Chapter XI

GLOW LAMPS IN DECODING LOGIC

Binary to Decimal Coverters and Digital to Binary Converters

Electronic counters are extensively used to make accuratc frequency, period, time interval and ratio measurements. Many of the indicating readout devices in today's solid state counters require high voltage or high current inputs. For reasons discussed in the preceding chapter, transistors can not coveniently be used to supply the drive for a readout matrix and still perform reliably at high speed.

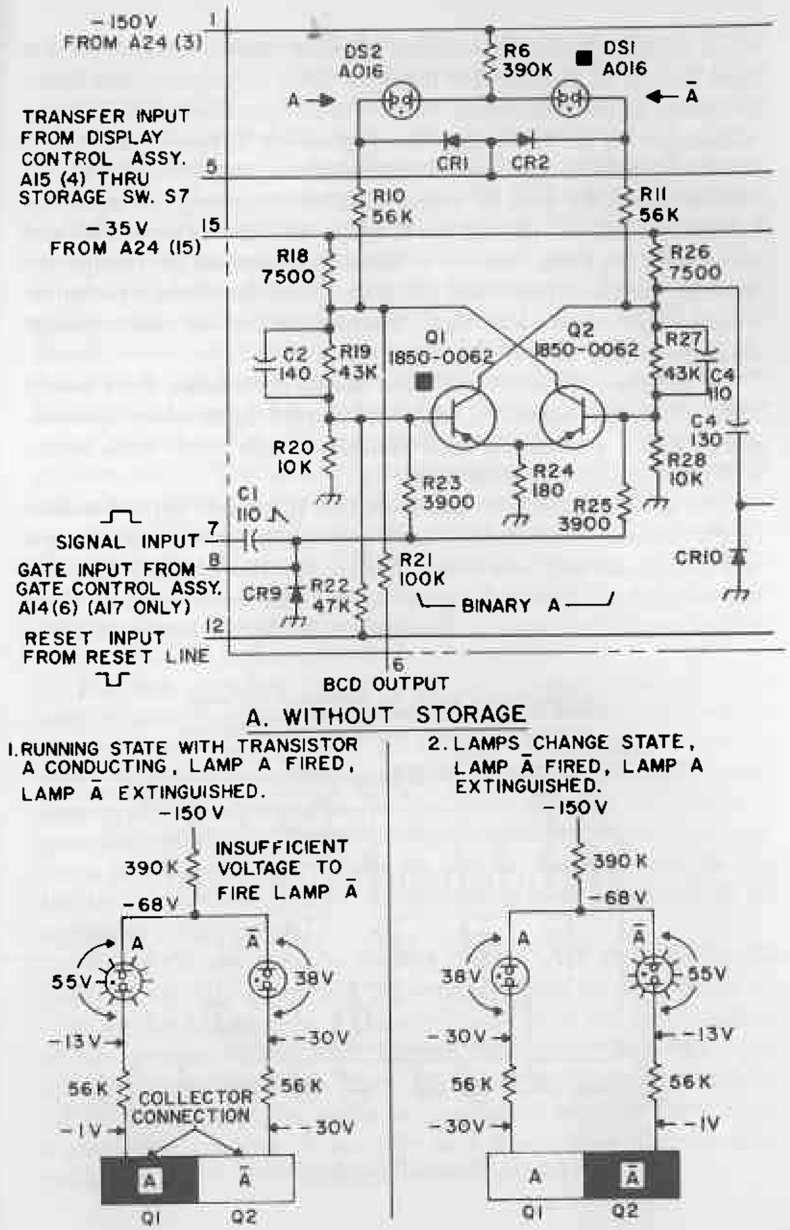
The conventional approach is to decode the binary information to decimal and, then, to add sufficient gain to the signal in order to drive the decimal indicators. This generally results in a fairly complex system consisting of a diode or resistive matrix plus ten amplifiers for each decade.

Hewlett-Packard has recently developed a technique in which neon glow lamps and solid state photoconductor elements provide the necessary gain and perform the decoding logic.[1] This system also has the advantage of having a memory by which the readout display remains undisturbed while the next counting operation continues.

Counting is accomplished by using a modified binary number system. It is binary in that each counting stage consists of four of these binaries interconnected in such a way that the circuit will cycle in 10 counts instead of the normal 16 counts.

Once the counter has accumulated the desired information it must be put in a format acceptable to people; i.e., the binary coded decimal information in which the counter has been operating must be converted to decimal information which will operate a visual display. This is where the neon lamps come into the picture.

1. Willrodt, Marvin, Hewlett-Packard Co. — "Binary To Decimal Decoding System Using Neon Lamps And A Photoconductor Matrix," *Signalite Application News*, Vol. 3, No. 3.

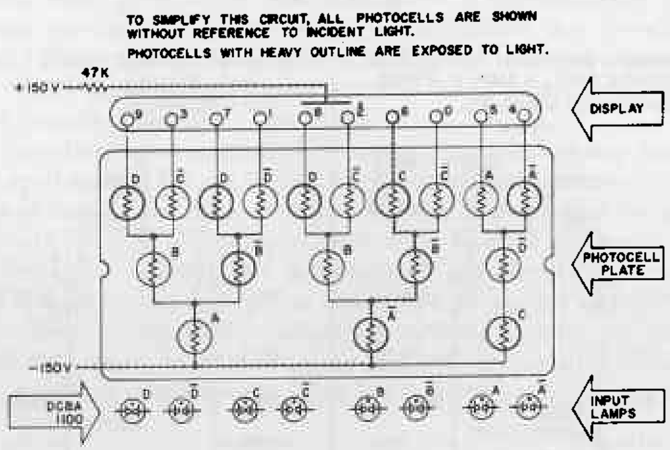


11-1 Schematic of one stage of a binary counter

A counting decade consists of four binary circuits of the kind shown in Figure 11-1 together with appropriate interconnections. Each binary has two neon lamps, DS1 and DS2, associated with it. The lamps are Signalite's Type AO 16 which can be provided for specific breakdown voltages within ±1 volt between 64 and 80 volts. Their maintaining voltages are held to within ±1/2 volt for a value selected between 52 and 60 volts. This close control is necessary because the lamps are used in matched pairs and reliable operation of the system requires that *their electrical characteristics do not change throughout the life of the instrument.*

If diodes CR1 and CR2 were not in the circuit, DS1 would light when Q1 conducts, and DS2 would light when Q2 conducts. Since a common load resistor, R6, is used, both neons will not light at the same time.

Neon lamps are also connected to the other three binaries of the decade so that four, and only four, of the eight lamps will be on at any one time. These are the INPUT LAMPS shown at the bottom of Figure 11-2. Light from each of these lamps can fall on two, or in some cases three, photoconductor



11-2 Photocell display matrix

elements on the photocell plate, which is shown schematically on Figure 11-2. Since this whole assembly is in a light-tight plastic mounting, photoconductor elements are illuminated only when the associated neon lamp is turned on.

These photoconductive elements behave electrically as resistors which have a resistance of under 10K when illuminated and above 10 megohms when in the dark. They behave as if they were light activated switches which turn on when illuminated and are off when dark. By interconnecting 18 of these photoconductive elements as in Figure 11-2 a circuit is produced which always has three photoconductive cells in series between B– and each numerical electrode. Of the sixteen combinations of four lamps on and four lamps off, there are only ten that are used that permit only one path at a time in order to have each of the three photoconductor elements illuminated. All other paths have at least one element that is not illuminated. The illuminated photocell path has low resistance all the way from the common, –150 volts, and can carry current to deflect a meter, light a gas display tube, light another neon lamp or operate some other readout system. In Figure 11-2 the path to the "6" is the one which is complete.

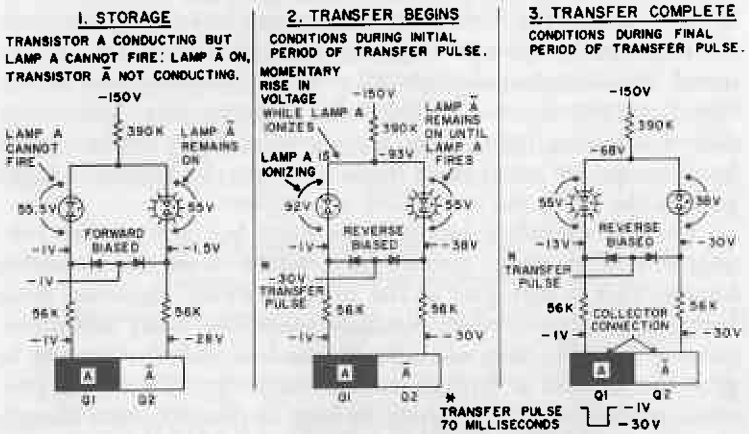
For this decoding function the neon lamps must fire reliably in total darkness at voltages available from the transistor binary. This is only part of the story, however. By using neon lamps which have stable, carefully controlled firing and maintaining voltages, they can also be used as circuit elements to give the counter a display storage capability. That is, a previous reading can be retained as long as desired, even though the transistor binary might be switching back and forth to accumulate a new count.

Storage is achieved by adding diodes CR1 and CR2 to the basic binary. To enter new information into storage, these diodes are back biased by a transfer pulse from the logic section of the counter. When back biased, the diodes look like open circuits; therefore, neon lamp DS1 will light when transistor Q1 conducts, and vice versa as mentioned earlier. To achieve a maximum number of samples in a given time, this transfer pulse should be kept as narrow as possible.

Storage is achieved by keeping these diodes in a conducting state. When conducting, these diodes tie one end of DS1 and one end of DS2 effectively to ground, thus the switching of the transistors will not cause the neon lamps to change state.

Figure 11-3 indicates the voltage during the "transfer" and "store" cycle. Requirements which the neon lamps must meet to make this feature reliable are:

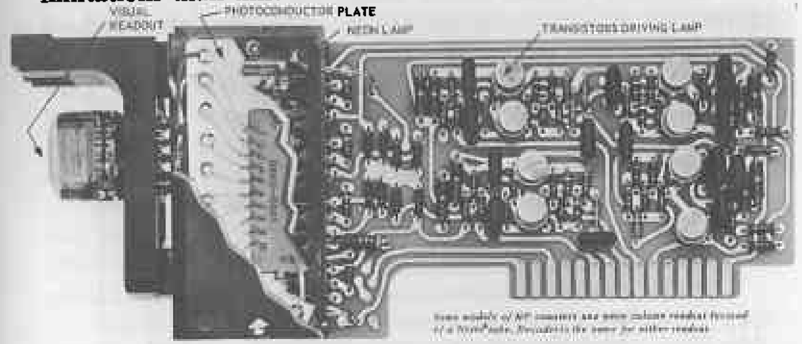
1. Rapid firing in complete darkness with a narrow pulse;
2. Carefully controlled firing and maintaining voltages, not only initially but throughout the life of the lamp. Life expectancy of the neon lamps is good—in excess of 40,000 hours.



11-3 Lamp control in storage modes

The speed of switching in this circuit is a function of the photoconductor since the neon lamp is capable of considerably faster response than is the photoconductor. Through the proper use of materials and construction, response speed in the 300 μsec. region could be obtained. Since the parameters that affect switching speed also effect other characteristics, a switching

time of a few milliseconds produces good resistance stability and good lifetime expectancy. Speed in this range is completely adequate for visual display since the eye itself has greater limitations than this.



11-4 Photo Decimal Counting Assembly

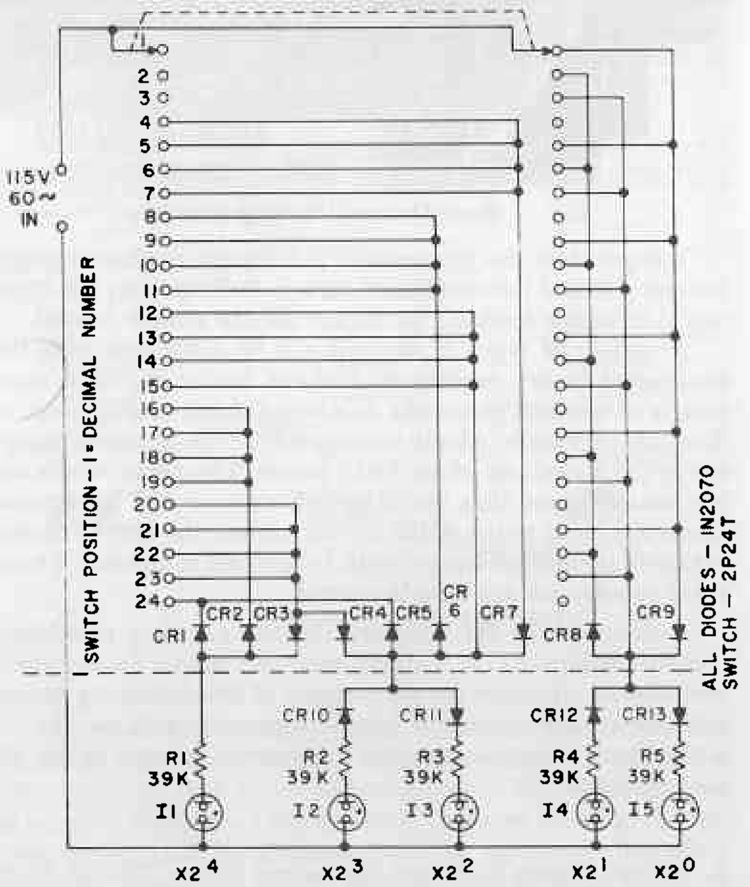
It is possible, also, to use neon glow lamps in circuits which convert decimal information to binary. Such circuits are quite useful in simple methods for supervisory or remote control.

A variety of types of readout can be associated with the decimal to binary translation. Perhaps one of the most common is to connect photocells in a series shunt arrangement so that the photocells which correspond to the actuated lamps are in the series arm of an AND circuit. The neons which are not actuated, and thus are in the off state, would be shunted across the input to the AND. In this manner the proper combination of on and off lamps could be utilized to operate a transistor or relay for any simple control.

A circuit which illustrates the decimal to binary translation is shown in Figure 11-5. This is a relatively simple device which was created originally for the purpose of demonstrating binary arithmetic.[2] The readout is housed separately and may be remote. Four conductors connect the decimal selector to the binary readout.

2. Ashburn, Claude W., Physics International Co. — "Decimal To Binary Translation," *Signalite Application News*, Vol. 3, No. 3.

The decimal selector in this example is essentially a two-pole, twenty-four throw rotary switch. This was selected for convenience, not because of a limitation of the circuit. A three-pole, sixty-four position switch would enable sixty-four bits of information to be transmitted over the four conductors instead of the twenty-four shown here. If the readout is to be through photocells, as discussed above, high brightness neon glow lamps such as Signalite's AO 72 should be used.



11-5 24-Bit Decimal to Binary Translator

CHAPTER XII

SOME INTERESTING INDICATOR APPLICATIONS

When the neon glow lamp was first developed commercially over 40 years ago, it found immediate application as a pilot light in appliances and as a location indicator. While light output is relatively low compared to the incandescent lamps it replaced, it was sufficient for the purposes to which it was put, and it offered many other advantages.

Since the neon lamp has no filament to burn out, the lamp has an extremely long life, generally much longer than the appliance in which it is installed. This characteristic permits the neon lamp to be wired into the circuitry permanently.

Power requirements for neon lamps are extremely low. Standard lamps running on 115 volts ac with the 100K resistor dissipate only 1/10 watt. They draw only .6 milliamperes. Thus, they may be run continuously at an insignificant cost. This means, also, that they may be operated directly from line voltage without the necessity for a step-down transformer.

The neon lamp is one of the most rugged components made. It is virtually unaffected by average shock and vibration. Thermal shock, such a major factor in the life of an incandescent lamp, does not exist with the neon lamp. Consequently, repeated on-off cycling has virtually no effect on its lifetime. The neon lamp runs at a relatively low temperature, averaging perhaps 120°F in ambient temperatures of 70°F, so that under normal conditions it feels only warm to the touch and is not detrimental to temperature sensitive devices in close proximity to it.

Light output is generally confined to the bright orange range, a color that historically has been associated with warning devices and, thus, commands attention. The light level of a standard brightness lamp is sufficient in applications which are related to darkness, such as night lights and electric blankets. Where a higher degree of light is desired, the high brightness neon lamps provide an indication which can readily be seen under normal ambient lighting conditions. These lamps

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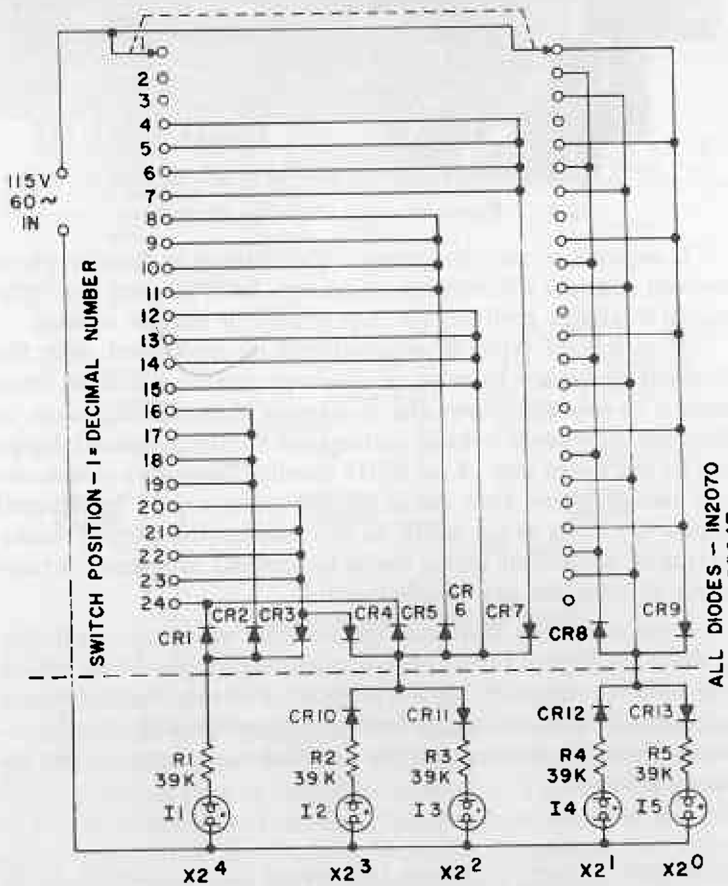

11-5 24-Bit Decimal to Binary Translator