage (E)	170V	250V	300V	300V
Series Resistor (R)	5.6K	22K	33 K	27 K

Note 1. Due to life considerations only long life NIXIE tubes are recommended for pulsed operation.

Note 2. The minimum supply voltage should be as stated for each tube type. However, the use of the highest voltage available, with the appropriate series resistor to maintain cathode current within the specified limits, is recommended.

MECHANICAL DATA

	LARGE	JUMBO
	B8091 Long Life Wide Angle	*B7094 Long Life Wide Angle*
Outline Drawing	Figure 9	Figure 10
Sockets	Page 25	Page 25
Wiring Plugs	Not Applicable	Not Applicable
Pin Straighteners	Page 25	Page 25
Pin Connections	Figure 11	Figure 11

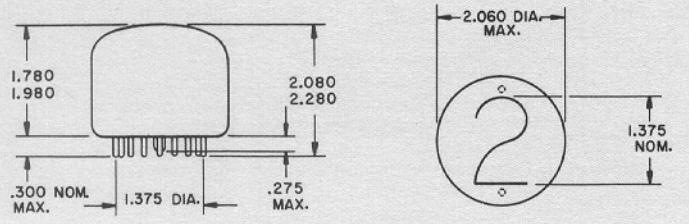


Fig. 9 — Outline Drawing for all Large Tube Types

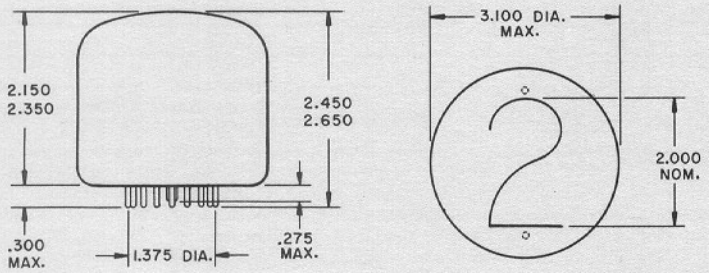
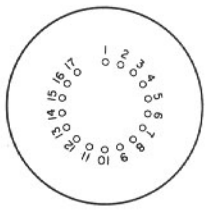


Fig. 10 — Outline Drawing for Jumbo Tube Types

PIN CONNECTIONS



BOTTOM VIEW

For Proper viewing — Pins 1 and 10 should be vertically aligned with Pin 10 on top

PIN NO	CHARACTER
1 —	Internal Connection
2 —	Anode
3 —	Numeral 0
4 —	Numeral 9
5 —	Internal Connection
6 —	Internal Connection
7 —	Numeral 8
8 —	Numeral 7
9 —	Numeral 6
10 —	Internal Connection
11 —	Internal Connection
12 —	Numeral 5
13 —	Numeral 4
14 —	Numeral 3
15 —	Internal Connection
16 —	Numeral 2
17 —	Numeral 1

Fig. 11 — Pin Connections

ENVIRONMENTAL DATA — Contact Applications Department for specific data on individual tube types —
See Page 20 for general information

NIXIE TUBE CHARACTERISTICS AND CIRCUIT DESIGN DATA

SUMMARY

The electrical characteristics are explained and circuit design data is discussed. Ionization and operating voltages as well as full glow current requirements are defined. The method of selecting the circuit parameters such as supply voltage, series resistance, pre-bias voltage and switching voltage are discussed.

ELECTRICAL CHARACTERISTICS

The equivalent circuit of a NIXIE indicator tube is shown in Figure 12.

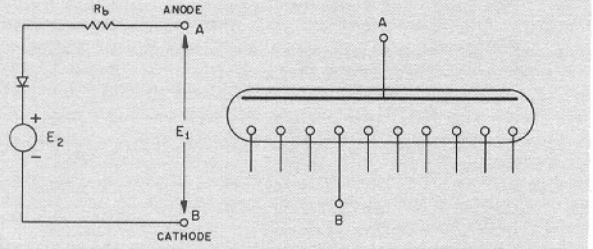


Fig. 12 — Nixie Tube and its Equivalent Circuit

This circuit represents the NIXIE tube electrically when considering the anode and one of the tube's ten cathodes. When looking into terminals A and B, this "two terminal" device will appear as a constant voltage source, E_2, in series with an internal impedance, R_b (approximately 10 K ohm) and a diode. The diode represents the fact that the NIXIE is a cold cathode gas tube in which current flow ceases when E_1 drops below the value of E_2.

E_2 is equal to E_1-IR_b where E_1 is the average sustaining voltage under average current conditions. If E_2 were absolutely constant for each NIXIE tube, then all tubes would exhibit the same tube voltage drop and cathode current. However, variations exist in E_2 between different tube types and to a lesser extent from tube to tube within a given type. Therefore, corresponding variations will exist in the tube voltage drop and cathode current of individual NIXIE tubes. These variations are shown for the type B5092 Standard NIXIE tube by the parallel lines which represent the limiting curves of the tube characteristics in Figure 13.

NIXIE indicator tubes are current operated devices. They require a minimum cathode current density to assure complete glow and a maximum cathode current limit to provide maximum life. Sufficient B+ voltage and appropriate series resistance are the means for assuring ionization and control of the cathodes within the specified limits.

Figure 1, page 6, is the basic NIXIE tube test circuit. This circuit was used to obtain the characteristic curves of the type B5092 Standard NIXIE tube shown in Figure 13. The same circuit with fixed B+ and fixed series resistor is used as a production test for all types. The B+ and fixed resistor values as well as the cathode current limits for the various NIXIE tubes are shown in tabulated form under Test Conditions in the Electrical Data Section of the brochure.

Figure 13 shows the limits of the tube voltage versus cathode current (E_t vs. I_k) characteristics curves for the B5092 NIXIE tube. The following interpretation and discussion of the characteristic curves applies equally to similar curves which could be drawn for all types of NIXIE tubes. As shown in Figure 13, a 170 volt, 10 K ohm load line intersects the characteristic curves at points E and F corresponding to the cathode current limits of 1.5 ma and 3.0 ma. Other recommended load lines are also shown. The minimum cathode current necessary for full glow of any cathode is slightly less than 1.5 ma for the type B5092. Increasing the cathode current results in greater intensity, but shortens tube life. In order to obtain sufficient brilliancy and maximum tube life, the cathode current should not be allowed to exceed the limits of 1.5 ma to 3.0 ma. The optimum design would be a constant current circuit providing a cathode current of 2.25 ma for this tube type.

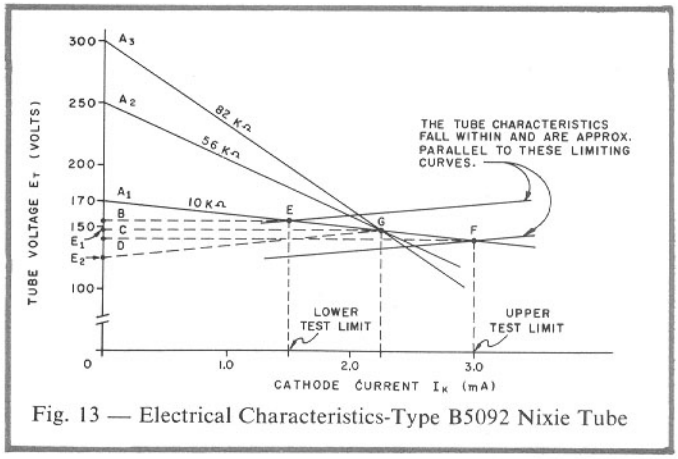


Fig. 13 — Electrical Characteristics-Type B5092 Nixie Tube

SUPPLY, IONIZATION AND SUSTAINING VOLTAGES

As mentioned above, the NIXIE tube is basically a current operated device. However, the voltage necessary to provide the required cathode current is also very important for satisfactory operation of the tube. As shown in the Electrical Data Section of this brochure, the recommended minimum supply voltage is the same as the maximum ionization voltage. This is to assure ionization and proper operation of the particular NIXIE tube type. For example, the maximum ionization voltage and minimum supply voltage for the type B5092 is 170 volts. Although many B5092 NIXIE tubes will ionize below point B (Figure 13), the ionization voltage range should be considered to extend up to point A_1, (170 volts). Therefore, A_1 represents the recommended minimum supply voltage. In addition, if a B+ voltage less than the minimum recommended supply voltage of 170 volts is used, a load resistor smaller than 10 K ohms would be necessary to establish the average cathode current of 2.25 ma for the type B5092. The resulting loadline would intersect the limiting characteristic curves above and below the recommended cathode current limits. Again, this infers that the use of a supply voltage of less than +170V for the type B5092 is not good engineering practice and is not recommended.

In Figure 13, points E and F projected onto the ordinate establish points B and D. The distances OB and OD, therefore, represent the limits of tube voltage drop as the operating point moves along the 10 K ohm loadline from point E to point F. The voltage represented by distance OC is the average tube voltage drop under average current conditions or E_1.

SERIES RESISTOR

For most B5092 applications, the results obtained by using a 170 volt supply in conjunction with a 10 K ohm load resistor are satisfactory. However, in many applications, it is preferred to keep the range of cathode currents and glow intensities to a minimum. One way of accomplishing this is to select a higher supply voltage and use an appropriate higher value of load resistance. The higher the B+ and series resistor, the more nearly a constant current is approached and, as a result, better NIXIE tube operation is obtained.

Knowing the available supply voltage, the method of selecting the series load resistance is as follows, using Figure 13:

(1) Select the center value of cathode current, e.g. 2.25 ma for the type B5092.

(2) Erect a line normal to the abscissa at this point. This normal line will intersect a line drawn midway between and parallel to the limiting characteristic curves at point G.

(3) Connect this point G with the selected supply voltage on the ordinate, e.g. 250 volts point A_2. The inverse slope of this line will represent the necessary load impedance which in this case is 47 K ohms. In other words, the voltage drop across the series resistor must be such that the tube voltage drop (E_I) is the same for all values of supply voltage. For the type B5092, the series resistor (R_L) in K ohms for any given supply voltage is B+ minus 147 volts (E_I) divided by 2.25 ma (average cathode current). It is evident that the range of cathode current diminishes as the slope of the loadline becomes steeper. Therefore, a higher supply voltage is always preferred, e.g. points A_2 or A_3, as compared to A_1.

In order to simplify the selection of series resistors for the various NIXIE tube types, the following chart has been prepared. By merely substituting the selected operating voltage (B+), the average tube voltage drop, E_I, and the average cathode current, I_k (av), in the formula

$$R_L = \frac{B+ - E_I}{I_{K\,(AV)}}$$

the approximate value of the required series resistor (R_L) can be obtained.

Tube Group	*Tube Type*	E_I	I_k *(av) ma.*
Miniature	7009	102	.95
	7977 (B4032)	154	1.05
	B4021	102	1.05
	B4081	102	1.05
Standard	B5092	147	2.25
	8037 (B5031)	147	2.25
	6844A	135	2.25
Super	B6091	147	3.0
	B6033	147	3.0
	7153	143	2.5
Large	B8091	145	4.75
Jumbo	B7094	150	5.5

PRE-BIAS

From the preceding discussions, it might be assumed that a signal equal in amplitude to the minimum supply voltage is required to turn "on" (ionize) the selected NIXIE tube number or character (cathode); however, this is not true since in practice, the switching device driving the NIXIE tube need only be capable of switching a much smaller *pre-bias* voltage. This is particularly important when the tubes are to be used in low voltage semiconductor circuits where large amplitude signals are not available.

Pre-bias voltage is defined here as the potential difference between the 1 "on" cathode and the 9 "off" cathodes within the tubes. The curves in Figure 14 show the range of currents which an "off" cathode will draw as its potential is changed with respect to the "on" cathode. The curves were obtained by the use of a

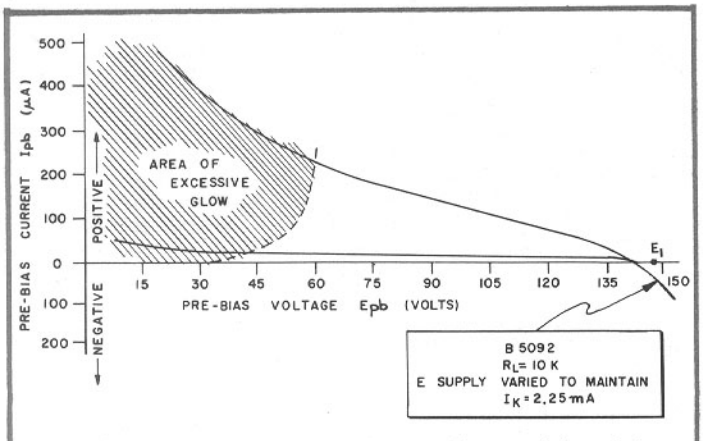


Fig. 14 — Pre-Bias Voltage vs Current Characteristics of the Type B5092 Nixie Tube

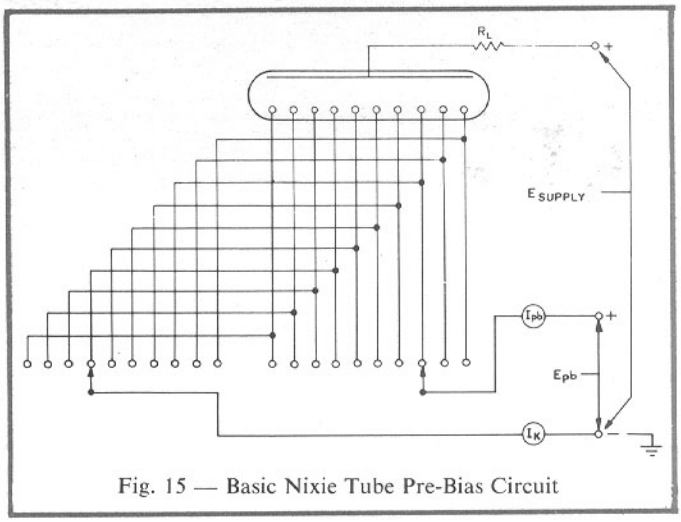


Fig. 15 — Basic Nixie Tube Pre-Bias Circuit

circuit such as that shown in Figure 15. In this circuit, one cathode is grounded and, therefore, ionized while another cathode is connected to the pre-bias supply (E_{pb}). The curves in Figure 14 show that if the "off" cathode voltage is raised above the sustaining voltage (E_I), it will take over as the anode and accept electron current. The anode and series anode resistor would then lose control of limiting the "on" cathode's current. Figure 14 also shows that as the "off" cathodes' voltage is lowered below the anode voltage, it will begin to accept ion current. If this ion current is excessive, the "off" cathode will become ionized and produce a background haze. From this discussion it can be seen that the upper limit of the pre-bias voltage is less than the lowest sustaining voltage of a "high current" NIXIE tube (point D, Figure 13) for type B5092. The lower limit of the pre-bias voltage is determined by the objection of the eye to the background haze caused by the ionization of the "off" cathodes.

Since NIXIE tube cathodes are stacked within the tube envelope, the distance between combinations of "on" and "off" cathodes will be different and consequently the effects of pre-bias will vary from one combination to the next. This is why a spread of curves representing minimum and maximum effects is shown in Figure 14. The area within the dotted line represents that area in which objectionable background haze occurred for the various combinations. The table below illustrates pre-bias voltage limits for the various NIXIE tubes.

Tube Group	*Tube Type*	*Pre-bias Voltage Limits (referenced to the "on" cathode)*
Miniature	7009	50 V to 75 V
	B4081	50 V to 75 V
	B4021	50 V to 75 V
	7977 (B4032)	50 V to 120 V
Standard	All Types	50 V to 120 V
Super	All Types	50 V to 120 V
Large	All Types	50 V to 120 V
Jumbo	All Types	50 V to 120 V

Note 1: Due to the small physical size of the Miniature NIXIE tubes, a relatively greater degree of background haze is evident for a given pre-bias voltage; however, the Low Voltage Miniature NIXIE tube type B4021 is a specially selected tube. This tube exhibits less background haze than other Miniature types at the lower limit of pre-bias voltage (50 V).

Note 2: In general the same pre-bias limits apply to both numeral and special character tubes in a given tube type.

The lower the pre-bias voltage, the lower the voltage swing required from the driving source. Due to the present availability of a number of different types of economical medium and high voltage transistors, the design engineer has latitude in the choice of a particular device with which to drive the NIXIE tube. Detailed information concerning transistor operation of NIXIE tubes will be found in the Applications Section of this brochure (Pg.14). The information includes a listing of currently available transistors which are suitable for use with the tubes, as well as photographs of completely packaged transistor drive modules (TRIXIE® modules). Specifications on the packaged modules will be found in the Accessories Section on Pages 22 and 24.

APPLICATIONS INFORMATION

SUMMARY

Typical applications of NIXIE tubes are discussed. Specific methods of operating NIXIE tubes are described, including electro-mechanical switches, transistors and BEAM-X® switches. Typical power supply circuits and specialized circuit techniques such as dimming and blanking are discussed. Suggested methods of mounting and environmental data are given.

NIXIE TUBE APPLICATIONS

NIXIE tubes have found application in literally every type of equipment from elevators to electronic instruments, from process control flowmeters to missile count-down displays. The following is a brief listing of some typical applications which indicate the scope, versatility and capabilities of these unique readout devices.

- Digital Clocks
- Aircraft Channel Indicators
- Computer Console Readouts
- Airline Displays
- Frequency Counters
- Direct Readout Oscilloscopes
- Digital Tachometers
- Flight Simulators
- Teaching Machines
- Stock Quotation Displays
- Digital Voltmeters
- Flowmeters
- Tank Level Indicators

In each of these applications, a particular set of conditions exists which dictates the manner in which the tubes will be operated. In some cases, occurrences are to be counted and displayed using either electronic or electro-mechanical circuits; in others, coded information must be converted to decimal form and displayed visually. In still other applications, a simple ten-position switch can select the desired characters without need for elaborate circuitry. On the following pages, various methods of NIXIE tube operation are described in detail to assist the design engineer in incorporating the tubes into his equipment.

DRIVER CIRCUITS

BEAM-X SWITCH CIRCUITS

Since the NIXIE indicator tube is a current operated device, the ideal driver for the tube is a constant current source such as the BEAM-X Switch. Thus, the NIXIE tube and the BEAM-X Switch are inherently compatible devices. Having been designed as companion units, their operating voltages and currents are such that optimum performance of the NIXIE tube readout is assured.

The BEAM-X Switch is a high-speed, ten-position, electronic switching device. Within the device are ten arrays of independent elements positioned around a centrally located cathode. See cross section Figure 16.

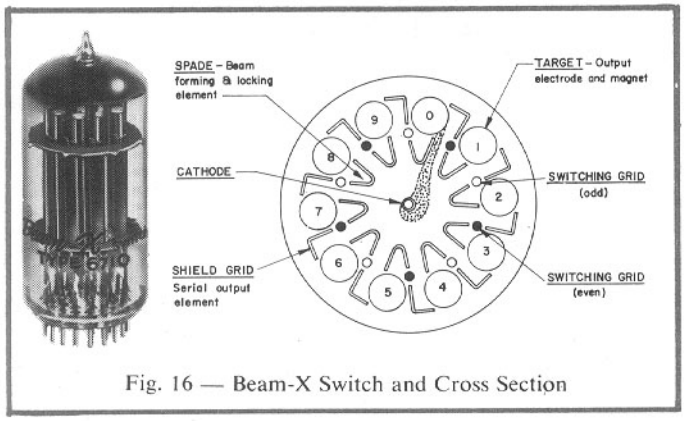


Fig. 16 — Beam-X Switch and Cross Section

An electron beam can be formed from the cathode to any one position and then can be switched sequentially or at random by use of the elements in each array to any of the other nine positions of the tube. When the beam is formed at a given position, the output current available at that position can be used to operate NIXIE tubes, printers, and to perform gating or presetting functions.

The versatile design of the BEAM-X Switch allows it to perform the two most common functions in a readout system. The BEAM-X Switch can count pulses reliably at both low and high frequencies, and it can decode binary coded decimal information to decimal form.

DECADE COUNTING WITH THE BEAM-X SWITCH.

A number of different techniques can be utilized to operate the BEAM-X Switch as a counting device. Typical are 100 KC and 1 MC flip-flop circuits which use transistors, vacuum tubes or Nuvistors to drive the switching grids of the BEAM-X Switch and advance the electron beam through the ten positions of the device. A cascade output pulse from the ninth or tenth position of the BEAM-X Switch is normally used to drive succeeding decades. At lower frequencies (below 10 KC), flip-flop drive circuits can be eliminated and the switching grids can be pulsed directly. In either case, the ten constant current outputs of the BEAM-X Switch operate remote or local NIXIE tube readouts directly without need for decoder, buffer or amplifier circuits. BEAM-X Switch/NIXIE tube circuit design criteria is discussed in detail in the BEAM-X Switch brochure (BX-535-A). In the following sections, typical BEAM-X Switch circuits are shown.

TRANSISTOR BEAM-X COUNTER CIRCUITS

Figure 17 shows the schematic diagram of a 1 MC Transistorized BEAM-X Counter. A total of only eleven active components (three silicon transistors, seven diodes and one BEAM-X Switch) are required to perform the counting function. In addition to operating the NIXIE tube directly, ten electrical outputs are available to drive gates and printers.

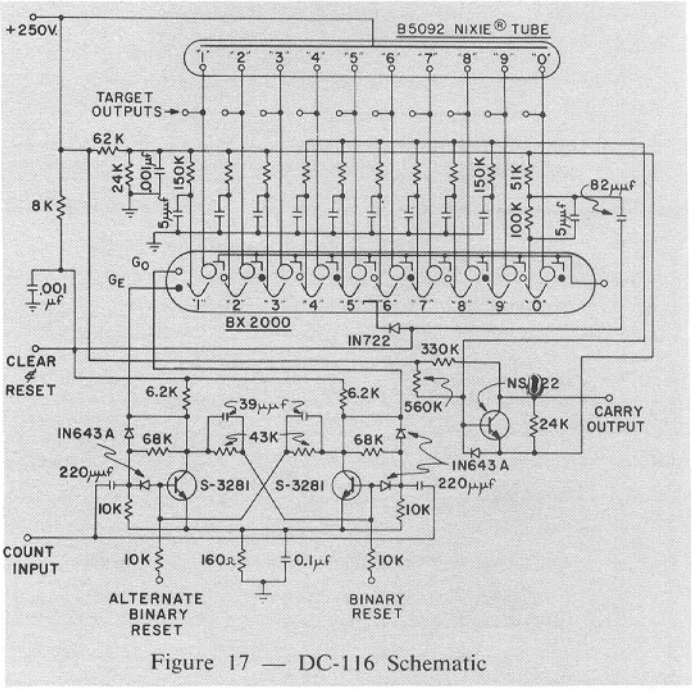


Figure 17 — DC-116 Schematic

This circuit is commercially available as a plug-in module which is designed for front panel mounting in direct readout counting systems (see Figure 18). For counting applications requiring 110 KC maximum pulse resolution, a germanium transistor circuit is available. This circuit is electrically compatible with the 1 MC circuit shown above so that complete high-speed systems can be designed using the two units together.

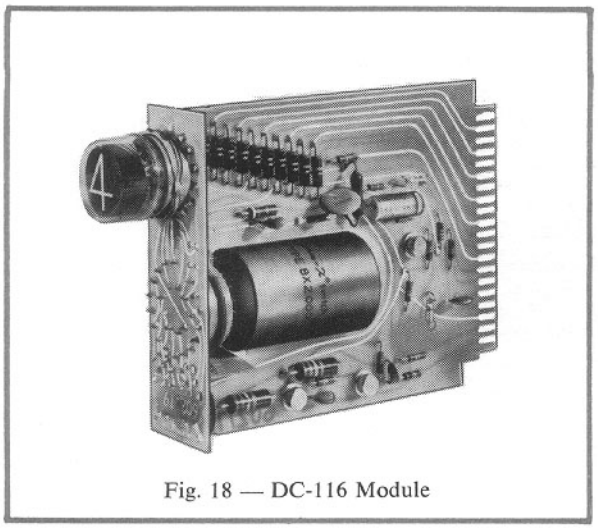


Fig. 18 — DC-116 Module

Each unit contains an integral NIXIE tube (standard long life Type B5092) and a magnetically shielded BEAM-X Switch to facilitate side-by-side mounting. In addition, a 110 KC unit is available without integral NIXIE tube for those applications in which remote readout is desired. Complete specifications for the units can be found in the BEAM-X Modules Brochure #405.

VACUUM TUBE BEAM-X COUNTER CIRCUITS

BEAM-X Switches can be driven at all frequencies with suitable vacuum tube flip-flop circuits. A typical 110 KC circuit is shown in Figure 19. Here a transistor amplifier is used to couple succeeding stages.

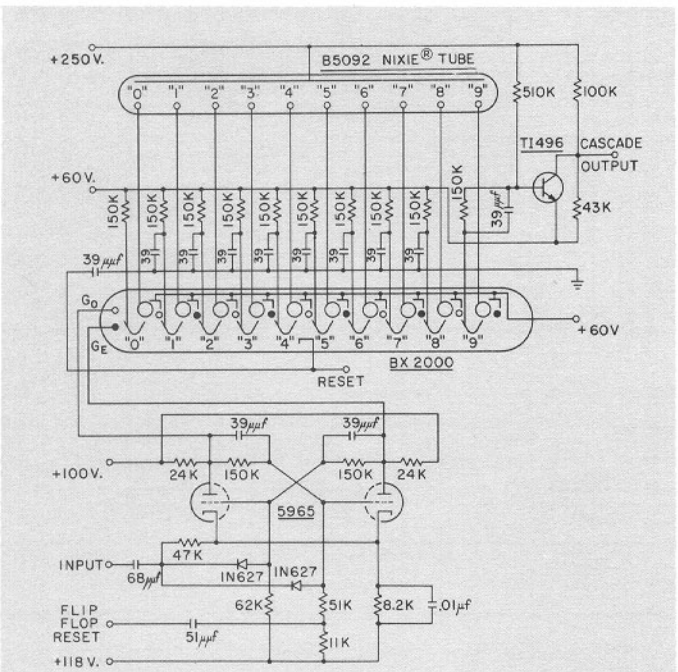


Fig. 19 — 110 KC Vacuum Tube Counter Circuit

A unique vacuum tube-BEAM-X Switch combination is that of the Burroughs BEAM-X module, Type DC-112. This unit utilizes a high gain screen grid pentode to provide the cascade output to drive the next succeeding decade. This unit is insensitive to large noise pulses. For this reason, the counter is ideal for use in industrial counting systems where electrical noise can cause difficulties with flip-flop circuits which are relatively noise sensitive.

The circuit for the DC-112 module is shown in Figure 20 below.

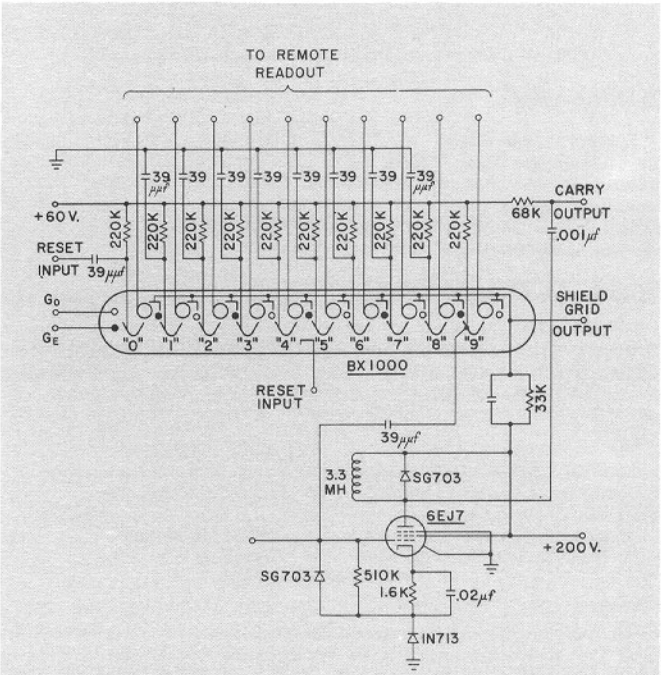


Fig. 20 — Beam-X Switch Counter Circuit.

A remote NIXIE tube can be operated from the target output terminals directly. Figure 21 is a photograph of the unit.

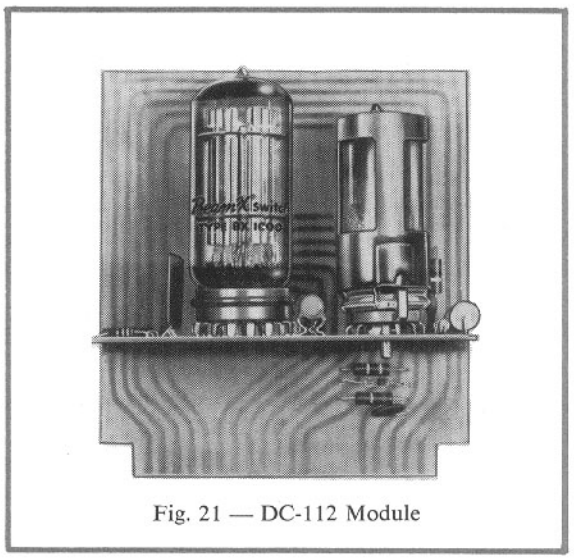


Fig. 21 — DC-112 Module

NUVISTOR BEAM-X COUNTER CIRCUITS

Figure 22 is supplied to show the compatibility of the BEAM-X Switch with Nuvistor tubes for decade counting. Here, a two Nuvistor tetrode flip-flop and a Nuvistor triode output amplifier are used. This circuit is capable of 1 MC operation.

This circuit shows the ability of a high current BEAM-X Switch to operate multiple remote NIXIE tubes of miniature, standard or

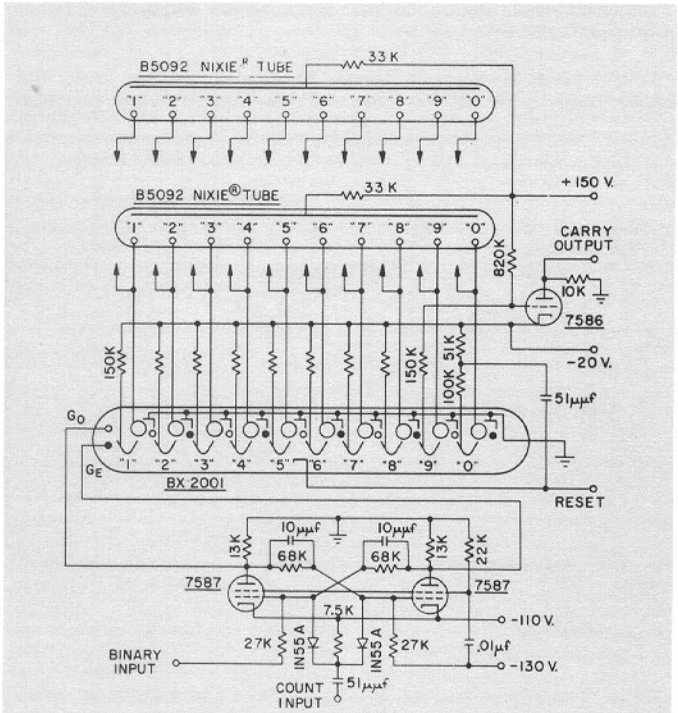


Fig. 22 — I MC Nuvistor-Beam-X Switch Counter Circuit

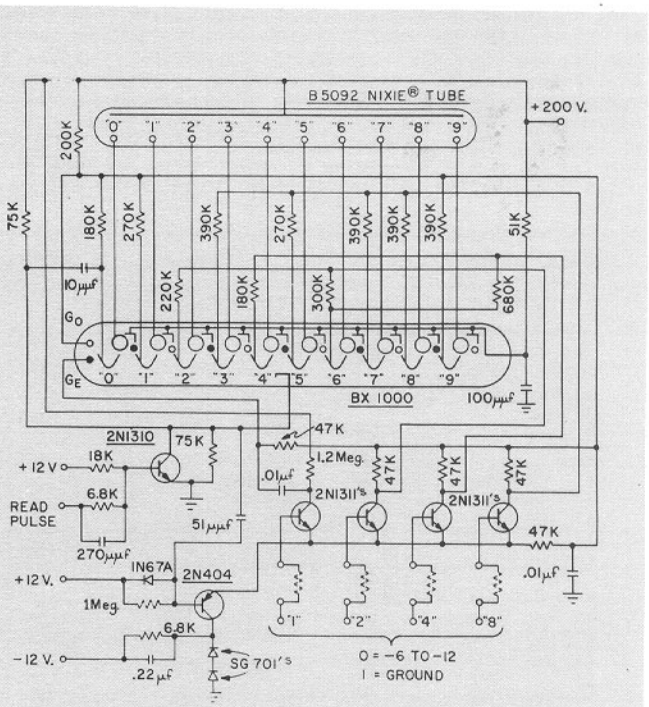


Fig. 23 — Transistorized Beam-X Switch Decoder

super sizes. In Figure 22, 2 type B5092 standard tubes are being operated remotely. The BEAM-X Switch, Type BX-2001 used, provides a minimum of 4.0 ma of constant current output which is sufficient to light 4 miniature NIXIE tubes or 2 standard size tubes. Transistor and standard vacuum tube circuits can also be combined with high-current BEAM-X Switches to perform the same function.

DECODING WITH THE BEAM-X SWITCH

One of the most common circuit requirements in readout systems is the need for conversions of binary coded data to decimal form. In almost every case, the information is available for only a short period of time so that a decoding device which has both data storage and high speed operation capabilities is required. A typical example is the activation of computer console displays from binary coded decimal information.

The BEAM-X Switch is a device which satisfies all of the basic requirements of a decoding system. It has high access speed (ten microseconds or less) and provides electronic storage in decimal form for the data. It can be combined with transistors in a circuit such as that shown in Figure 23. This circuit is designed to decode 8-4-2-1 BCD to decimal form with four-line access and single line read gate control.

In performing the decoding function, the ten-position BEAM-X Switch operates as a homing switch. A read gate pulse, amplified by a transistor, clears the previously stored information from the BEAM-X Switch and then resets the switch to the "zero" position. As the BEAM-X Switch resets, a second transistor generates an information access gate pulse which turns on four binary information input transistors. Depending upon the binary information at the input to these transistors during the access gate time, voltage levels are established within the BEAM-X Switch so that the beam switches to the decimal output position corresponding to the binary input. Upon termination of the information access gate, the four binary input transistors are turned off. The BEAM-X Switch retains the information stored in it until the next conversion cycle begins.

This type of decoder operation is commercially available in a series of BEAM-X decoder modules (Types DC-115-A, DC-115-B, DC-115-C, etc). The modules are designed to decode various BCD codes to decimal form.

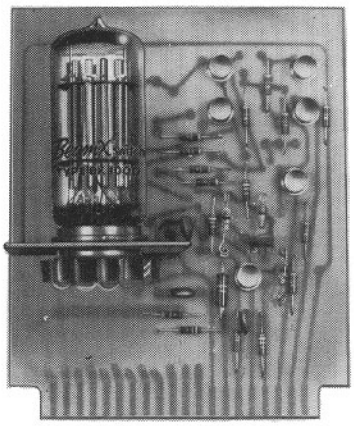


Fig. 24 — DC-115 Module

A photograph of a typical DC-115 module is shown in Figure 24. Each unit is designed to operate remotely located NIXIE tubes directly. The table below lists the various modules and the data which they convert. Detailed technical specifications can be obtained by referring to the BEAM-X Modules Brochure #405. Other codes can also be converted and modules can be prepared to your specifications.

Decoder Type #	*Code Converted*
DC-115-A	8-4-2-1
DC-115-B	8-4-2-1 (constant current read gate)
DC-115-C	4-2-2-1
DC-115-D	2-4-2-1
DC-115-F	5-3-1-1

In the preceding sections, typical circuits have been supplied as a guide to the operation of NIXIE tubes in electronic counting and decoding systems by means of the BEAM-X Switch. The BEAM-X Switch holds a definite advantage over other electronic techniques in these areas since the device replaces as many as eighteen transistors, and forty diodes or resistors which would be required to perform the same function in an all-solid state design. This can be seen by comparing the all-transistor decoding circuit shown in Figure 25A with the transistor-BEAM-X decoder shown in Figure 25B.

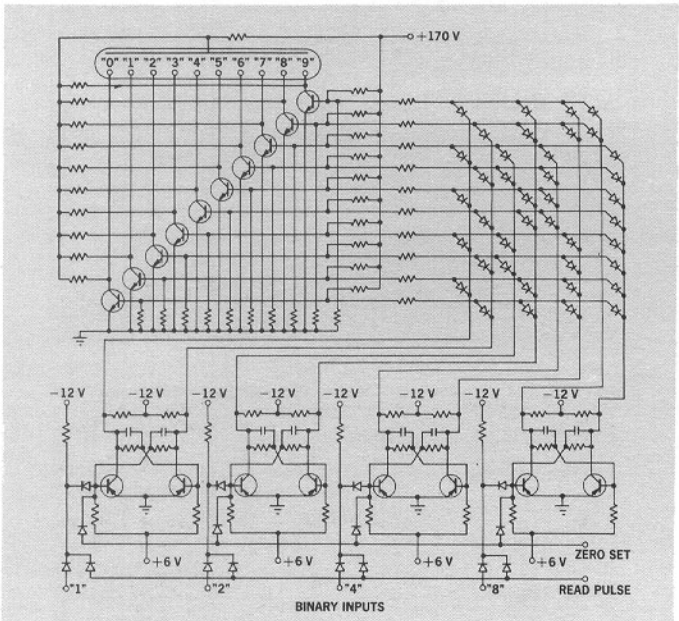


Fig. 25A — Typical All-Transistor Decoder Circuit

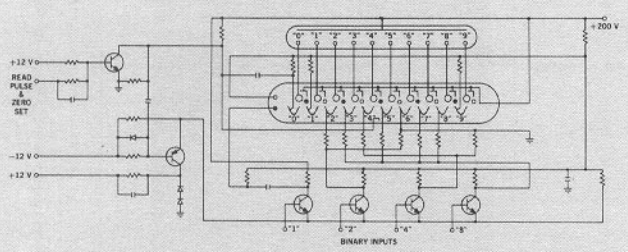


Fig. 25B — Beam-X Switch Decoder Circuit

TRANSISTOR CIRCUITS

Low cost NPN transistors suitable for driving NIXIE tubes have been developed by leading semi-conductor manufacturers. When the NIXIE tube was originally introduced to the market, there was some difficulty in obtaining NPN transistors which would drive the NIXIE tube conveniently. Being a neon device, the NIXIE tube requires a relatively high voltage and low current. The total power involved is quite small since the neon glow is an efficient light emitter and very little heat is generated. Transistors are typically low voltage, high current devices, and a problem of compatibility existed.

Originally, it was felt that the transistors used with the NIXIE tubes would have to be able to switch voltages approaching 100 volts. Later experience showed that the pre-bias voltage which must be switched to operate the NIXIE tube reliably is approximately 33% (usually about 50 V) of the sustaining voltage for the NIXIE tube being used. It was further determined that relatively inexpensive and low voltage transistors can be used with the NIXIE tube by employing the TRIXIE® driver technique. (Packaged TRIXIE modules are described on Pages 15, 22 and 24 of this brochure).

In the TRIXIE driver technique, transistors used to select the number desired to be "on" are operated as saturated switches.

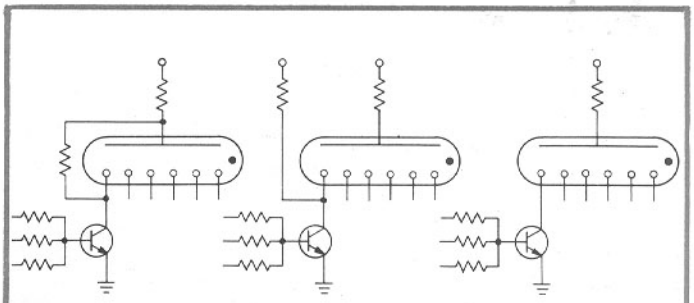


Fig. 26 — Typical TRIXIE Circuit Configuration

The "off" transistors are usually operated in a back bias BCVEX condition with a base resistor or a combination of base resistors. The electrical characteristics of the NIXIE tube's "off" cathodes are important because they help determine the operating point of the transistor associated with the "off" cathode. The "off" cathode looks like a current source to the transistor associated with this cathode. The source current is a function of the leakage currents between the NIXIE tube "off" cathode and the anode, and the "off" cathode and the "on" cathode. This current is dependent upon the physical position within the tube of the "off" cathode with respect to the "on" number. The following graph shows a typical V-I plot of this characteristic. This curve is similar to that shown as Figure 14 in the discussion of pre-bias (page 10).

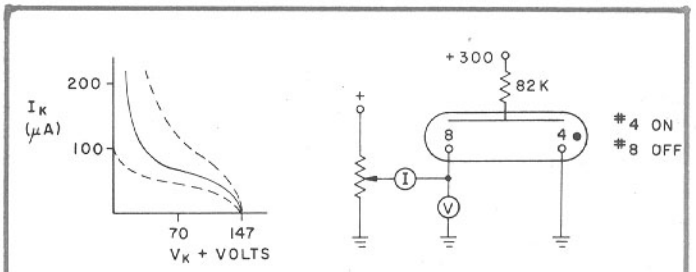


Fig. 27 — Characteristics of NIXIE tube "off" cathodes

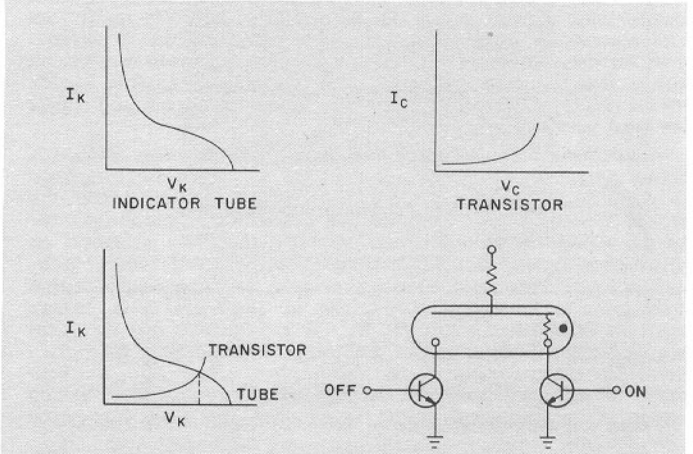


Fig. 28 — Combination of NIXIE tube and Transistor Curves

The exact shape of the curve depends on the number selected, the ambient temperature, and the characteristics of the NIXIE tube used. If the operating voltage of the "off" cathode is less than about 50 volts and the current greater than 100 microamperes, there will be a glow forming on the "off" cathode. This is an undesirable operating condition and reduces the resolution of the "on" number. The amount of leakage current is dependent upon the voltage breakdown characteristics of the transistor used. The operating point of the transistor-NIXIE tube combination is that point where the NIXIE tube characteristic intersects the transistor voltage breakdown curve. Figure 28 shows the combination of a typical transistor characteristic curve and an average NIXIE tube V-I curve similar to that in Figure 14. This point establishes the voltage of the "off" cathodes.

General circuit configurations in use at the present time are illustrated below:

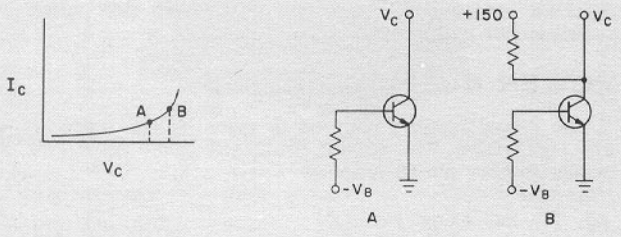


Fig. 29 — General Circuit Configuration

The purpose of the extra resistor connected to the collector of the transistor is to cause the transistor to operate at a higher voltage level than if the resistor was not present. The extra resistor connected to the collector should not be necessary with transistors having high breakdown voltages. Operating conditions for the transistor when used as a switch with the ultra long life NIXIE tube are as follows:

OFF: The NIXIE tube "off" cathode looks like 140 volts in series with 600 kilohms. This together with any external resistor is the current source for the transistor. The transistor is usually operated in a BVCEX condition. Back bias ranges from −3 volts to −10 volts, base resistance ranges from 1,000 to 20,000 ohms.

ON: The NIXIE tube in the "on" condition looks like 140 volts in series with 50,000 ohms. The current ranges from 1.5 milliamperes to 3 milliamperes maximum. The absolute values of voltage and current depend on the supply voltage used and the operating point chosen by the designer.

Important facts to consider in the choice of a transistor for use as a NIXIE tube driver are:

1. The breakdown voltage under conditions of back bias and base resistance should be high enough so that under worst case conditions there will be no glow on an "off" number (see table of pre-bias limits, page 10).
2. The dc beta must be high enough to keep the transistor in the "on" condition under minimum base drive.
3. The high temperature leakage should be low enough to be insignificant.
4. The transistor should not exhibit avalanche breakdown within the operating conditions (see Figure 30). This is an important consideration when silicon transistors are used. Collector currents as low as 100 microamperes may cause a unit to "fire" to a lower voltage. This lower voltage may be called the sustaining voltage. If the transistor will fire under the operating conditions, the switch may act as a free running sawtooth generator (see Figures 30, 30A and 30B) . The amplitude of the sawtooth will depend on the difference between BVCEX and LVCEX. To avoid this condition, transistors should be selected to have firing currents higher than 500 microamperes.

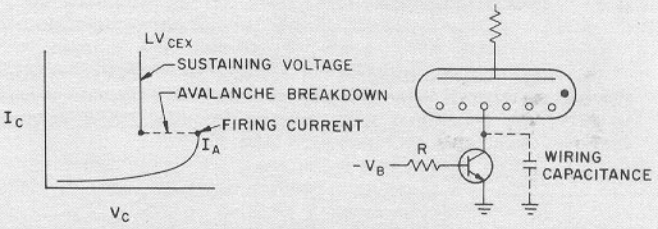


Fig. 30 — Typical Voltage Breakdown Characteristic Triple-Diffused Silicon Transistor

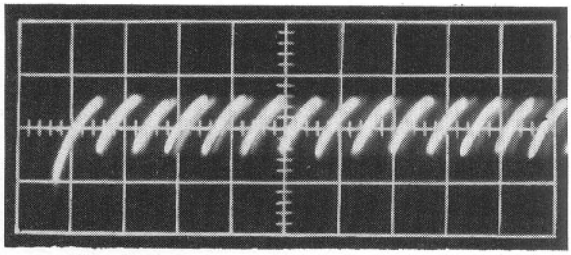


Fig. 30A — Photo of Waveform 500 μsec/div.

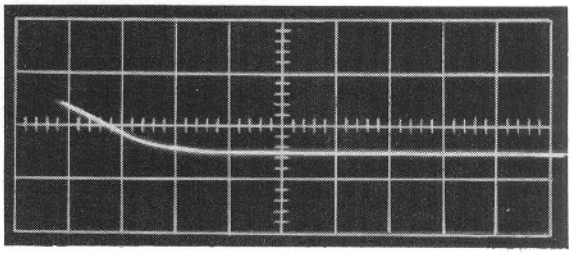


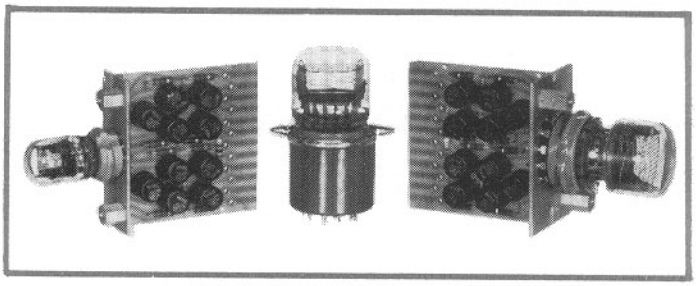
Fig. 30B — Photo of Waveform 0.1 μsec/div.

A number of transistors suitable for operation with NIXIE tubes are currently available. Among these are the following:

SILICON		*GERMANIUM*	
Company	*Type*	*Company*	*Type*
Pacific Semiconductor	PT 1413	General Transistor Corp.	2N1310, 2N1311, 2N1672A
Texas Instruments Co.	TI 496		
Industro Transistor Corp.	TRS 3281		
Fairchild Semiconductor	2N1990		

PACKAGED TRIXIE MODULES

Burroughs has developed a series of transistor driver modules to drive NIXIE tubes. The pictures of these modules are shown below:



Two series of modules are available, one using germanium transistors and the other using silicon transistors. The germanium transistor modules are types TR-40, TR-59, and TR-57. The silicon TRIXIE series includes the TR-41 and TR-58 types. Specifications for the germanium series and silicon series TRIXIE modules are given in the Accessories Section of this brochure on pages 22 and 24.

TRANSISTOR DECODING

The base current required to activate the TRIXIE transistors driving the NIXIE tube is relatively small. It is therefore feasible to drive the transistors with resistor decoding matrices such as the ones illustrated in Figures 31 and 32.

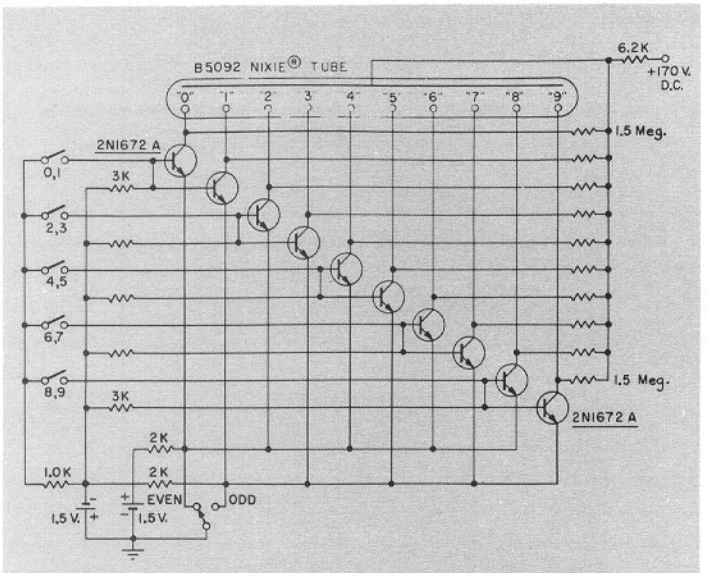


Fig. 31 — Bi-Quinary Code to Decimal Readout Translator

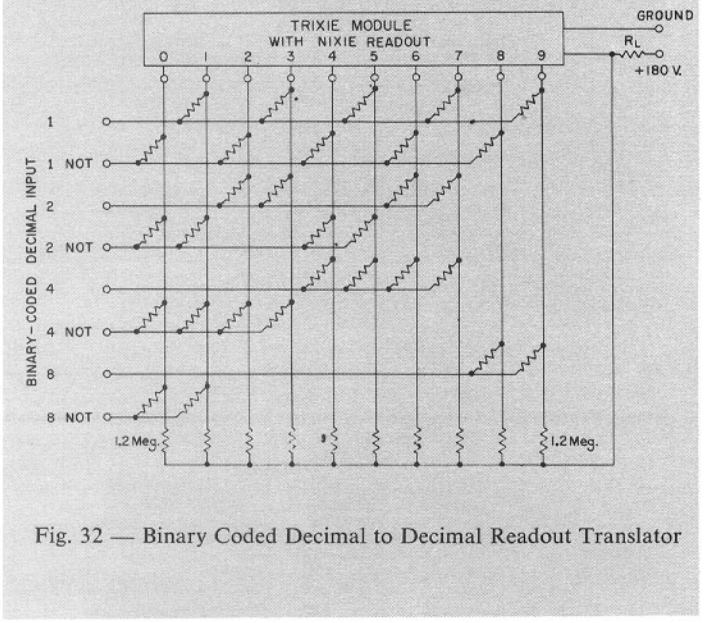


Fig. 32 — Binary Coded Decimal to Decimal Readout Translator

ELECTRO-MECHANICAL DRIVE CIRCUITS

In addition to the relatively sophisticated types of drive circuits described above (BEAM-X Switch, transistors), a NIXIE tube may be operated in a simple electro-mechanical circuit in which each cathode is turned "on" by operating a mechanical switch. A typical circuit of this type is shown in the figure below:

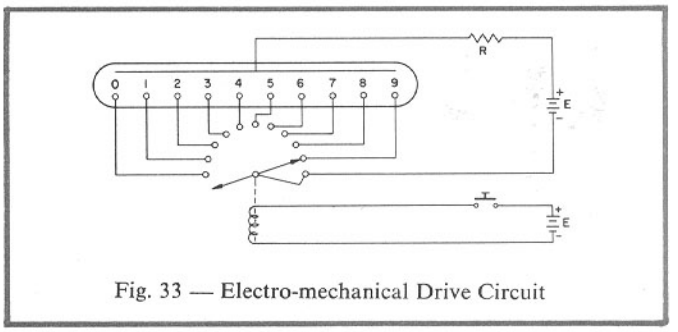


Fig. 33 — Electro-mechanical Drive Circuit

Typical applications of this technique would be in the areas of status boards, data loggers, cable testers, and automatic similar checkout equipment, in which the relatively slow speed of the switch is not prohibitive.

POWER SUPPLY CIRCUITS

The power supplies required to drive NIXIE tubes are simple and inexpensive. The circuits illustrated below show how several power supplies can be designed.

AC TO DC CONVERSION

A closely regulated supply is not required, since relatively large amounts of ripple in the power supply will not cause a noticeable flicker or change in brightness in the NIXIE tube. Typical circuits are shown in Figures 34 and 35.

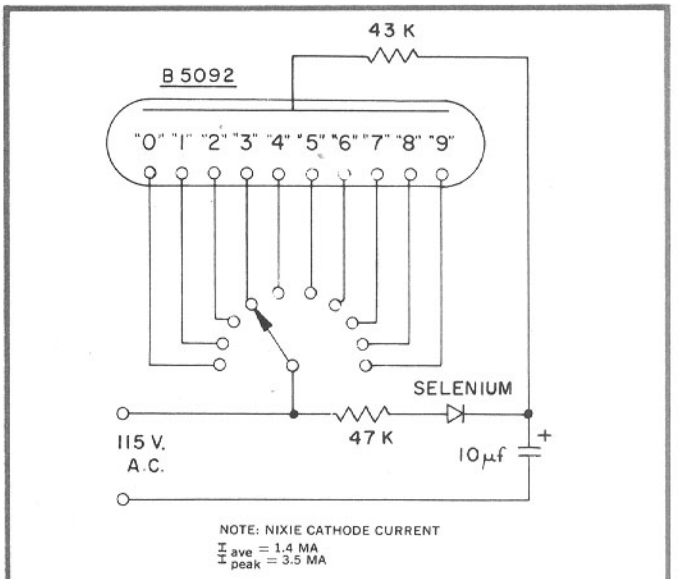


Fig. 34 — Nixie tube operation from 115 V.A.C.

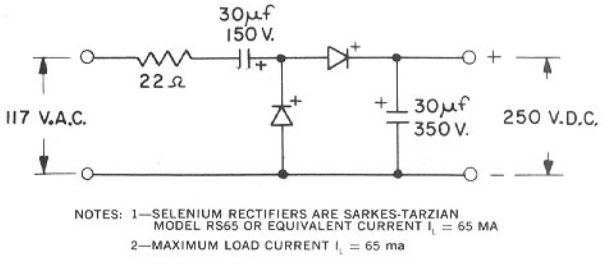


Fig. 35 — Power Supply (250 volts)

DC TO DC CONVERSION

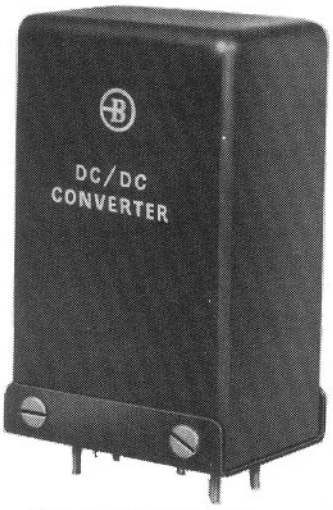


Fig. 36 — VC 12-170 DC/DC Converter Module

In some equipments, AC power is not available. For these applications, Burroughs has developed a line of DC/DC Converter Modules which are capable of converting either 12 or 28 volts DC to 170 volt DC for operating NIXIE tubes. The circuits for the 12 and 28 volt converters are given below. The dimensions for the units are approximately 2½" wide, 1½" deep, 3¾" high.

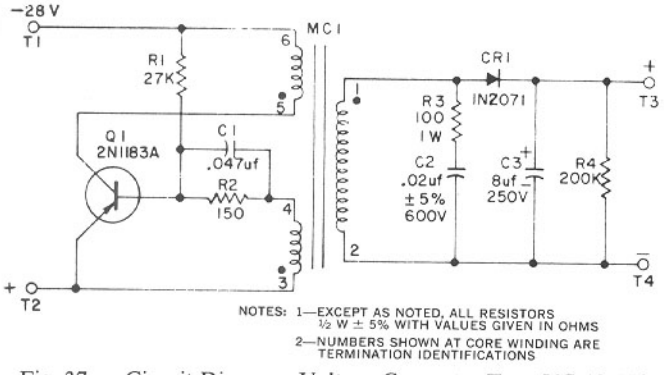


Fig. 37 — Circuit Diagram, Voltage Converter Type VC 12-170

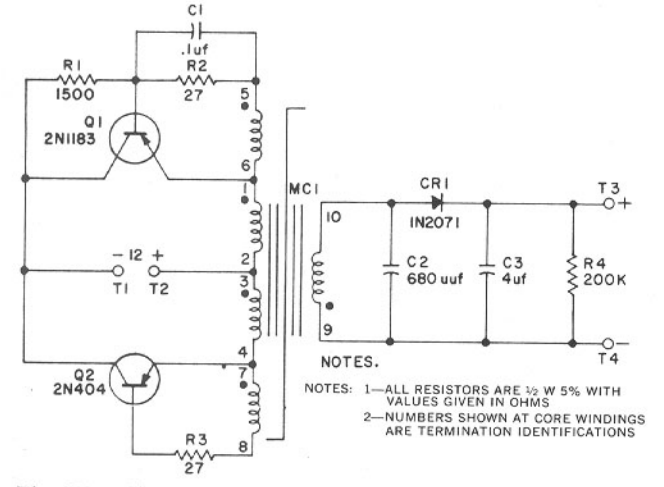


Fig. 38 — Circuit Diagram, Voltage Converter Type VC 28-170

Specifications for the packaged voltage converters are given in the Accessories Section of this brochure (Page 26). These units, when used in conjunction with the TRIXIE modules, provide an ideal combination for use in fully transistorized systems.

DIMMING

The NIXIE tube is a constant current device, and consequently, under normal conditions exhibits a constant intensity glow. When the NIXIE tube is to be used in areas where the ambient light is subdued, such as in radar rooms, the intensity of the NIXIE can be diminished by using dimming circuits, which turn the NIXIE tube on and off. The duration of the off part of the on-off cycle controls the degree of dimming. The on-off cycle rate should be fast enough to prevent visible flicker. Several circuits illustrating how this may be done are given below.

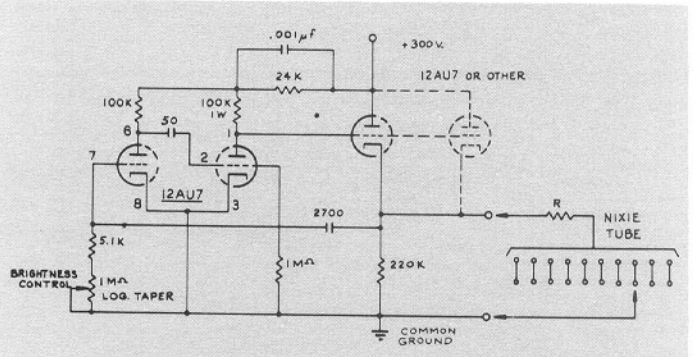


Fig. 39 — Nixie Tube Dimming Circuit

Figure 39 shows a low cost method of controlling the brightness of a NIXIE tube display. The circuit consists of a free-running multivibrator, one output of which is directly coupled to a cathode follower. The multivibrator produces positive pulses of 200 volts amplitude and 100 microseconds duration at variable repetition rates. The high output impedance of the multivibrator is transformed by the cathode follower to a low impedance source driving the NIXIE tube or tubes.

The cathode follower is also made a functional part of the multivibrator charging the large 2700 uuf capacitor by its output. Plate one of the multivibrator is thereby allowed quickly to recover to its positive buss, being loaded only by the high impedance input of the cathode follower.

The 1.0 megohm potentiometer is part of the time constant that determines the repetition rate of positive pulses appearing at the output and is therefore used as a brightness control. Potentiometers having a logarithmic or similar taper will allow the brightness of the NIXIE tube to be a nearly linear function of the control shaft's displacement.

The cathode follower swings between approximately 50 volts and 250 volts above ground in accordance with the output of the multivibrator. It must be capable of handling the total current required for the number of NIXIE tubes used. The type 12AU7 tube can handle several NIXIE tubes and is, therefore, sufficient for most applications of this circuit. The average cathode current for various types of NIXIE tubes is tabulated in the Electrical Data Section of this brochure and can be used to calculate the total current drain through the cathode follower.

Every NIXIE tube should have a separate current limiting resistor R whose value is shown below.

Tube Group	*Tube Type*	*Value of R*
Miniature	7009	100 K ohm
	7977 (B4032)	82 K ohm
	B4021	100 K ohm
	B4081	100 K ohm
Standard	6844A	39 K ohm
	8037 (B5031)	36 K ohm
	B5092	36 K ohm
Super	7153	33 K ohm
	B6033	27 K ohm
	B6091	27 K ohm

Figures 40 and 41 show transistorized dimming circuits for NIXIE tubes. Both utilize a standard, commercially available EECO multivibrator type T-104. The +12 volt supply can be obtained readily by use of a resistor from the higher B+ supply.

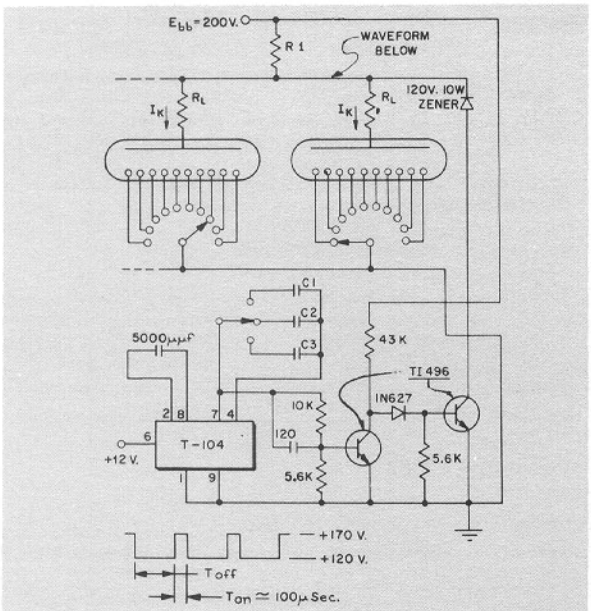


Fig. 40 — Nixie Tube Dimming Circuit

In Figure 40, a switch type input is used. The value of R_L is dependent upon the number and type of NIXIE tubes used. R_L can be calculated by use of the formula

$$R_L = \frac{E_{bb} - E_b}{(I_k)\ (\text{No. of Tubes})}$$

where $E_b = +170V$ and I_k is the average cathode current of the NIXIE tube type selected. For 3 type B5092 standard tubes, the value of R_L would be 4.3 K ohm. In operation, the circuit alternately lowers and raises the anode buss (E_b) of the NIXIE tubes by a 50V step. This action causes the tube to extinguish and ionize at a rate which is controlled by the value of the capacitor selected (C_1, C_2, C_3, etc.).

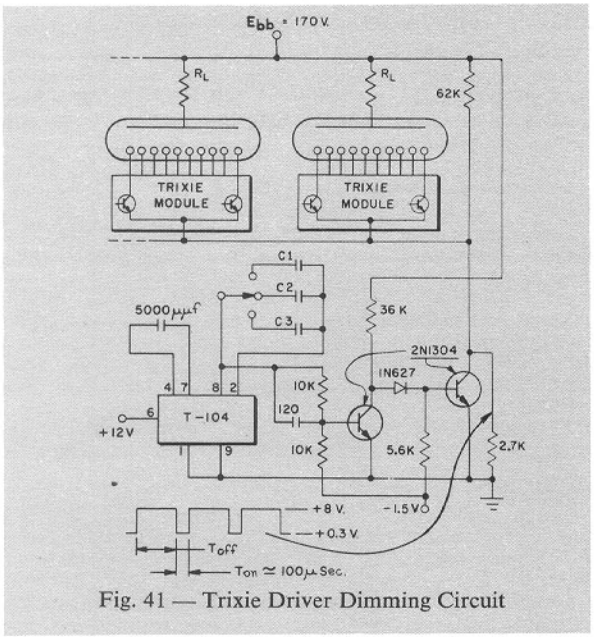


Fig. 41 — Trixie Driver Dimming Circuit

Figure 41 shows a similar circuit for use with transistorized NIXIE tubes such as TRIXIE driver modules. Here the voltage step is applied to the common emitters of the transistors gating them "on" and "off" at a predetermined rate which again is established by the value of the capacitors selected. This circuit operates directly from the NIXIE anode supply (+170V) which eliminates the need for selecting an additional series resistor as in Figure 40.

Both circuits (Figures 40 and 41) are capable of operating as many as 12 standard size NIXIE tubes. The values of R_L in these circuits will be determined by the type of NIXIE tube used and can be found in the Electrical Data Section of this brochure.

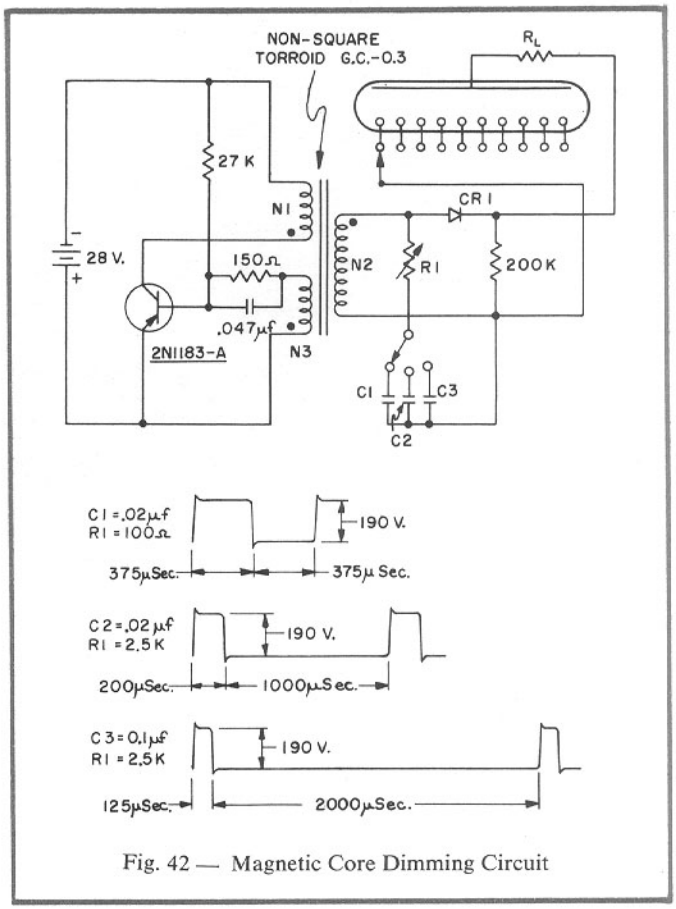


Fig. 42 — Magnetic Core Dimming Circuit

Another unique dimming circuit has been developed around the DC to DC Converter modules which were described under Power Sources. Not only does the circuit allow the NIXIE tube to be operated from a low voltage supply (28 V in this case), but it also provides a wide range of brightness. A free-running blocking oscillator is used as a DC to AC converter and converts the low voltage of the supply into high voltage pulses (190 V) suitable for lighting the NIXIES. When R_L in the circuit is at its maximum setting and C, is in the circuit, the frequency is 1.5 KC at a 50-50 duty cycle. The brilliance of the NIXIE tube is very nearly equal to that obtained with 170V DC. Brightness control is achieved by varying the ratio of on-to-off time of the oscillator and hence the NIXIE tube. Intensity ratios of greater than 10:1 have been achieved.

Operation is as follows: When the transistor conducts, power is delivered to the load and C_1 charges to the full secondary voltage via R_L. When the core saturates, the cut-off cycle is initiated. C_1 discharges through the secondary winding via R_L, thus resetting the core to the opposite end of the hysteresis loop and allowing the cycle to start over. By varying R_L and C_1, the amount of reset current can be controlled. This in turn determines the amount of flux switched in the core. Thus, the reset or "off" period can be changed by varying the ϕ in the equation.

$$E = \frac{Nd\phi}{dt}$$

The diode blocks the backswing of the transformer and presents pulses of uniform height to the NIXIE tubes.

BLANKING

In some readout applications, it is desirable to have the NIXIE tubes lighted (ionized) only when data is to be observed. At all other times the display is darkened even though the peripheral circuitry may still be accumulating new data.

Blanking of NIXIE tubes can be accomplished most simply by merely inserting a mechanical switch in the anode circuit of the tube. When the switch is closed, the full supply voltage is applied to the NIXIE tube anode. Assuming that input information is present on one of the cathodes of the tube, the corresponding data will be displayed.

Electronic methods of blanking are also readily achieved. Figure 43 shows several variations of a transistorized blanking technique

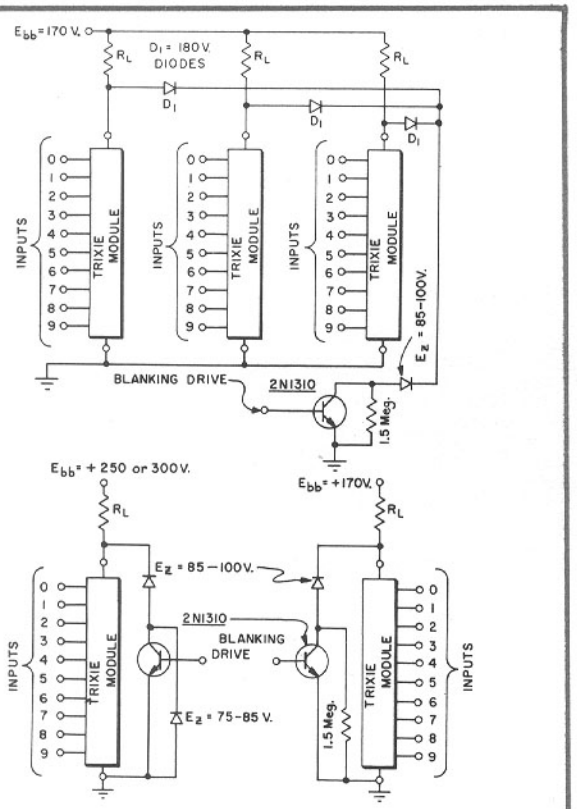


Fig. 43 — Blanking Circuit for TRIXIE Modules

which is applicable to the TRIXIE modules. In each circuit, the blanking current drive is 800 ua per TRIXIE module. Detailed specifications for TRIXIE modules are contained in the Accessories Section of this brochure.

Values of R_L (anode series registor) to be used in the blanking circuit for various NIXIE tube types are the same as those contained in TRIXIE module specifications. Power ratings for R_L and the Zener diode can be calculated by use of the following formulas:

$$P_{R_L} = \frac{(E_{bb} - E_Z)^2}{R_L} \qquad P_Z = \frac{(E_{bb} - E_Z)\, E_Z}{R_L}$$

where E_Z is the Zener Voltage drop of the diode.

Blanking circuits can also be incorporated in BEAM-X Switch — NIXIE tube circuits. For example, on page 11 of this brochure, the circuit of a 1 MC Decade Counter was shown (Type DC-116, Figures 17 and 18) and reference was made to other BEAM-X Counters in the section. These circuits can be adapted for blanking by merely connecting the target output terminals through diodes to a common blanking input pulse of 90 volt amplitude. Figure 44 shows how the connections are made between the input, the target outputs of the BEAM-X Switch circuit, and the NIXIE tube cathodes. This circuit should be used in conjunction with Figure 17, the DC-116 circuit.

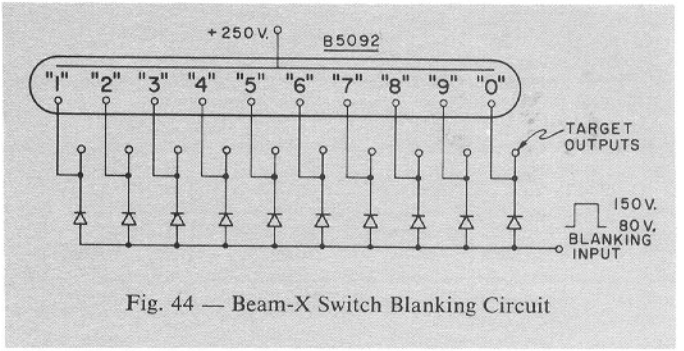


Fig. 44 — Beam-X Switch Blanking Circuit

The operation is as follows: The targets of the BEAM-X Switch would normally fall to a +100 volt potential when the NIXIE tube is ionized. However, when the blanking pulse is present, the targets are held at a +150 volt level which limits the amount of voltage which can develop across the NIXIE tube. Under these conditions, the NIXIE tube will not ionize and the display will be dark.

IONIZATION TIME

When the NIXIE tubes are to be photographed for data recording purposes, the ionization time is generally of interest. Burroughs has conducted a series of tests to determine what the ionization time is for NIXIE tubes. The results of these tests indicate that the ionization time is quite variable and depends on several factors. One of the most important factors is the ambient light in the vicinity of the NIXIE tube. When a strong ambient light is available in the vicinity of the NIXIE tube, ionization may occur in intervals ranging from twenty microseconds to 300 microseconds. Where strong ambient light is not available, ionization times tend to be considerably longer. Under conditions where no ambient light is available, ionization times may be very long and in the order of several seconds. This can normally be overcome by using a relatively large voltage and series resistance with the NIXIE tube. The larger voltage across the tube causes ionization to occur more readily and speeds up the ionization once it occurs. Tests have shown that dark ionization can also be improved by putting small amounts of radioactive material inside the tube. Should an application involving dark ionization occur, Burroughs is prepared to supply special dark ionization NIXIE tubes.

READABILITY AND MOUNTING INFORMATION

The appearance of an electronic instrument or other piece of equipment in which a digital display is used can be greatly enhanced by careful attention to the way in which the readout device is mounted and by giving consideration to the factors which are discussed in the following paragraphs.

The NIXIE tube is a relatively bright indicator, and can be read easily under normal ambient lighting conditions at distances approximating 40 feet per inch of character height. For example, the commonly used ultra long life, wide angle NIXIE tube, type B5092, can be read at distances of about 27 feet by people with normal eyesight. When ambient light conditions are either very bright or very dim, the maximum viewing distance is somewhat reduced. The maximum included angle of viewability for all NIXIE tubes is greater than 100°. The newer wide angle series of NIXIE tubes has an especially broad viewing angle (160°) and they are recommended for applications where the display must be seen from extreme angles.

Burroughs conducted a series of readability tests which were used to determine both the maximum reading distance and viewing angle for both the NIXIE tubes and competitive readouts. The results of this series of readability tests are tabulated and discussed in a brochure entitled, "Readout Fact Finder". Information on size, weight, cost, and other factors involved in selection of readouts, is also included in the Readout Fact Finder. This brochure is available on request.

Generally speaking, it is desirable to mount NIXIE tubes in an enclosure which has been painted with a dull black paint so that reflected light is minimized. The coating will eliminate reflections both from ambient light sources and from the glow generated in the NIXIE tubes themselves. When the equipment is to be used in an area where the ambient light level is relatively bright, a piece of filter material should be placed in front of the NIXIE tubes to cover the recess in which the NIXIE tubes are mounted. A piece of circular polarizing material or an ordinary red or amber plastic filter is useful. Both the Polaroid filter and plastic filter will reduce the amount of ambient light reflected from the glass surface of the NIXIE tubes, and from the numbers within the tube. This serves to improve the contrast and consequently, the readability of the display. Red or amber filters are recommended since the glow of the NIXIE tubes is in this sector of the color spectrum. The ultra long life series of NIXIE tubes has a characteristic bluish halo which is associated with the ultra long life feature. This bluish haze is also eliminated by using red or amber filters.

The density of the filter used with the NIXIE tube is not critical, but should be related to the ambient light condition anticipated. If the NIXIE tube is to be used in a darkened area, such as a radar room, it is desirable to use a relatively dense filter so that the brightness of the display is compatible with the other illumination in the area. Polaroid filters are generally preferred in all readout applications and are particularly useful when high ambient light levels are encountered. Polaroid filters are constructed so that ambient light entering the display through the filter will be polarized into a single plane. The filter material is approximately ¼ wave length thick and will impart a 45° rotation to the ambient light which passes through the filter. When the ambient light is reflected from the surface of the NIXIE tube or from the numbers inside the NIXIE tube, it is given a further 45° rotation so that when it reaches the inner surface of the filter, it is now 90° out of phase with the polarizing layer. By this means, nearly all of the ambient light which would ordinarily be reflected off the surface of the NIXIE tube is eliminated and consequently, the contrast between the glow generated by the NIXIE tubes and the background around the NIXIE tubes is greatly enhanced. Further information on polaroid filters may be obtained by writing The Polaroid Corporation, Cambridge 39, Massachusetts.

The design of the enclosure and bezels used with the NIXIE tube display has a strong influence on the viewing angle and appearance of the display. The aperture of the bezel which is used with the NIXIE tube should be as large as possible, consistent with the panel space available. If the aperture of the bezel is too small, it will tend to limit the viewing angle of the NIXIE tubes. The depth of the recess in which the NIXIE tube is mounted should be only slightly greater than the depth of the tube itself. The front surface of the NIXIE tube should be just behind the plane in which the filter material is mounted. The wide viewing angle series of NIXIE tubes feature envelopes which are flat in the front and the numbers are positioned closer to the face of the tube. The result is that the numbers themselves can be positioned a great deal closer to the front of the bezel for maximum readability. The following diagram shows a typical bezel construction for a standard size NIXIE tube display.

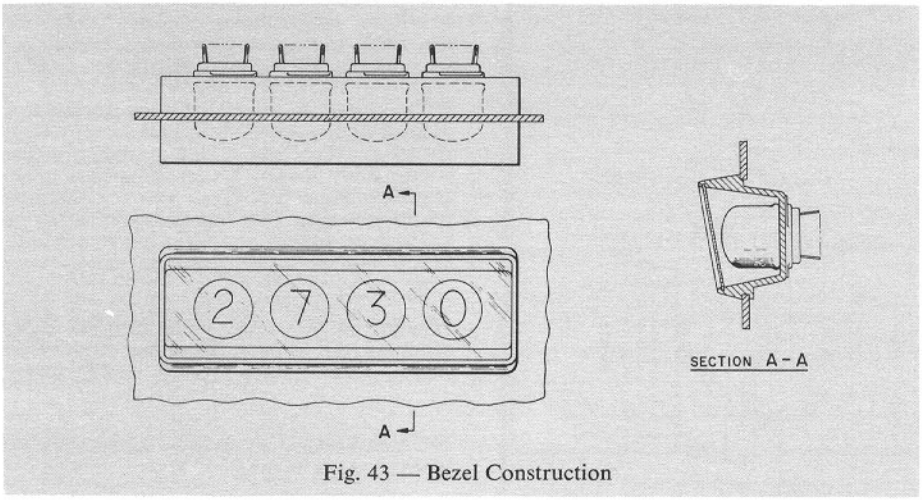


Fig. 43 — Bezel Construction

NIXIE TUBE ENVIRONMENTAL DATA

Environmental tests have been performed successfully as a part of the design test for most of the tube types listed in this catalog. These typical tests are:

ALTITUDE: 70,000 feet. The tubes were tested for high voltage breakdown per MIL-E-1D, Paragraph 4.9.12.1

TEMPERATURE: −65° C. to +85° C. operating and non-operating.

SHOCK: 250G, 1.5 ± 1 millisecond duration ½ sine wave pulse.

VIBRATION: (1) 10 to 50 to 10 cps, .08 inch double amplitude excursion, five minutes duration per MIL-E-1D, paragraph 4.9.20.3.

In addition to the above tests, some NIXIE tube types have been tested to specific environmental tests such as:

SHOCK: 50G, 11 ± 1 millisecond duration. The test exceeded the requirements of MIL-STD-202, Method 205B, Cond. C.

VIBRATION: 10-500-10 CPS, 10G's, per MIL-STD-202 Cond. A, Method 204A.

FATIGUE: MIL-E-1D, 25 cycle, .08 inch excursion, 96 hours Paragraph 4.9.20.6

SALT SPRAY: MIL-STD-202B, Method 101A, Cond. A 96 hours.

HUMIDITY: MIL-E-1D, 96 hours — Paragraph 4.9.9

GLASS STRAIN: MIL-E-1D — Paragraph 4.9.6.3

ACCESSORIES

The Burroughs Corporation has a complete line of Accessories to be utilized for the successful incorporation of NIXIE Indicator Tubes into your equipment. These Accessories consist of Sockets, Pin Straighteners, Wiring Plugs, TRIXIE Driver Modules and DC/DC Power Supplies.

SOCKETS

All sockets* are made of materials that will meet military specification requirements as follows:

1. The phenolic material used on the socket body is mica-filled, MFE, per MIL 14 and conforms to the requirements of MIL-S-12883.
2. The material used in the contacts is beryllium copper.

These sockets will also meet shock and vibration requirements per MIL-T-21200. It should be noted that none of these sockets have been qualified for the above referenced specification.

*The only exception to the above listing would be sockets that will be referenced later as commercial grade sockets which will not meet these material requirements.

PIN STRAIGHTENERS

Pin Straighteners have been developed for use with the NIXIE Indicator Tubes to insure that all pins are in perfect alignment before insertion in socket. It is highly recommended that they be used on all equipment since it eliminates the possibility of tube breakage due to jammed or bent pins.

WIRING PLUGS

Wiring Plugs are designed to insure that the socket contacts are maintained in proper alignment for the receipt of the NIXIE Indicator Tubes. This is especially true in configurations where the contacts are rigidly held during the wiring process in a specific equipment. At the present time wiring plugs are available for standard and super size tube sockets only.

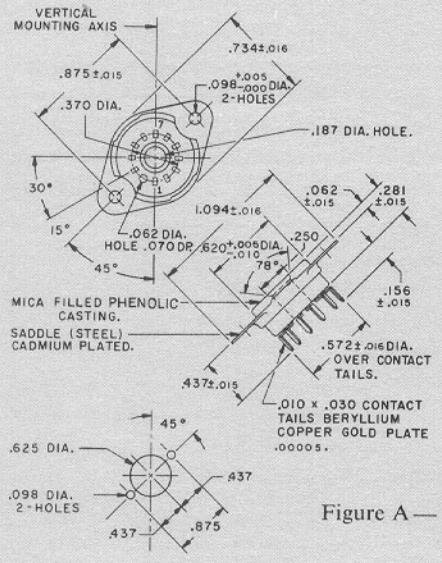
TRIXIE DRIVER MODULES

Since the NIXIE Indicator Tubes are essentially high voltage low current devices, and transistors are low voltage high current devices, a basic incompatability normally exists between them. Burroughs Corporation has developed a special driving technique which enables the NIXIE tubes to be directly operated by transistors. This technique is described in detail in the technical section on pages 14 and 15.

Specifications for available modules to drive miniature, standard, and super size NIXIE tubes are listed within the following pages.

All these accessory units will be classified according to the respective sizes of NIXIE Indicator Tubes to which they apply.

MINIATURE TUBES



SOCKETS

The following additional sockets are available which are mechanically and physically identical to the SK116A except as noted.

SK118A — Equivalent to SK116A except socket without saddle.

SK119A — Equivalent to SK116A except saddle is reversed for top panel mounting.

Figure A — Outline Drawing of SK116A

PIN STRAIGHTENER

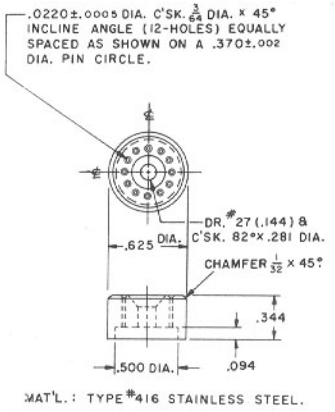
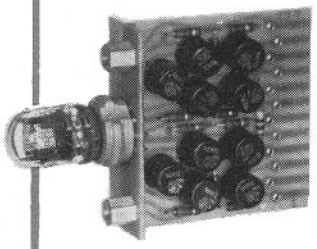


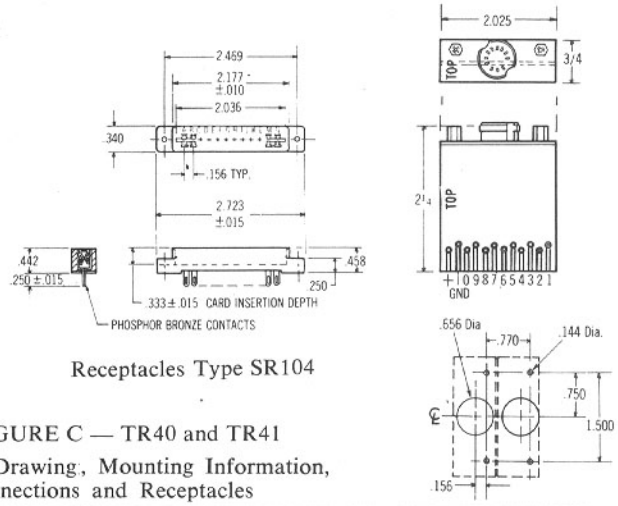
Figure B — Pin Straightener LS208

TRIXIE DRIVER MODULES

TRIXIE readouts are low-voltage input modules for driving NIXIE indicator tubes. Two units are available for Miniature type Nixie tubes: Type TR 40 using germanium transistors, and Type TR 41, which utilizes silicon transistors. Both units are of printed-circuit construction and are used with printed circuit receptacles.

The technical discussion of transistor drive of NIXIE tubes has been presented on Pages 14 and 15.





Receptacles Type SR104

FIGURE C — TR40 and TR41
Outline Drawing, Mounting Information, Connections and Receptacles

ELECTRICAL CHARACTERISTICS

	TR40	TR41
RATINGS, ABSOLUTE (25° C AMBIENT)		
Bias Voltage (each of 9 inputs)	−3 V Max, Note 5	−1.0 V Max, Note 1
Dissipation Per Transistor (Transistor)	150 mW Max	0.6 W Max
Collector Junction Temperature (Transistor)	85°C Max	+126°C Max
Collector Current (Per saturated transistor)	100 mA	50 mA
TEST CONDITIONS (@ 25° C)		
Bias Voltage	−1.5 V	−0.5 V
Drive Current (one input)	0.22 mA, Note 2	0.3 mA, Note 2
Anode Current	3 mA	3 mA
TEST LIMITS (@ 25° C)		
Bias Current (each of 9 inputs)	0.4 mA Max, Notes 3 & 4	0.2 mA Max, Notes 3 & 4
Base-Emitter Saturation Voltage	0.5 V Max, Note 4	1.0 V Max, Note 4
Collector-Emitter Voltage (saturated transistor)	1.0 V (Nom)	2.0 V Max
Collector-Emitter Voltage (off transistor)	50 V Min	60 V Min

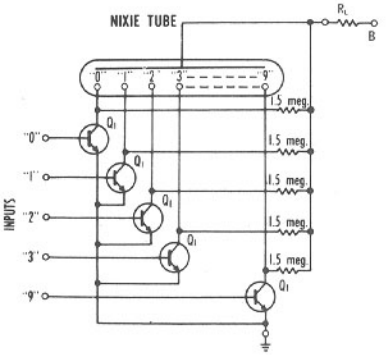


Figure D — Circuit Drawing

NOTES

1. This is the emitter to base breakdown voltage ratings of the transistors. A bias source in excess of this value may be used with appropriate current limiting resistor in series with each base.
2. At lower temperatures, greater base drive may be required to compensate for the decreased current gain of the transistor.
3. At elevated temperatures, the bias current may increase above the indicated limit.
4. This is an approximate value not normally tested in the TRIXIE module.
5. If this bias voltage is exceeded the quality of the readout may be impaired.

SOCKETS

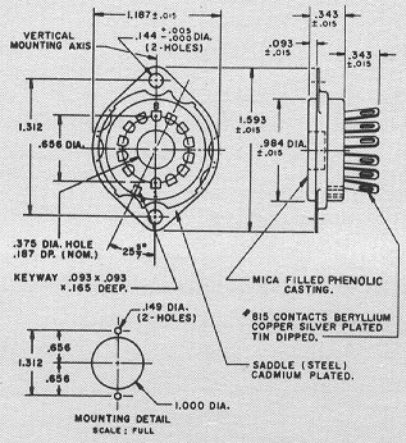


Figure A — SK 112
General Purpose Vertical Mount Socket

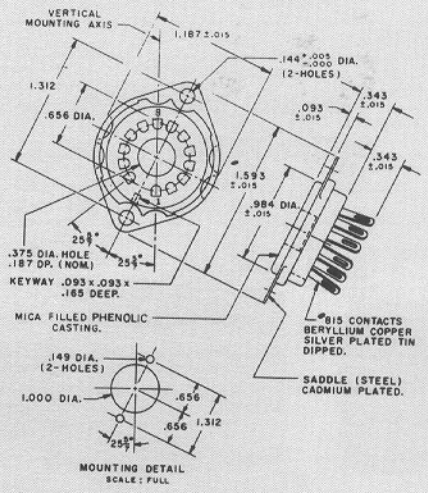


Figure B — SK 106
General Purpose Angle Mount Socket

The following additional sockets are available which are mechanically and physically identical to the SK106 or SK112 except as noted.—

SK120 — *Commercial* Socket. Mechanically and physically same as SK112 except casting is general purpose black phenolic and contacts are brass-cadmium plated finish.

SK124 — Mechanically and physically same as SK112 except supplied without saddle.

SK129 — Mechanically and physically same as SK112 except saddle is nickel plated brass.

SK127 — Mechanically and physically same as SK106 except saddle is nickel plated brass.

SK128 — *Commercial* Socket. Mechanically and physically same as SK106 except casting material is general purpose black phenolic and contacts are brass-cadmium plated finish.

SK134 — Mechanically and physically same as SK106 except saddle is brass, bronze iridite cadmium plated per QQP416 Type II Class A.

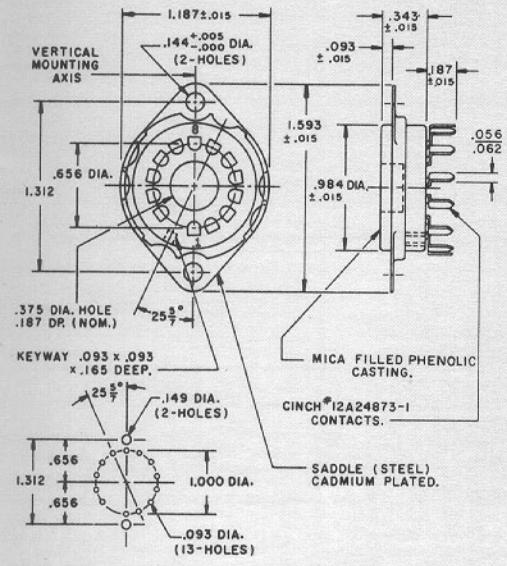


Figure C — SK 130
Standoff Printed Circuit Socket

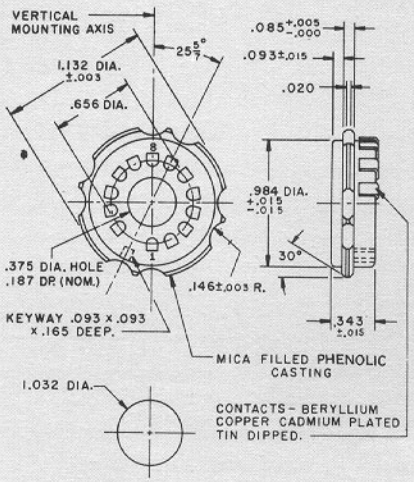


Figure D — SK 109
Butt Type Printed Circuit Socket

SK 125 — Mechanically and physically the same as the SK 130 except without saddle.

WIRING PLUG

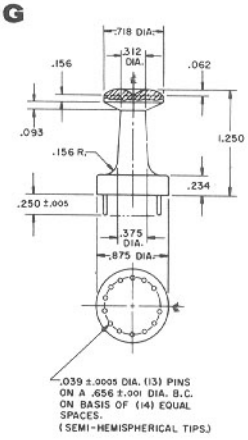


Figure E
Wiring Plug
YF 237

PIN STRAIGHTENER

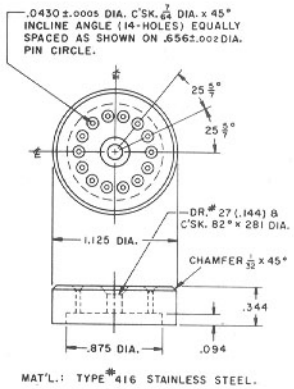
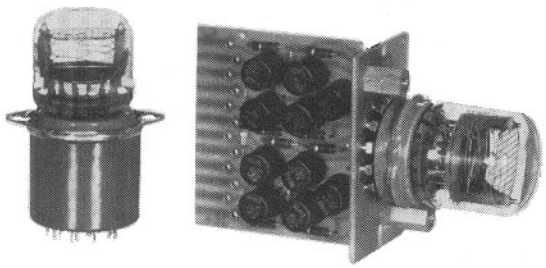


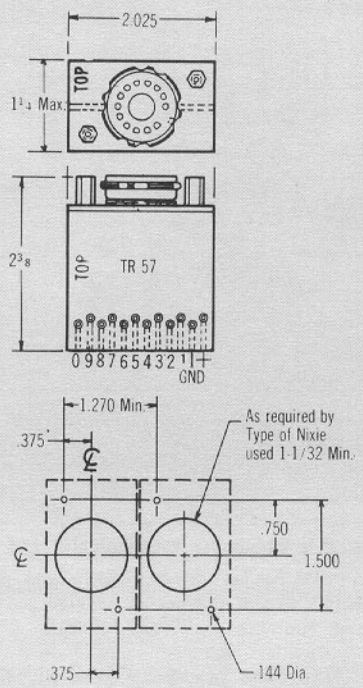
Figure F
Pin Straightener
LS 202

STANDARD AND SUPER TUBES

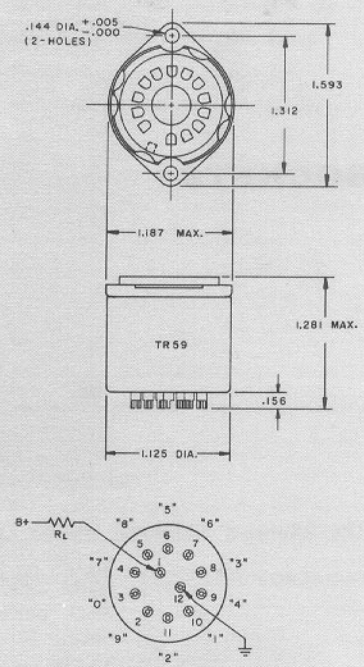
TRIXIE DRIVER MODULES



Three models of TRIXIE drivers are available for use with Standard and Super NIXIE tubes. Types TR 59 and 57 employ germanium transistors. Silicon transistors are used in the TR 58. Both TR 57 and 58 are printed circuit board construction. The TR 59 is a welded construction, and is designed for direct soldering into circuit boards.



TR57-58



TR59

FIGURE G — TR57, TR58 and TR59

Outline Drawing, Mounting Information, and Connections

ELECTRICAL CHARACTERISTICS:

	TR59	TR57	TR58
RATINGS, ABSOLUTE			
Bias Voltage (each of 9 inputs)	−3 V Max.Note 5	−3 V Max Note 5	−1.0 V Max Note 1
Dissipation Per Transistor	150 mW Max.	150 mW Max.	0.6 W Max.
Collector Junction Temperature	+85° C Max.	+85° C Max.	+126° C Max.
Collector Current (Per saturated transistor)	100 mA	100 mA	50 mA
TEST CONDITIONS (@ 25° C)			
Bias Voltage	−1.5 V	−1.5 V	−0.5 V
Drive Current (one input)	0.22 mA Note 2	0.22 mA Note 2	0.3 mA Note 2
Anode Current	3 mA	3 mA	3 mA
TEST LIMITS (@ 25° C)			
Bias Current (each of 9 inputs)	0.4 mA Max.Notes 3 & 4	0.4 mA Max.Notes 3 & 4	0.2 mA Max Notes 3 & 4
Base-Emitter Saturation Voltage	0.5 V Max.Note 4	0.5 V Max.Note 4	1.0 V Max.Note 4
Collector-Emitter Voltage (saturated transistor)	1.0 V (Nom)	1.0 V (Nom)	2.0 V Max.
Collector-Emitter Voltage (off transistor)	50 V Min.	50 V Min.	60 V Min.

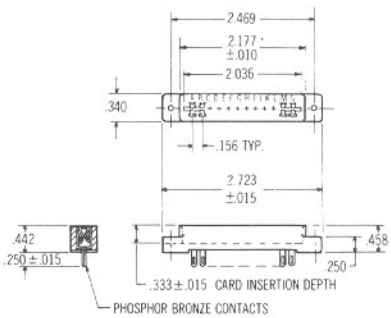


FIGURE H — Receptacle SR104

NOTES

1. This is the emitter to base breakdown voltage ratings of the transistors. A bias source in excess of this value may be used with appropriate current limiting resistor in series with each base.
2. At lower temperatures, greater base drive may be required to compensate for the decreased current gain of the transistor.
3. At elevated temperatures, the bias current may increase above the indicated limit.
4. This is an approximate value not normally tested in the TRIXIE module.
5. If this bias voltage is exceeded the quality of the readout may be impaired.

LARGE AND JUMBO TUBES

SOCKET

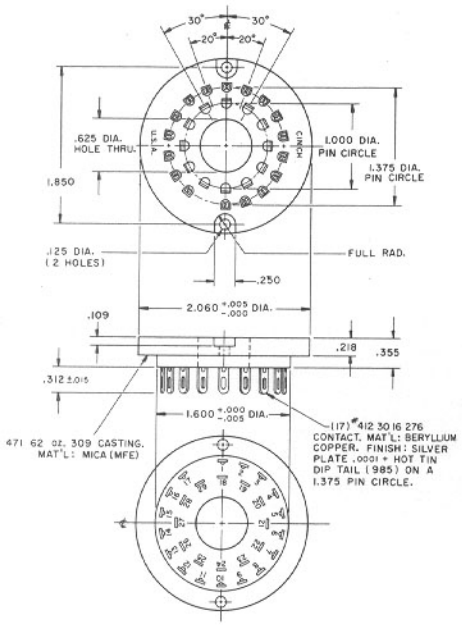


FIGURE A — SK-137 Socket

PIN STRAIGHTENER

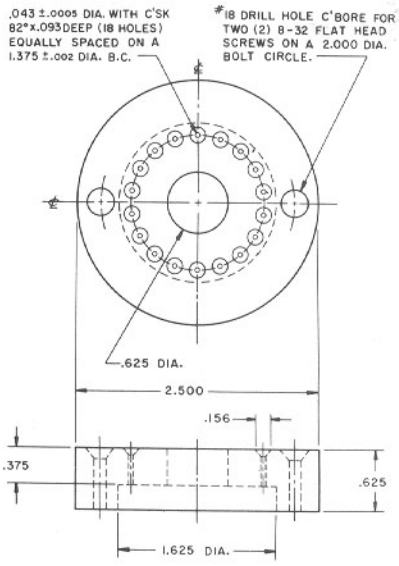


FIGURE B — Jumbo Pin Straightener — LS-209

DC/DC CONVERTER FOR ALL NIXIE TUBE TYPES

DESCRIPTION:

The Burroughs DC/DC Converter Modules, types VC12-170 and VC28-170, accept 12 VDC and 28 VDC, respectively, and provide a 170 VDC output suitable for operating NIXIE Indicator Tubes. The converter is intended for use in electronic equipment where a high level DC voltage is not available. These units, when used in conjunction with the TRIXIE Modules (transistor drivers for NIXIE tubes) provide a perfect combination for use in fully transistorized systems.

MODE OF OPERATION:

The voltage level conversion is obtained by means of a transistor oscillator, transformer, and rectifier technique.

ELECTRICAL CHARACTERISTICS:

INPUT RATINGS	VC12-170	VC28-170
Voltage	12 volts ±5%	28 volts ±5%
Current	750 ma max. (at full load)	300 ma max. (at full load)
OUTPUT RATINGS	**VC12-170**	**VC28-170**
Voltage, full load	170 VDC, min.	170 VDC, min.
Voltage, no load	200 VDC ±5%	200 VDC ±5%
Current, full load	30 ma	30 ma
Impedance	330 ohms nom.	600 ohms nom.
Ripple	4V pp max, (at full load)	4V pp max, (at full load)

TERMINAL ARRANGEMENT:

Input	Pins 1 and 2 (Pin 2 positive)
Output	Pins 3 and 4 (Pin 3 positive)

APPLICATIONS NOTES:

The voltage converters can be used with any of the NIXIE indicator tubes having a maximum ionization voltage rating of 170 volts or less. Since the output voltage of the converter decreases about 1 volt for each 1 ma of load current, the size of the current limiting anode resistance used with each NIXIE tube will depend on the number and type of NIXIE tubes being supplied. The size of the appropriate anode resistance for the NIXIE tube is determined as follows.

The load current to be supplied by the converter is obtained by multiplying the number (N) of NIXIE tubes to be supplied by the maximum current for the type of NIXIE tube being used. For example, the type B5092 standard NIXIE tube has a maximum cathode current of 3.0 ma. Thus, if 6 type B5092 tubes are to be operated from the converter, the load current would be 18 ma (6 x 3). The converter output voltage V_0 would be 182 VDC (200-18). The NIXIE tube catalogue specifies the amount of current limiting series resistance to be used with a given type of NIXIE tube when a supply voltage of 170 VDC is used (For the type B5092 this value is 10 K ohm). Where the supply voltage is greater than 170 VDC, the series resistance should be increased so that the average current through the NIXIE tube will not change. Thus, if the converter output voltage (V_0) is 182 VDC, the series resistance used with each NIXIE tube would be increased enough to provide an additional 12 VDC (182-170) voltage drop across the series resistance. For type B5092 NIXIE tubes with a maximum current of 3 ma, the additional series resistance required would be about 4000 ohms. Since the series resistance specified for the 5092 at 170 VDC is 10 K ohms, the series resistance required with a voltage of 182 VDC applied would be 14 K ohms.

SUMMARY:

The converter output voltage decreases by about 1 VDC for each 1 ma of load current. The series resistance required for each NIXIE tube being supplied will depend on the number and type of NIXIE tube being used.

MAXIMUM NUMBER OF TUBES CAPABLE OF BEING DRIVEN FROM DC/DC CONVERTERS

TUBE GROUP	VC12/170	VC28/170
Miniature	20	20
Standard	10	10
Super	7	7
Large	5	5

SPECIAL CHARACTER TUBES

NIXIE tubes which contain special characters are available in all five sizes. Typical of the characters displayed are:

1. All twenty-six letters of the alphabet
2. Plus and Minus signs
3. Ω, <, >, ~, θ, μ, φ, Arrows, %, ÷, Fractions (eg: ⅛, ¼, ½)
4. Multiple Symbols (see note below)

In all cases, as many as ten of these characters can be contained in one tube without difficulty. In special cases, it is sometimes possible to employ as many as twelve characters in a single tube. In addition, characters can be combined with digits to form alpha-numerical displays in all tube sizes.

Due to the particularly heavy demand for plus and minus and alphabet tubes, certain types are maintained in stock for immediate delivery. They are the following:

MINIATURE SIZE

TYPE	DESCRIPTION	USED WITH NUMERICAL TUBE TYPES
B4022 (BD-255)	Plus and minus	7009
B4028	Plus and minus (low voltage type)	B4021
B4031	Plus and minus (long life type)	7977 (B4032)

STANDARD SIZE

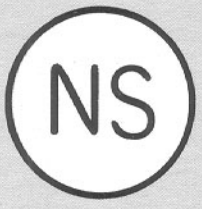
TYPE	DESCRIPTION	USED WITH NUMERICAL TUBE TYPE
B5016 (BD-214)	Plus and minus	6844A
B5032	Plus and minus (long life type)	8037 (B5031)
B50911	Plus and minus (long life type)	B5092
B5018 (BD-216)	A through K less I	6844A
B50113 (BD-221)	L through X less O, Q, and U	6844A

SUPER SIZE

TYPE	DESCRIPTION	USED WITH NUMERICAL TUBE TYPE
B6012 (BD-214)	Plus and minus	7153
B6034	Plus and minus (long life type)	B6033, B6091

Electrical and mechanical characteristics of special character tubes are generally the same as those for the regular lines of NIXIE tubes to which they correspond.

NOTE: Additional examples of special tubes that can be designed and fabricated include:



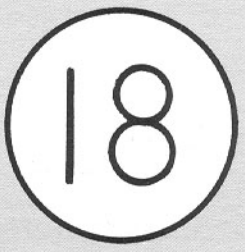
B5094

Two stacks of three miniature characters in a standard size bulb.

Left side N, M, μ

Right side S, V, A

Such combinations as nanosecond (NS), millisecond (MS), millivolt (MV), microvolt (μV), microsecond (μS), can be obtained with this tube.



B6037

Two stacks of standard size digits in a super size bulb.

0-9 on the right side with an additional number 1 digit on the left providing indication from 0 through 19.

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