APPLICATION NOTE 5

# ℗ MODEL AC-4D DECADE COUNTER UNIT

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The ℗AC-4D Decade Counter unit used in the ℗523B Electronic Counter was developed to provide a maximum counting rate in excess of one megacycle as well as a neon lamp readout and a staircase voltage output. The purpose of this paper is to provide a general understanding of the unique circuitry employed in the ℗AC-4D and of the operation of the Magnetron Beam Switching tube used to obtain the one megacycle counting rate.

## Magnetron Beam Switching Tube

The heart of the ℗AC-4D Decade Counter unit is the Magnetron Beam Switching tube. This tube is effectively an electronic switch providing ten outputs, each of which is capable of operating a neon lamp or some other indicating device.

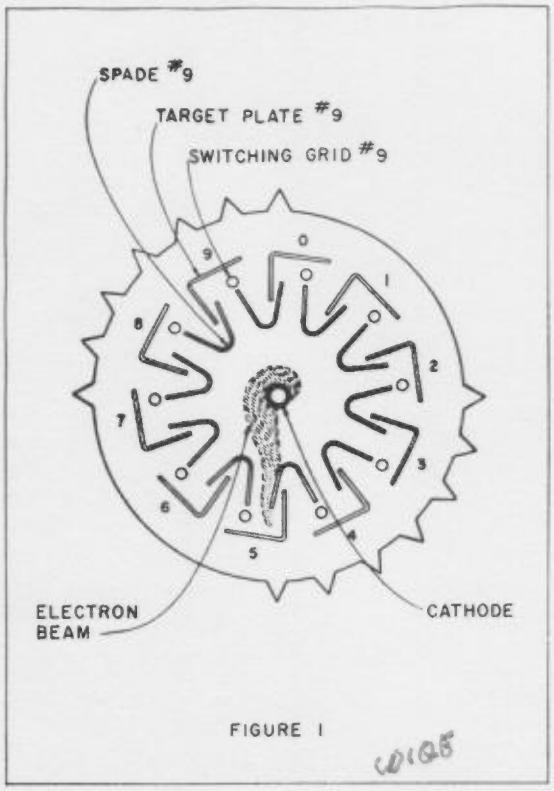


FIGURE 1

The Magnetron Beam Switching tube (Figure 1) is a high vacuum tube with a centrally located cathode, surrounded by ten identical arrays. Each array is composed of a plate (target), a grid (switching grid) and a beam forming and locking element (spade). A small cylindrical permanent magnet is mounted outside the tube envelope.

In normal operation the electron beam is formed between the central cathode and one of the ten external arrays or "positions". The beam can flow to only one of the ten positions at any given time. The greatest portion of the beam current flows to the target (plate) where it provides a useful output to operate a neon lamp or some other indicating device. However, the spade draws enough of the beam current to be maintained at approximately cathode potential and thus locks the beam on the target.

The beam may remain indefinitely in any one position or may be advanced from position to position. The direction of this advance is determined by the polarity of the magnetic field.

The position at which the beam is formed is called the ON position. The adjacent electrode group to which the beam normally advances is called the LEAD position. In Figure 1 position five is the ON position and position six is the LEAD position.

The beam is switched from the ON position to the LEAD position by applying a large negative pulse to the ON grid. This pulse frees the ON target of the electron beam and allows the magnetic field to rotate the beam. It impinges upon the highly positive LEAD position which conducts and falls rapidly to approximately cathode potential thus forming and locking the electron beam on the LEAD target. The LEAD target now becomes the ON target as the count is advanced.

To reset the tube to zero a large negative pulse is supplied all spades simultaneously. This extinguishes the electron beam. The beam is reformed at the zero position because the negative potential on the zero spade is maintained slightly longer than the negative potentials on the other nine spades, thus forming and locking the electron beam on the zero target.

## Operation of the ℗ AC-4D Decade Counter Unit

In a normal counting sequence, the ℗ AC-4D (Figure 2) is first reset to zero. An external reset pulse is applied to the grid of the reset amplifier (V102A). The amplifier output is a highly negative pulse about two microseconds wide which is applied to all spades of the Magnetron Beam Switching tube, thus extinguishing the electron beam. After the negative pulse, the spades return to their normal potential and the beam reforms on the zero position since the negative pulse is maintained longer on the zero spade than on the other spades.

The signal to be counted is fed to the grid of the input pulse amplifier (V101A). The output pulses from the amplifier are passed through a series-parallel combination of peaking coils which with associated circuitry simultaneously provide negative, 175 volt, 0.15 microsecond pulses to all the switching grids of the beam switching tube. The short width pulse is essential to insure single step sequential switching. A wider pulse might cause the beam to switch two or more positions since the actual switching time is only about 0.1 microseconds.

A single output pulse for every ten input pulses is provided at pin four of the ℗ AC-4D plug-in socket. The output pulse can be used to drive another decade counting unit or similar device. The pulse is obtained by the differentiation and amplification of the positive going pulse which occurs at the target of the ninth position when the beam switches from the ninth to the zero position.

## Staircase Output

In a normal counting sequence -- zero through nine -- a staircase potential is obtained from pin five of the decade plug-in socket. The staircase output levels are maintained around a given reference potential by the staircase regulator tube (V101B).

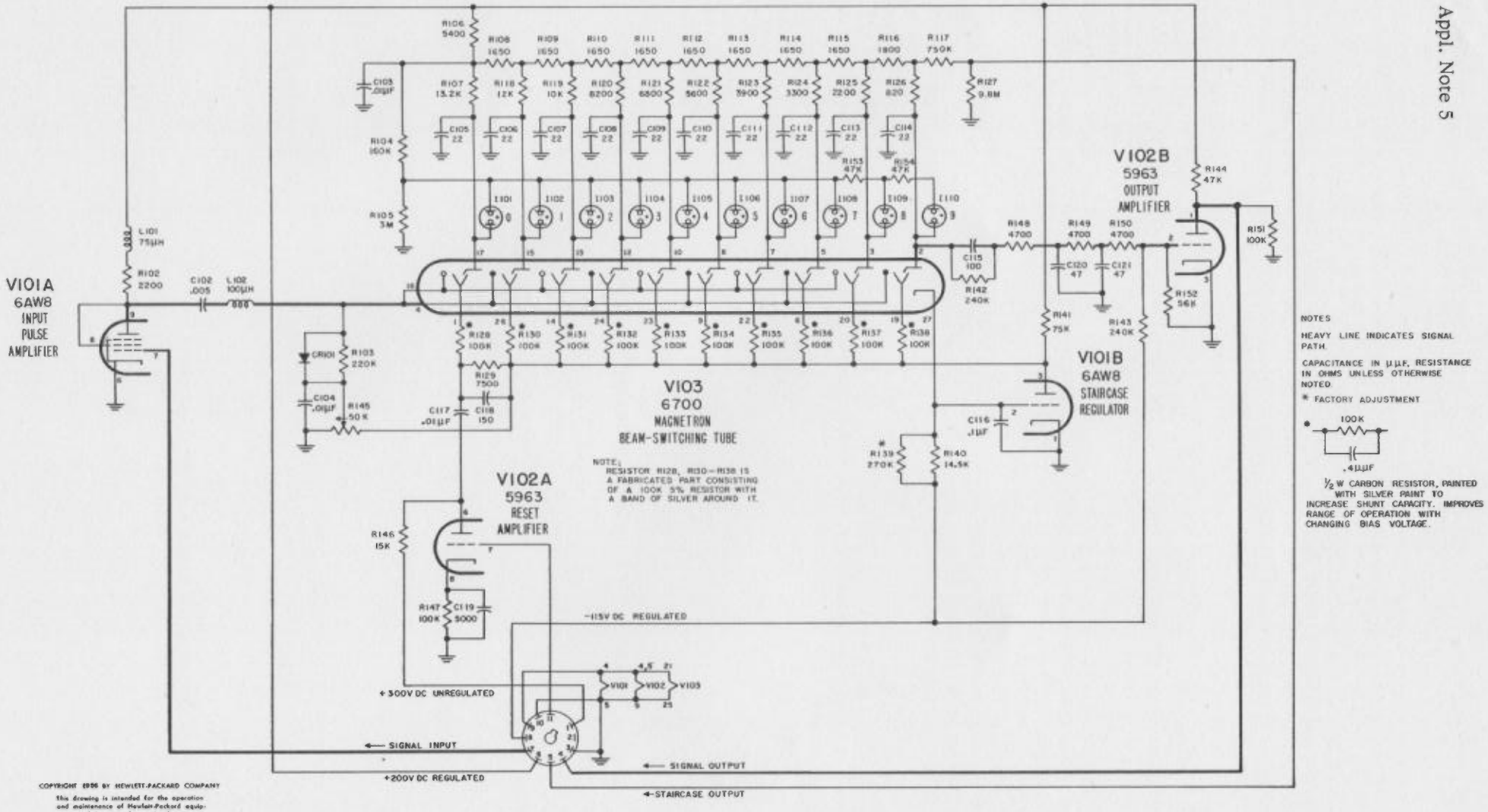




FIGURE 2