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tech tips

Understanding How CRTs Work And How They Are Numbered

Each of the CR70 "BEAM BUILDER"™ Universal CRT Analyzer and Restorer tests closely duplicates the operation of the CRT in the circuit. This Tech Tip reviews how CRTs work and how they are numbered, so you can relate CRT testing to the functions of the operating CRT.

How CRTs Work

The concept behind a CRT is very simple: an electron beam from the cathode strikes the screen which gives off light. Circuits external to the CRT deflect this beam so it fills the whole viewing screen of the CRT. Some CRTs, like those used in scopes, contain special internal deflection plates.

The CRT can be divided into three major groups of elements: the cathode, the control grids, and the phosphor screen. The cathode is the source of the electron beam. The cathode is coated with a material (such as barium or thorium) which gives off large numbers of electrons when heated by the filament. The hot cathode emits electrons which form a cloud around the cathode until something pulls them away.

The next group of elements, directly in front of the cathode, consists of several grids. Each grid has a specific function. The grid closest to the cathode, G1 is the control grid. A bias voltage (negative voltage compared to the cathode) is placed on this grid which repels the electrons back towards the cathode. The amount of negative bias determines how many electrons pass towards the screen. The control grid is cylindrical in shape, having a hole in the center. The electrons are pulled through this hole by the next grid (G2), called the screen grid, forming a thin stream of electrons.

The screen grid has a positive voltage on it to pull the electrons through the control grid. Only the electrons which pass through the hole in the control grid form the true beam current or the current that eventually strikes the face of the CRT. The screen grid is shaped like the control grid and also has a hole through which the electron beam passes.

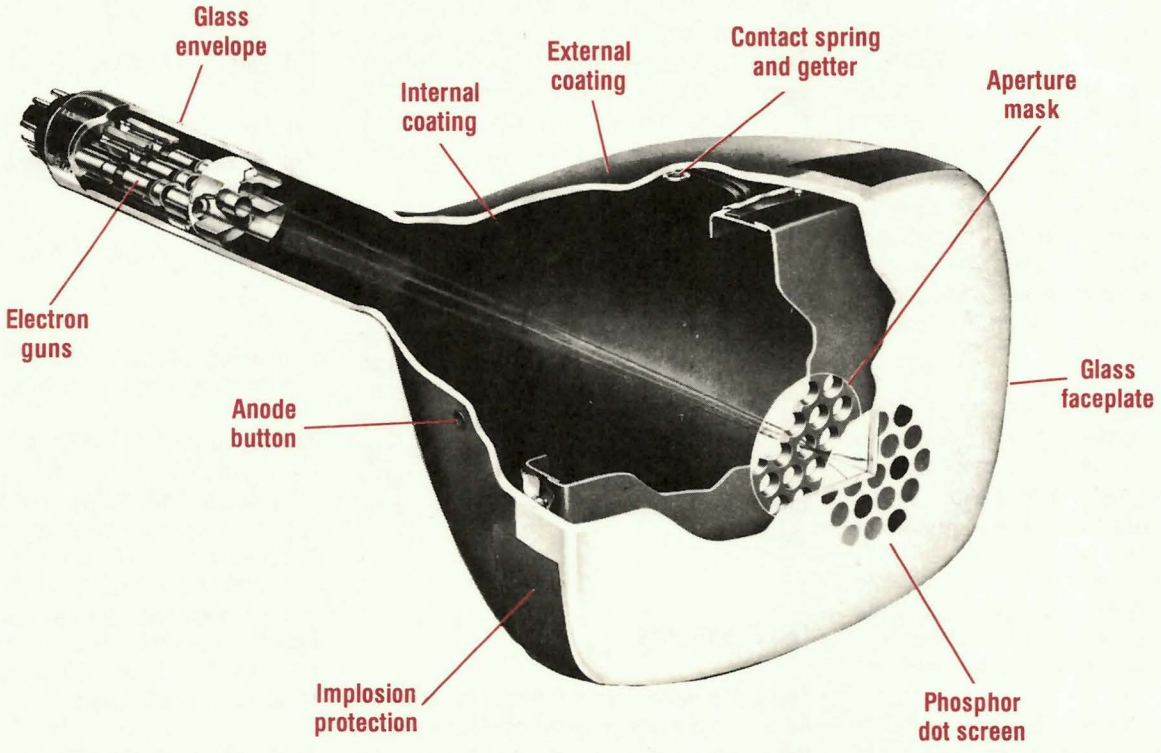

Fig. 1: The electrons produced by the cathode are regulated and accelerated until they collide with the phosphor to produce light. (Courtesy GE)

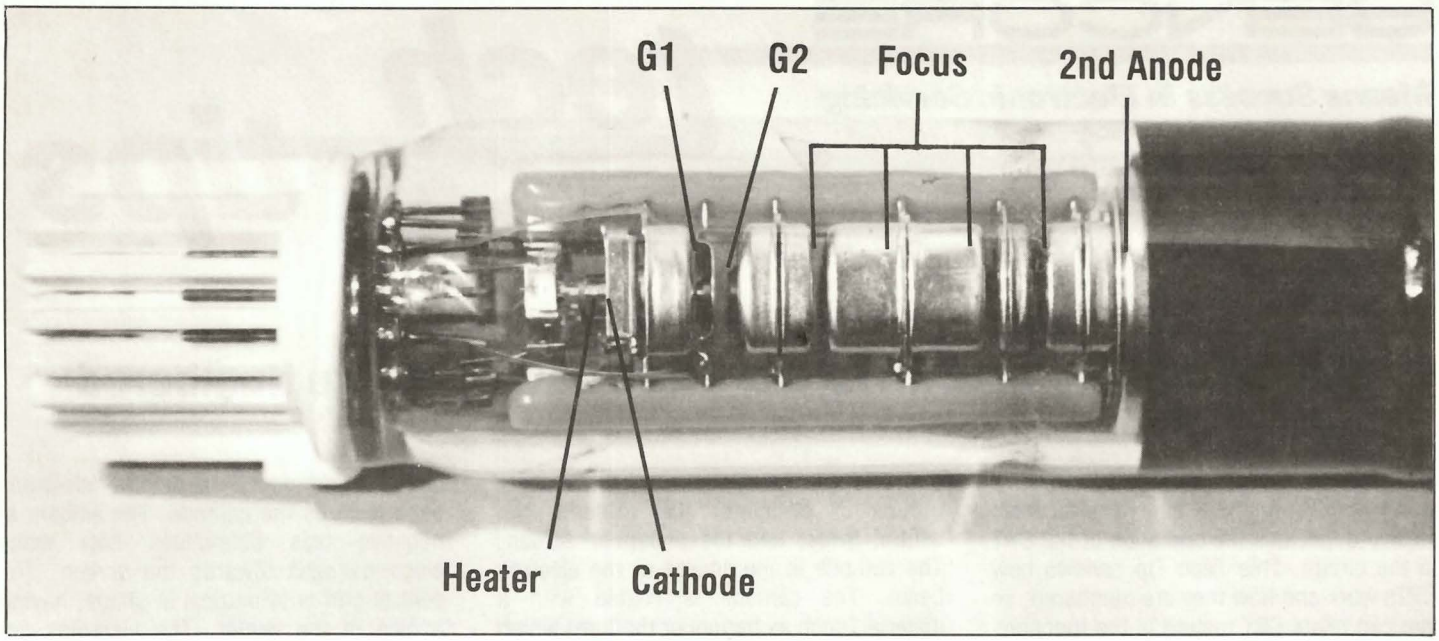

Fig. 2: A CRT gun has five basic elements.

One or more accelerating grids follow the screen grid (each of which has increasing levels of positive bias) to increase the speed of the electron beam. In addition, one or more focus grids form the electron beam into a fine hair-like thread which hits the phosphor screen, resulting in a very tiny spot of light.

The final group of CRT elements is responsible for producing the visual image. These elements include the phosphor screen and a structure called the second anode. The second anode is quite similar in shape to the other grids but it has a very high positive potential on it. An aquadag coating lines the inside of the CRT between the second anode and phosphor screen. This is at the same potential as the second anode and keeps the beam from being distracted off course.

The second anode speeds the electron beam to an extremely high rate. The beam then suddenly collides with the phosphor screen, causing light to be emitted by the phosphor. A color CRT has a phosphor screen with three colors of phosphor (red, blue, and green) which are very close to each other. Each one is struck by electrons from the corresponding beam from one of three identical electron gun assemblies.

In order for an image to be produced on the screen, the electron beam must be made to vary in intensity by changing the bias between the cathode and control grid.

The CRT beam is cut off with the normal DC bias which is applied to the control grid. This results in a black level being displayed on the screen, since no beam current reaches the screen. Video information is applied to the cathode, control grid or to both the cathode and control grid, which reduces the amount of G1 bias, enabling more of the electron beam to strike the phosphor screen. Reducing the bias to zero allows maximum beam current and maximum CRT brightness. Varying the bias produces brightness levels between cutoff and full brightness.

Understanding CRT Numbers

Most CRTs are registered according to some kind of industry standard. These standards define certain characteristics of the tube. Since April 1, 1982, these standards have been combined into one worldwide standard. Prior to that date, several non-universal standards were used.

Old Standards

The CRTs which were introduced prior to April 1, 1982 were registered differently in the United States, Japan, and Europe. In general, the registration number broke down into three parts. This is the

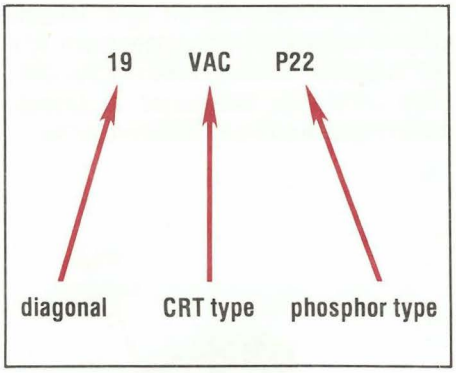

Fig. 3: The old standard can be broken into three groups.

numbering system with which everyone has become at least somewhat familiar.

The first part of the CRT number is a series of digits which signify the minimum diagonal viewing measure of the CRT. For American tubes, which are listed in the first half of the CR70 Setup Book, this size is in inches. Thus, a 19VACP22 would have a viewing diagonal measure of 19 inches. Japanese tubes, which appear later in the book, have this distance measured in millimeters.

The next part of the CRT number consists of one to four letters which designate a particular CRT within a group of CRTs

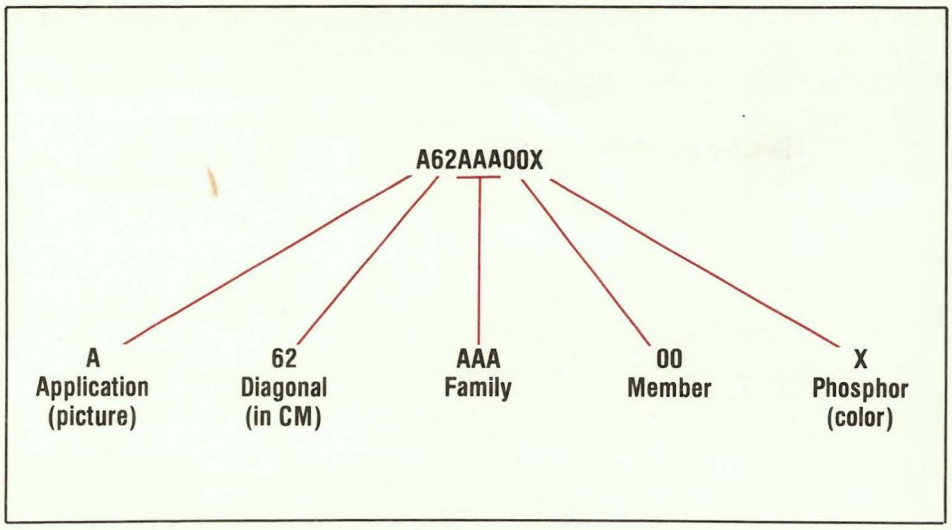

Fig. 4: The WTDS system uses six groups of symbols to identify CRTs.

having the same screen size. The final part of the CRT designation indicates the type of phosphor used. Black and white video CRTs use a P4 designation for American listings or a B4 listing for Japanese listings while color CRTs use a P22 (American) or B22 (Japanese) listing. Computer CRTs or scope CRTs may use some other type of phosphor, and will have a different number following the ''P'' or ''B''. But, as you see, the ''P'' or ''B'' is not part of the tube designation.

Some CRTs have listings that do not have a ''P'' or ''B'' ending. The most common non-standard ending is ''TC01'' or ''TC02''. These CRTs always have bonded yokes (or some other component) permanently attached to the CRT neck. The ''TC'' ending simply indicates the type of yoke plug the CRT uses to connect to the chassis. The CRT is identical to one with a ''P22'' or ''B22'' ending. For example, a 15VAETC01 is identical to a 15VAEP22. Only the standard (P22 or B22) listings appear in the CR70 Setup Book.

WTDS Standard

Since April 1, 1982, a new system for categorizing and numbering CRTs has been in use. This system is officially called Worldwide Type Designation System (WTDS) for TV picture tubes and monitor tubes. Until the adoption of this system, American, Japanese, and European tube manufacturers had all numbered their tubes differently. This has led to confusion and incomplete or inaccurate information in the past. The new WTDS numbering is an effort to simplify and unify CRT designations.

The WTDS number consists of six groups of symbols. The first symbol defines the application of the tube. This symbol is always a single letter; either an A for picture tubes or an M for monitor tubes. The second group of symbols is a two digit number which defines the minimum diagonal view. This measurement is always listed in centimeters (1 inch = 2.54 cm.).

The next group of symbols consists of three letters. These letters designate a family code for the CRT. Tubes within a particular family have specific mechanical and electrical characteristics. These letters are assigned alphabetically beginning with AAA, followed by AAB, AAC, etc. *Tubes which contain the same sequence of letters are identical as far as their setup for the CR70 is concerned.*

One or two digits follow the family code. These digits indicate a specific member within a particular family. A different member number would be assigned to tubes within the same family that have different neck diameters, for example. A single digit member symbol indicates a monochrome tube while a two digit number indicates a color tube.

Following the one or two digit member symbol is the phosphor type designation. Color picture tubes are designated by the single letter X, while color monitor tubes may have some other single letter designation. Monochrome picture tubes are designed by the two letters, WW. Other monochrome tubes, such as monitors, have a different, specific two letter code to designate the phosphor type.

Some tubes contain integral neck components, such as bonded yokes. These tubes have a sixth group of symbols assigned to them. A two digit number is used to define the characteristics of these integral neck components.

Tubes which follow the WTDS number format are listed in the CR70 Setup Book. The whole WTDS number is included in the setup book, (even though the three letter family code is the only part of the designation which is required for proper setup), to avoid the possibility of confusion with some other number that may appear on the CRT, such as a manufacturer's part number. Tubes having the sixth symbol (designating an integral neck component) are listed without this sixth symbol just as ''TC01'' endings are deleted from the conventional CRT numbers.

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