

How to Manufacture a Black & White Picture Tube

COMPONENTS, MANUFACTURING STEPS, USES, DETAILED DESCRIPTION

INSTRUCTIONS OF HOW TO PROCESS A CATHODE RAY TUBE (CRT).

COMPONENTS OF THE PICTURE TUBE (CRT):

- a. **GLASS BULB** a/k/a Bulb, Tube, CRT
- b. **ELECTRON GUN**
- c. **PHOSPHOR COATING**
- d. **CONDUCTIVE (ELECTRICITY) COATING** Liquid-paint (Aquadag)
- e. **BAKELITE PLASTIC BASE**
- f. **OUTER CONDUCTIVE (ELECTRICITY) COATING**

ELECTRON GUNS

PARTS OF AN ELECTROSTATIC FOCUS ELECTRON GUN (in order of sequence):

(# 1) FILAMENT Wound tungsten coated element, (non conductive coating) much like an element in a light Bulb, to produce heat for the Cathode Coating, to initiate a process called **“THERMIONIC EMISSION”**.

(# 2) CATHODE CYLINDER Hollow metal Electrode, the top of which is Coated with Coatings, which may Emit Electrons/Ions, while the Filament is placed inside to supply the heat needed.

(# 3) FIRST GRID [G1]; controls the initial Generated Electron/Ion Stream

(# 4) SECOND GRID [G2]; Accelerates the beam even faster.

(# 5) **SPLIT-ANODE**, where (2) structures were physically separated, but joined together with a wire {so as the (2) structures, may be considered as one and the same, voltage-wise}

NOTE: ANODE, in “**Electromagnetic**” **Focus Electron Guns**: Focusing was achieved by the use of a magnet, attached to, (part of), a spring arrangement, which circled the outside of the neck of the CRT, (like a ring on your finger). These types of guns, had a ONE-PIECE, **ANODE** structure.

(# 6) **FOCUS RING** A metallic ring, appearing, but NOT connected to, AND residing between (2) structures, {see (# 5) above, {“split-anode”}. This type of gun was called an “**Electrostatic Focus Gun**”, indicating that focus was achieved, automatically, as it was part of the Gun structure assembly. The necessary voltage, to create the required magnetic field, was provided by the circuitry of the T.V. set. See “**MAGNETIC FOCUS Electron Gun** below,

(# 7) **CROWN** The very top of the Anode (cylinder), upon which Spiders, See “**Spiders**” (# 8) and “**Getters**” (# 9) are attached

(# 8) **SPIDERS** (10) TO (12) pieces of metal, bendable, shaped like a Spider’s legs, emanating from the Crown (**TOP**) of the Anode , which makes contact with Electrical Coating, inside the Tube (Glass Envelope).

(# 9) The **Spider’s** function was, to make contact with the conductive coating, (**Aquadag**), painted uniformly throughout the whole interior of the **CRT**, which was needed to carry the High Voltage (**10,000** to **25,000** volts), [dependent on Tube size] necessary, for the tube to function properly!

The **Aquadag**, highly Electric-conductive coating, is painted over the metal button, (“**Anode Button**“), which is melted into the side of the Glass bulb { is common to both the inside AND the outside of the bulb}. When a heavy-duty wire, emanating from the High Voltage supply circuit is attached to it, that completes the electrical circuit, providing High Voltage to the Electron gun part called the “**ANODE**”, (#5).

(#10) “**GETTER**” A “U-shaped” element, with a bar across the top, attached to, and sitting upon the very top of the Anode. This bar contains an element called

“Barium”. When the bar is heated up, from an external source of Radio-Frequency Waves { **“R F”**}, much like a Kitchen Microwave Oven), (except that that the type of R F equipment supplying that Energy, was meant specifically to heat metal).

The R F activated the Barium, which caused it to absorb any gas remaining inside the CRT. It also left a deposit in the glass of the neck of the Tube, directly opposite of the **GETTER** location.

NOTE: A good indication of whether or not there was a high degree of vacuum, coupled with a low residual gaseous condition is that when the **Barium** is activated, it has the ability to absorb any gasses. If few gasses are absorbed, the inner side of the glass neck where the Getter is located, assumes a bright silver look. If there is a Poor vacuum and/or a high gas content, then in that case, a **SMOKEY-black** coating appears, instead of, the **BRIGHT SILVERY EFFECT**.

For whatever reason, when **OXYGEN/** (air), enters the tube, the coating, (whether **SILVERY** or **‘Smokey Black’**), the appearance on the glass neck becomes chalk **WHITE**. If High Voltage is presented to the **CRT** at that time, large sparks (and splats), are heard/seen bouncing between the elements of the **Electron gun** and the CRT will not function. In fact, if left on long enough, damage to Electrical Circuitry will ensue.

(#11) **“YOKE”**: **NOT** a connected part of the **Electron Gun**, but necessary for the Gun to be properly operated. It is series of coils, (connected as one piece), on the outside of the neck. When the tube CRT is inserted (neck-first), into the **Yoke**, the **Yoke fits** up against the bulb, (where the neck joins the bulb). When different voltages are applied, they cause the **Electron Stream** to be directed left-to-right (**Horizontally**) and Up-and-down (**Vertically**). That function/ arrangement, is generally referred to as, **“SWEEP CIRCUITS”**

MAGNETIC FOCUS ELECTRON GUNS

NOTE: Among the first Television Tubes appearing in the U.S., were of the **“Magnetic Focus”** type. The **Electron Gun** in those tubes, **did NOT** have a **“Split Anode”** [(# 5) of PARTS], as indicated hereinbefore, but a single gun structure, simply noted as the **“Anode”**. It also **did NOT** contain a **“Focus Ring”** (# 6) as an integral part of the Electron Gun, as Focusing was achieved by another Coil, constructed as an integral part of the **YOKE** (#11).

An **ELECTRON** is a single part of an atom. The simplest Ion is a (**MONOATOMIC ION**) consisting of (**1**) **COMPLETE ATOM**, (usually containing many parts). Other **Ions**, may even be composed of a bunch of Atoms, called **POLYATOMIC IONS**.

It has been calculated, that **Polyatomic Ions** might weigh as much as, {**844**} times, or more, than an **ELECTRON**. **Ions**, with **NEGATIVE charge**, are called **ANIONS** whereas **POSITIVELY-CHARGED IONS** are called **CATIONS**.

Electrons are easily manipulated, (whereas **IONS**, which are many times heavier), are much harder to influence, with the same-strength magnetic field, of an **Ion Trap**. The **Ion-Trap** easily bends the **Electron Stream**, but because of the **ION's** much heavier mass, there is very little, if any, effect on the **Ions**, (whether **Positive** or **Negative**).

Therefore the **Ions**, when so concentrated, could be a **very destructive energy** force, particularly on the Phosphor coating,. The Phosphor Coating was meant to display video information, **NOT for ION bombardment**. **Note:** See the power of concentrated, uncontrolled **IONS**, later herein!

NOTE: Later on, a thin coating of aluminum again allowed the “**Straight Gun**” to be used. There, the aluminum took the brunt of the impact by the **Ions**, accompanied by **Electrons**, in the **COMBINED Electron/Ion Stream** . It went through the aluminum coating, and delivered the information so to “**DRAW**” the picture, which was signaled by the sending source.

The magnetic field, generated by the “**YOKE**”, **WAS/IS powerful** enough to control the **Ions** (while the **Electrons** went along for the ride), but non-the-less, they caused the screen to light up (fluoresce), even brighter for any given amount of **electrons** in the Stream.. (See “**ALUMINIZING**” later herein).

The **Electron/Ion** pinpoint Stream initially has the power to penetrate the aluminum layer, going forward, but **NOT** enough to bounce back out, in the opposite direction. Further, that Aluminum Shield, also causes all light to be directed/reflected, toward the viewer, making a far brighter picture, than that, with a phosphor-alone, **NON**-aluminum protected, bent-gun CRT.

CATHODE COATING

This emitting of **Electrons/Ions**, are produced by a heating element, (much like a conventional 100-watt light bulb), which is fitted into the hollow Cathode cylinder, directly below the flat, coated side, of the Cathode Cylinder. These coatings, (stimulated by the intense heat of the Filament, which is prox **{800 Degrees C }**, [**1472 Degrees F**], generated many **Electrons** and **Ions**.

Then, via instructions from the set-up, of the T.V., obeying directions from the Televising source, the Cathode Coating released varying amount of Electrons. This varying intensity of the combined **Electron/Ion** Stream, dictated whether the Phosphor would glow brighter, less brighter, or have **NO** brightness at all.

Generally there is a combination of **(3)** materials, containing many diverse **Ions**, which are deposited on the flat top-side of the round metallic cylinder, (**CATHODE**) which was to be the recipient of the heat, generated by the filament.

The **FIRST** coating of the Triple-combination, was chosen because it liberated **Electrons/ Ions** very quickly, after the filament lights up, but, would only do so, for several years.

The **SECOND** coating, took a little longer to start providing the **Electrons/Ions**, but, it could continue to do so, for **(5)** to **(10)** years.

The **THIRD** coating, took longer yet to begin to supply the **Electrons/Ions**, but, could continue to do so for a long time. **NOTE:** Once the third coating, was heated long enough, it could then continue to provide enough **Electrons**, to present a good picture for **(20)** years or longer.

NOTE: That is why, as sets aged, they would take longer and longer to provide a good picture, but eventually worked pretty well.

The Cathode Coating, (physically, about **1/4** the diameter of a **# 2** pencil-eraser and as thick as **(3)** sheets of **20 lb Paper**), was deposited on the flat, outer top-surface of the Cathode Cylinder, (which contained the heating element "**Filament**").

As disclosed earlier, in considering a Black and White Picture Tube, the more **Electrons** present in the pinpoint stream of **electrons**, the brighter the phosphor glowed in that one spot (**PIXEL**/Picture Element). The lesser amount of **electrons** which are contained in the **Electron Stream** (less mass), a less lighter/darker image is portrayed.

This way, all shades of black-to-gray-to-white, could be portrayed. As color television tubes were starting to appear, the varying amount of **Electrons**, increased/decreased, the color of the impacted Phosphor, (**INTENSITY**).

DOUBLE-QUADRUPLE PRINCIPLE (LAW)

According to (1) of the laws of physics, entitled “**Double-Quadruple**” Principle, the Japanese **1,080** Horizontal-line system, (I do **NOT** know how the Japanese arrived at **1080**, because double **525** is **1050**. Double the amount of horizontal lines projected than that of the American **525** Line-system) Anyhow, HDTV provides a (4)times **BETTER picture** that the U.S. **525**-line system.

Example: of “**Double-Quadruple** “. If a (1) inch hose, can pump (100) gallons of water per minute, then a (2) inch hose can pump, (400) gallons of water, **NOT** the (200) gallons per minute, that “**common sense**” would dictate. The **double-quadruple law** impacts many other common-day occurrences, perhaps unknown to lay-people and even most of the populace.

Another MORE COMPLEX Example: A certain “**Wind Generator**” produces (1,000) One Thousand Watts of electricity in a (7) mile an hour wind. However, if you increase the wind speed to 14 MPH, the same windmill will produce (4,000) watts of electricity.

Then if the original **diameter** of the **Wind-Blades** are (3) feet, and you increase the Wind-Blade diameter to (6) feet, you **NOW** produce 4,000 Watts of electricity in the 7 MPH wind. Again, if you do **both upgrades at once**, (double the wind speed **AND** double the blade diameter), you now will produce (16,000) Thousand Watts of Electricity, in the (6) foot Wind-Blade, in the 14 MPH wind).

Most of the information herein relative to “**Electron Guns**” have reference to those “**GUNS**” used for presentation of Black & White Television. The following, is some extra information regarding “**Electron Beam Color Guns**”.

COLOR PICTURE TUBES

In a REGULAR Color CRT, there are (3) {Black and White} guns, physically arranged together in a triangular configuration, which are called the “Red Gun”, the “Blue Gun” and the “Green Gun”. However, they all produce Electrons, which are COLORLESS.

The Colors ascribed to the GUNS, are really for the sake of convenience and ease of discussion. The (3) phosphors, deposited on the face of the CRT, are in the form of minute dots, which are arranged in a triangular configuration.

The Electron guns, likewise are situated in TRIANGULAR array, in the far end of the neck of the CRT. They are positioned such that Electrons emanating from the “RED” gun could hit only Red-colored phosphor dots, but NOT Blue nor Green Phosphor Dots. This was because of an ingenious use of a “SHADOW MASK SCREEN” (much like a common window screen).

This Shadow Mask Screen was fixed, in place, a short distance in front of the color dots of Phosphor, {TRI-COLOR} SCREEN. It was located between the top of the Electron Gun and the Tri-color Screen. In turn, the “BLUE” Gun could only impact the Blue Phosphor Dots, (but NOT the Red, Nor the Green Dots). Similarly the “GREEN” Gun Electron Stream could only impact Green Phosphor Dots, but like-wise, could NOT hit the Red, NOR the Blue Phosphor Dots.

Later advanced models color CRTs, consisted of BANDS (strips) of the (3) colors (in vertical array) and the extremely fine portions of all (3) color Bands were bounded {by dark Blue bands, in the Horizontal Axis. The guns in that case were situated in a straight line, NEXT to each other ...NOT ...in a triangular alignment. The Bands of TRI-Color bits, likewise achieved all Colors and thousands of variations as was possible, with the “Tri-Color Dot” Phosphor arrangement.

Note: UPDATE in color cathode-ray tubes, YELLOW is/was, produced by a combination of the red and the green beams. Later, (2009), in “Flat-Panel”, digital T.V. sets, a 4th color, “Yellow” was added. This was instead of the red/green mix. It thereby created even more-vibrant, color pictures

How Television is Provided Through the Electron Gun:

Typical voltages and/or applied voltages for general Television Tubes were as follows: {with all voltages DC positive, except where indicated} :

Filament: **6.3 V AC @ 600 MA**;

Cathode **-5 V** ;

(G1) **10 to 30** volts ;

(G2) **250 to 400 V** ;

Focus Ring **0 to 300 V** ;

Anode/Spit-anode **8,000 V to 20,000** Volts.

Electron Guns, operating at higher than **20,000** Volts, required **“WARNING-LABELS”**, of possible radiation side-effects.

NOTE: The Warning Label recommendation was, that there should be at least **(3)** feet or more, between the viewer and the face of the Tube! As Tube sizes increased, so did the necessity for increased High (Anode) Voltages. Therefore, a proper Viewing-Distance Chart, was thereby developed.

This was not as bad as it sounds because the **X-ray radiation** was bound by the **INVERSE SQUARE RULE** ,(as you **double the distance away** from an **X-ray** source, radiation, (in Roentgens), **decreases** by the **Square** of the **Distance** , (in Centimeters).

At a meager **6.3** volts, A.C., drawing **600** milliamps of current, there was heat generated to approximately **800** degrees (**C**), or **1,472** degrees (**F**), so as to cause the electrons and ions to be emitted in a cloud. Then, different voltages, presented by, and to, the gun shaped the electron/ion beam , focused it and ultimately propelled it as a pinpoint stream into the Phosphor Screen.

Then by instructions from the transmitting signal, either to the Cathode or G1, it directed the resultant, focused electron-beam, to display a **“mirror image”** picture of the one being sent from the televised source onto the phosphor screen, to be viewed.

The **Filament** (Heater), supplied the heat necessary to liberate **Electrons/Ions** from the **(3)** coatings. **TECHNICALLY**, there was enough coating to supply **Electrons/Ions** for **(100)** years. Some CRT's, were found to be still working, (with an acceptable picture), after **(50)** years

SCREEN BURNS

Originally, (circa 1944), DUMONT used a magnetically-deflected, electronically-focused “STRAIGHT GUN”, where the Electron/Ion beam was sent directly to the screen. Unfortunately, it was found, after a period of (1) to (3) years, that the straight Gun, produced a burn in the visible screen, which RESEMBLED the PATTERN, being broadcast by the T.V. Station. In 1946, television programming was only broadcast (1) or (2) hours a day.

At 5 P.M., Ch 5, Allen B. Dumont. (WABD), showed “HOWDY-DOODIE”, 5 days a week. But, none-the-less, some people left their T V. lit up all day, hoping to see whatever else MIGHT be broadcast (hence the signal being bombarded/burned into the Phosphor Screen). Come to think of it, was it good or bad advertising to see the WABD Signal (pattern) burned into your screen, while the set was NOT even turned on !

Worse yet, with T.V. being a novelty, people were NOT sure how to use the T.V., they always left their T.V. sets turned on (10) to (15) hours a day. So, even when there was NO station-identification signal being broadcast, they STILL left their T.V. sets turned ON. However, all of the propelling voltages, relative to the Electron stream, were still being performed, (albeit with no video information), showing a fully-illuminated bright screen).

In those cases, after X amount of hours, in the alternative to having the WABD Test Pattern displayed, you had an un-interesting “Skull and Crossbones-like effect, as the phosphor began to have that image etched onto itself, NEVER to disappear, even when normal video information was only meant to be seen, un-acceptably ever-present on the screen

The only remedy was to cut the CRT open, wash out that burned screen and cause a new screen to be deposited. However, some tubes, which were exposed to that constant Electron/Ion bombardment for many years, ignored that distracting, ever-present occurrence, continued to suffer that annoying effect, because, replacing the CRT was the most expensive part in the T.V. Set.

NOTE: Even when returning that burned-screen tube was returned for replacement, the manufacturer attempting to reprocess, (REBUILD OR “RE-GUN”) the CRT, it found that even when removing the old phosphor screen, such still revealed, that “Skull and Crossbones” or “TEST-PATTERN” effect.

That was because that “picture” of a **Skull and Crossbones** was etched/**BURNED-INTO** the glass itself, and the Bulb would thereby be useless. That is one of the reasons, we have “**SCREEN-SAVERS**” today, because “**Straight**” **Electron Guns**, **EVENTUALLY** were the ones of choice.

Note: Since the Television bulb **WAS** far the most expensive part of the T.V. Tube, many enterprising “**Re-Builders**”, later on, purchased that “useless’ CRT, (even tho the **Skull and Crossbones** was **BURNT** into the Glass itself) for only a small fraction of the original Bulb cost.

It then underwent remedial action (involving acids), which were used to obliterate that defect, by **ETCHING**, uniformly, the entire inner face of the CRT. After that treatment, there was absolutely **NO Skull and Crossbones defect** visible. Of course, you now also need a new **Electron Gun** and all the materials and work needed to fabricate a working CRT.

This end result of this process came to be known as a “**Rebuilt Picture Tube**”. It not only cost much less money, but many times, resulted in an upgraded **Electron Gun** and use of newer better Phosphors. Thereby it actually produced a **SUPERIOR** picture, than that provided originally. That Rebuilding process also conserved raw materials **AND** energy, at a price, more people could **AFFORD**.

“BENT” (on purpose) ELECTRON GUNS AND ION TRAPS

A very important **Electron Gun** **UPGRADE**, for the replacement Tube, was the “**Bent Gun**”, which allowed few, if any **IONS** to bombard the Phosphor Screen. The “**Straight gun**”, was then out of favor, because the Bent Gun was designed so that the **Electrons** and Ions which were generated, were separated. Then, the **Electrons** were gathered together, shaped to form an **Electron Stream {Electron Beam}**, accelerated in the initial part of the **Electron gun**, and propelled, to allow the stream to impinge on the Phosphor Screen.

A device called an “**ION TRAP**”, allowed the stream to proceed to its assigned task. It was a spring-loaded magnet, which fit around the outside neck of the CRT, that when rotated/aligned properly, allowed only the **Electrons** to provide the received broadcast, video instructions. **NOTE:** As technology evolves the “**Straight Gun**” will again be revived. (See later herein).

NOTE: That term “**Ion Trap**” is a **MISNOMER**. It should have been termed an

“ELECTRON BEAM BENDER”, because it did **NOT** trap **IONS**, but it had that effect. It allowed both **IONS AND ELECTRONS**, to emanate from the Cathode coating in a straight line. But, because of the **PURPOSELY** designed **Electron Gun**, **MIS-ALIGNMENT**, **neither IONS nor ELECTRONS** could impact the Phosphor Screen, when first emitted and attempted, to go through G 1 on its way, as an **Electron Stream(ray)**.

The **Ion Trap**, was of sufficient strength to, and **DID**, influence the **Electrons**, because their **MASS** was much, much, lighter **{1/844 th lighter}**, than that of **IONS**. Therefore the stream of **Electrons**, **WERE allowed** to transmit video information, onto the screen, while **MOST IONS**, were allowed to dissipate, harmlessly.

EXPLANATION: Since the **Electrons** generated, contained an electrical charge (negative), they were influenced (bent) by the permanent magnetic field, generated by the **ION Trap**. They were allowed to be collected, shaped, {focused}, propelled to impact the Phosphor Screen. As long as the **Ion Trap** was properly arranged/positioned, on the neck of the CRT, it tremendously retarded, if **not**, stopped the screen **Ion Burning**.

Because the much **HEAVIER Ions**, whether Positive or Negative, (even though they also contain an electrical charge, although most **IONS WERE** negative), was irrelevant, because **BOTH**, were **LESS effected** by the limited strength, of the **Ion Trap** magnetic field. Hence they **COULD NOT/DID-NOT**, impact the Phosphor Screen.

The **IONS** continued to rattle around in the **electron gun** structure, until they were finally dissipated and **did NOT** cause screen burning. As a backhand proof of this, consider the following. In a **RARE CASE**, a mis-positioned **Ion Trap**, (around the neck of the CRT), somehow, **WAS POSITIONED** (BY A technician), such that it allowed the **Ions Not** to be immediately dissipated.

Instead, **Electrons**, accompanied by some **IONS**, concentrated in the inadvertent mis-alignment of the **Electron Gun** to bombard the **Electron gun** anode, with such intensity, so as to cause it to initially glow in to an obvious red-hot appearance.

When the **Ion Trap** was slowly rotated, the redness of the anode lessened in the original area, while starting to get red-hot in a new area. Whichever way the trap was rotated, saw a corresponding part of the Anode, to glow. No doubt that something, generated in the Tube, was the cause.]

Since **IONS** are little effected by the magnetic field generated by the **ION Trap**, which influences the **Electrons**, the mis-directed **Electron Stream**, controlled by the re-positioning of the **ION Trap**, when allowed to stay in one position for longer than an hour, **EVENTUALLY**, caused a circular hole to be **BLASTED** into the anode part of the **Electron Gun**, (about (1/8th) the size of a #2 Pencil eraser).

NOTE:JUST LIKE BUCK ROGERS OR FLASH GORDON, A HAND-CARRIED PISTOL-LIKEWEAPON, THEY CALLED A “BLASTER, or a RAY-GUN? Right this second, this is a valuable **tool/weapon**, for use on the SPACE STATION, and wherever a Vacuum exists (natural or man-made. **NOTE**, some more: That “**ION TRAP**” magnet system, is **NO** longer being used (circa 1980).

Thus, it seems that even **IONS** and/or **Electrons**, **DO** have some weight {trillionths of a gram?} , { **28.375** Grams to the ounce,(**454** grams to the **lb**)}. But, traveling in the vacuum, in the CRT, at/or near the speed of light, the **Electron stream**, impacted the T.V. Phosphor screen AND caused **TINY PARTICLES** of phosphor to fluoresce or light-up, according to instructions from the sending source, thru the **Electron Gun**.

Even though the **Electrons** are virtually weightless, according to MR. **Hermann MINKOWSKI**},{one of **EINSTEIN’S** Professors}, He rightly suggested that, “**SPEED INCREASES MASS**”).

Later on, **EINSTEIN** HIMSELF, TAUGHT that, any object, attaining near the Speed of Light (**186,300** Miles per second), can have its Mass {weight}, multiplied by **200** times or more. Since the **Electron Beam** proceeds at or near the speed of light, their impact causes the selected impacted particles of phosphor to light up, {fluoresce}, momentarily. That effect, (on a particular particle of Phosphor, was later defined as a. “**PIXEL**” [Picture Element]. Then, when the **Electron Beam** moved on to the next Phosphor particle, the Phosphor light slowly died out/“**DECAYED**“.

NOTE: The smaller the diameter of the projected **Electron Stream**, the smaller amount of Phosphor particles may be impacted, thus able to produce a finer, MORE lifelike, picture, which is characterized as “**DEFINITION**”. **HDTV** achieves excellent Definition because of certain circuitry. It also provides information on **1,080** Horizontal lines, instead of **525** lines. This means (**4**) times as much information is able to be displayed, than the **525** system, as dictated by the “**DOUBLE-QUADRUPLE LAW**”.

NOTE: The combined mass of **Electrons/Ions**, propelled at such a velocity, may easily penetrate the aluminum, impinge on and light up, the phosphor particles. However they do not contain enough energy, to reverse course and re-penetrate the Aluminum core, back towards the **Electron gun**. Additionally, the Aluminum cover, which is bright shiny, then functions as a reflector. Therefore all **(100 %)**, of the available light-energy, is directed toward the viewer.

PHOSPHORS

Electro-luminescent” materials, deposited on the inner face of CRT’s, when impacted by energetic charges, causes them to **“FLUORESCENCE”**. When struck by the **Electron/Ion** Stream, they **“GLOW”** brightly and then start to lose energy and then the glow **FADES** out. That occurrence, in effect, is characterized by the word **“PERSISTENCE”**.

The amount of time it takes **PERSISTENCE** to occur/be measured is known as **“DECAY”** time. Phosphors come in different **DECAY** times, which depend on the ultimate use, for which the CRT will be used, **{Special Purpose Tubes}**). The Phosphors come in the following persistence ranges: **Extremely Short; Ultra Short; Very Short; Short; Medium Short; Medium; Medium Long; and Long.**

“DECAY” TIME”

Ascribed, as the period of time, (in Milliseconds), it takes the Phosphor to **LOSE** brightness, from **(1)** Foot Candle, to less than **(1)** % of that amount, for a Pixel to return from its excited (brightest) state, to little, or **NO** brightness. For example: for a Radar Tube, you wanted a phosphor with a long **persistence**. You didn’t want the blips to disappear, or blink on and off, (unless the program called on it to do so).

But, for a Child’s Arcade-like Game, you want a phosphor with an extremely short persistence, (much like a **“REFRESH RATE”** ABILITY), as to prevent **“BLEEDING”** {Colors mixing into the edge(s) of other colors} , thus the blurring of information, when it is presented at high speed.

This is because, the more intricate (life-like), pictures of people are portrayed, in an action program, (when calling for extremely fast action), demands that the Phosphor particles dim very quickly. If they do not dim fast enough, the brightness of **(1)** Pixel, mixes in with the excitation of another.

NOTE: Phosphors also come in different tints/colors. The combination generally used for a Black & White Picture Tubes is a “P4” Phosphor, which has a Medium Persistence, with a Blue/White tint. Color Tubes employ “P 31” Phosphors, with Medium Persistence also. For Photographic uses, certain Special Purpose, Black & White CRT’s, used a “P 11” Phosphor.

That was because the Greenish Tint, was better than the tint of the P 4 Phosphor, (more Blue), for filming, (with a Motion Picture Film Camera), DIRECTLY from the face of the CRT... (Pre (VCR/DVD time).

SWEEP CIRCUITS

“Sweep” circuits, provided by an external device surrounding the neck, are responsible for “DEFLECTION”. This involves moving the Electron Stream from Left to Right and from the top to the bottom., which presents the picture. In the American Version (pre H DT V), 525 lines of video information, per second, is produced onto the screen. (more later).

In certain tubes, such as Oscilloscope tubes, DEFLECTION, (“sweeps”), was created by electrodes, attached to the Electron Gun itself (internally). That type of Gun was known as an “Electrostatic Deflection Type”. It also contained Electro-static Focus capability, built in as part of the Gun, (as hereinbefore discussed).

INTERLACED SCANNING

This involves the use of 525 HORIZONTAL LINES OF INFORMATION. The American Television system was based on the SWEEP Circuits providing the 525 lines of Horizontal information, via a system called “INTER-LACED scanning”. This is a weaving together in an orderly fashion of all odd number “fields”, with all even number fields, to present a complete frame). By repeating each frame twice, it was brought into sync with 60 Hertz (Cycle), Alternating Current. It was done, primarily, to cut down on “flickering”, as was prevalent in the early days of moving pictures.

NOTE: That, also created a problem with European inter-mixing of television, because the European A.C. was put out at 50 cycles per second. That also created a problem This was controlled by the Horizontal frequency of 16,750 Cycles (now Hertz), per second, which drew pictures, based on the following procedure: First, a field of 262^{1/2} ODD lines of information were

transmitted/ received. Then, the field of **262 1/2 EVEN** lines, of information had the same thing done. Thereby, the Even and the Odd numbered fields, were then joined together and called a **FRAME**. Each frame was repeated twice. Then the **(60)** Frames were broadcast making a total of **(60)** Frames per second. with the combined frames.. Sixty **(60)** frames a second corresponded with **(60)** Cycle Alternating Current, which at that time, showed that such actions would prevent/reduce flickering effects.

This happens so rapidly, that combined with the “**RETENTIVITY**” of the phosphor, (to hold and slowly reduce the light generated by the high-velocity impact of the concentrated focused pinpoint **electron beam**”, usually called (called **DECAY TIME**) It helps fools the eyes into seeing a complete image (“**SNAPSHOT**”), thus producing a full completed picture, in “real time”.

NOTE: COMPUTER uses, favor “**PROGRESSIVE SCANNING**”, (transmitting of information in sequential form. That scanning method scans (lines **1, 2, 3, 4, 5, 6** etc.. in order), as opposed to “**Interlaced**” scanning, and is also projected at **(60)** Frames/second.

ELECTRON GUN

An **Electron Gun**, an early upgrade of the Straight gun, known as a “**BENT GUN**” type, has electro-magnetic focusing provided externally, by a “**focus ring**” (encircling the glass neck and an integral part of the **YOKE**). The gun was designed so as to be able to separate **Electrons** from **Ions**. Both, are generated/liberated from the “Cathode coating, (generally a combination of **Calcium/Barium/Strontium** or **Cesium** Oxides).

Imagine the **Electron Gun**, analogous with that of the operation of an automobile.

1. **Turn on the filament** (Start the Engine)
2. **Apply 10 Volts** of positive voltage to G 1 (Put Car in **FIRST** gear & start moving)
3. **Apply 300 Volts**, positive to the 2nd Grid (Put Car in Second gear & accelerate)
4. **Apply necessary voltage** to achieve Focus (Head for the proper destination)

Will head toward the **RIGHT** side of the **G2** aperture, while the **Electrons** emitted from the **RIGHT** side of the Cathode Coating, will head to the **LEFT** side of the **G 2** aperture.

Yet again, **Electrons** from the **TOP-SIDE** of the Cathode Coating, head to the **BOTTOM-SIDE** of **G 2**. Similarly, **Electrons** from the **BOTTOM-SIDE** of the Cathode head toward the **TOP-SIDE** of the **G 2** aperture. In fact, **Electrons** from every point (in a **360** Degree Circle), each and **ALL**, head for THEIR **opposite** location, ever-narrowing a funnel-like shape, until it reaches into a very **FINE POINT (DOT)**.

However , it **does NOT stay** in that fine point. The **CROSSING MOMENTUM CONTINUES**, so that the **Electron Stream** , starts to form a new funnel arrangement. At that transition point, when the very fine Dot starts its expansion, is called the **“CROSS-OVER POINT”**) and again, starts to expand (funnel-like).

As the **Electrons** keep on heading, toward the Phosphor Screen(picture), with the new momentum of expanding ever larger, it enters the influence of the Focus-generated magnetic field. Then, the **Electron stream** is then subjected/forced to again to begin to attempt another **“Cross-over”**, which ultimately results in the focus desired.

The Focus Coil for use with a **BENT-GUN** is mounted on the outside of the neck, immediately in front of, and part of the **“YOKE”** assembly. The **YOKE** sees/controls the ENTIRE COLLECTION OF **ELECTRONS (STREAM)**, and by various voltage signals (creating varying strength magnetic fields, move the **Electron Stream**, Left or Right; Up or Down, as only **(1)** complete part (**“YOKE”**, more, later herein).

At that time, the funnel, fully opened, starts to narrow again, attempting yet again, to achieve a **CROSSOVER** somewhere in the Bulb proper. Under the influence of the Focus Coil's strong magnetic field, the **Electron Stream** is heading to impact the Phosphor, while also trying to achieve a **Cross-over**.

If the Focus Coil voltage is too **LITTLE**, the **Electron Stream** wants to **CROSSOVER**, far **BEYOND** where the Phosphor coating is (technically, beyond the outside of the CRT). If too **MUCH** voltage is applied to the Focus Coil, it creates a stronger magnetic field, and **ACHIEVES CROSSOVER**, far in **FRONT** of the Phosphor Screen.

PROPER CROSSOVER POINT ACHIEVED, IDEAL FOCUSING OF THE ELECTRON BEAM:

With the proper Focus Voltage applied, the pinpoint dot of the **Electron Stream**, lands EXACTLY at the Phosphor Particle **DEPOSITION** on the inner face of the Bulb . Therefore the Electron **Stream** is STOPPED from effecting the **Crossover**, (**PERFECT FOCUS**). The smallest pinpoint **Electron Stream** impacting exactly at the Phosphor particles. That is exactly what is **NEEDED** to effect maximum **sharpness/clarity**, of the transmitted video material.

Too much/too little Focus voltage, and the Electron Stream does NOT impact the Phosphor particle(s), exactly were they are supposed to, therefore showing a **“FUZZY” (OUT OF FOCUS)** picture. But, by fine-tuning the Focus Voltage, we make the **Electron Stream** attempt the **“CROSSOVER”**, directly at the Phosphor coating, thereby allowing all the electrons to go to their broadcasted (signal) positions.

This creates a SHARP in-focus image, (UNLESS) there are too many Gas molecules present inside the CRT. If the **Electron Stream** collides with too many GAS molecules, even when the **Electron Stream** is perfectly effected, the striking of too many Gas molecules, WILL deflect the **Electron Stream**, so as to present a **“Blurry”** picture, DESPITE the Focus Coil’s perfect functioning.

HIGH-DEFINITION TELEVISION, JAPANESE STYLE:

High Definition Television, (HDTV), is an alleged **1,080** horizontal-lines SYSTEM, promoted by the Japanese. I do **NOT** know how they got **1080-**, when double **525** is**1050** !?! Whatever, it is becoming very popular in the U.S. (circa **2007**).

Unknown/Un-publicized by the Television Industry, a **1,050**-line System, **Ultra High Definition (UHD)**, was actually **INVENTED, constructed and used** by an American, **Carmin A. Cifaldi**. In **1956**), at a request from a Medical Facility in **Philadelphia**, he hand-crafted an **UHD Electron Gun** and installed it, alongwith with a special **high decay-speed tinted Phosphor**, in a **Special-purpose CRT**.

ULTRA HIGH DEFINITION SYSTEM (UHD) 1,050-LINE SYSTEM, USED IN 1956

Cifaldi’s “UHD” Electron Gun, was used in conjunction with a high-quality,

Motion Picture Camera, using **High-speed film**, to photograph directly from the face of the **CRT**, an **actual/live, laparoscopic gallbladder-removal operation**. **Unfortunately, Cifaldi's Electron Gun/1,050-line system was NOT patented**, because the Television Industry was **NOT able/ready to use it**, (mainly because of **"Bandwidth"** constrictions).

The **Bandwidth** spoken about here refers to space allocated for transmission of a signal over the air. It should **NOT** be confused with Bandwidth, which is relative to the amount of room /capacity, which a Televising System has available to project a signal. This includes video as well as audio, in any given **system/network**, (such as used with Cable resources).

HDTV is routinely credited today, as being of **Japanese** origin. Whatever the case, **HDTV**, when coupled with **"Flat Panel"** devices, may now produce a picture, rivaling the finest photographs, (circa **2000**).

TECHNICALLY, HOW "UHD" WAS ACCOMPLISHED, IN 1956:

Note: Now, **UHD**, the **1,050-line** system, can produce a picture, equal to the **1,080** Japanese system. Therefore, a **(4)** times better picture than the **525-line** system, can be projected, (as dictated by the **"Double-Quadruple Law [DQP]"**). Further, **NO extra** equipment is needed by the home viewer.

The **1050-line** capability was achieved as that similar to the **1,080** System by the appropriate circuitry, plus using the **"INVERSE"** of the **Double-quadruple Law**, in the following way: **EXPLANATION**, as to how the **"Double-Quadruple" Law**, produced the desired result.

Normally, the aperture (**hole**) in Grid One (G 1), is approximately Forty Thousandths (**40,000ths**) of an inch in diameter. Using an **Electron Gun** containing a G1 aperture of Twenty-Thousandths (**20,000ths**) of an inch, (**1/2** the diameter of the normal), has decreased the round circular shape of the electron beam, (**2**) times), but because of the **double-quadruple principle**, it effectively can access **(4)** times the amount of Phosphor particles.

EXAMPLE OF "INVERSE DOUBLE-QUADRUPLE PRINCIPLE, (LAW): A **(1)** inch **CIRCULAR** electron beam, is now shrunk to a **1/2"** diameter beam. Therefore, it may create **MORE** Horizontal lines of information, because of its ability to impact ever-smaller molecules of phosphor.

The **1,050**-line system may now show much finer detail. That is exactly what THE Medical people wanted, plus an easier-to-photograph, (in Black & White, {pre-color days}). A Green-tinted (Phosphor) Screen, (**P11**), was provided, with which to photograph the operation, directly from the face of the **CRT**, was., (pre VCR/DVD time).

Full implementation of either the **1,080** or **1,050** line system, is the fact, that most T.V. sets in use in the **1970's** could **NOT use** those signals, (as mandated by the FCC). Therefore, they were **NOT allowed** to be Broadcast over the air-waves because of limited Broadcasting (AIR) Bandwidth space. **EXCEPT**, now we have wide-spread use of Cable, Satellites and **"STREAMING"**, both of which have overcome the problem.

STREAMING

The use of **"STREAMING"**, encoding of **"DIGITAL SIGNALS"**, basically sending instructional signals in a straight line array, **INSTEAD** of using the Frequency Modulation or Amplitude Modulation formats. Both require wide areas of the AIR-Broadcast Bandwidth, thereby now allowing **PREVIOUSLY un-allowed** Broadcasting signals to be sent through Co-axial Cable, or Fiber-optic glass-pipes. Satellite-provided signals were **allowed** to beam information, in that manner, also. Therefore, Television signals received from Satellites, (in **Geo-synchronous orbit**), with associated equipment, are still a viable method of transmission.

Older sets were equipped with Conversion boxes, to receive **ALL** methods of transmission directly at the Television sets in the home. Over-the-air, Station Broadcasting, as still practiced by RADIO, is rarely used (**circa 1980's**). The **NEGATIVE** side, for that type of transmission is, that inclement weather conditions may interrupt signal receipt at any time.

Further, the receiving DISH **must not** become mis-aligned, resulting in total loss of signal. Signals may also be interrupted, when there is no obvious sign of localized inclement weather, because several miles away, they are receiving heavy rain squalls. Also when the Electricity fails in your area, there will be no signals received, either. On the **POSITIVE** side, the signals may be received where there **are NO** Cable lines. With certain equipment and/or batteries, the signals may **EVEN** be received/used, where **NO Electricity**, is available from traditional sources.

HOW THE TELEVISION PICTURE TUBE (CRT) IS MANUFACTURED:

(21) Steps

#1A A clear, clean Television Bulb, (as manufactured by Corning Glass), whose neck is placed over a standpipe, is connected to a fluid (water-like) pumping station which re-circulates a mild acid (Bi-fluoride or Caustic Soda), for 30 seconds and then rinsed with fresh, clean Tap-water (10 to 15 seconds).

SCREENING of CRT (DEPOSITION OF PHOSPHOR COATING).

#1B The Bulb, is then placed and CLAMPED onto an hydraulically-operated "Tilt Table", (which will be able to rotate smoothly, in a 160 degree arc). This will NOT cause ripples when water is pouring out. A SLURRY, of phosphor, and DISTILLED/DE-IONIZED water which will be introduced into the Tubes, in the next step of manufacture). This apparatus, (Tilt Table), can rotate FROM the Horizontal upright Tube (neck up) position, TO the Horizontal reverse or neck-down position.

#1C (1) to (3) gallons, (depending on size), of pure de--ionized or distilled water, containing a 1/10 Th % Barium Acetate reagent, is introduced into the bulb. Next, a water/phosphor slurry, is introduced, from a shower-like dispensing piece of hand-held equipment, called a "THISTLE TUBE". NOTE: Because of the expense of purchasing distilled water, many manufacturers of T.V. Tubes, bought their own DE-IONIZER machines. Generally such machines contained (4) (COLUMNS (Beds) with a double set of columns of ANION Resins and a double columns of CATION Resins.

NOTE: De-ionized water is fed through a combination of ROCK/SAND/ ACTIVATED-CHARCOAL filters, followed by a Stainless Steel (S.S.) container with an interior element, also of Stainless Steel. This S.S. Filter could filter out particles as small as (1) Micron, and if used with FILTER AID, could filter out particles as small as, (1/10) of a micron. DISTILLED WATER, (MUCH MORE EXPENSIVE), DID not HAVE TO GO THROUGH the filtering procedure.

Otherwise, de-ionized water treated this way, was indistinguishable from DISTILLED Water, at about 10 % of the cost. Having said that, at certain times in the year, organisms killed by the chlorine introduced into the water-system

by the water suppliers, showed up in the water. In the tube, in the organisms, evidenced themselves, in the form of bubbles, (surrounding the dead organisms).

Later on when the phosphor slurry was deposited and then decanted, (poured out), the bubbles left streaks in the phosphor coating, (which rendered that bulb useless). It then had to be re-washed and re-screened). A solution to this problem was to put the bulb under vacuum, (when the phosphor was settled.) This broke all the bubbles surrounding, the organisms and were then decanted, alongwith the water.

The amount of phosphor for each Tube proportioned therein, ranges from approx. (5) to (15) Grams of Phosphor (28 1/3 Grams to the Ounce), relative to the size of the Bulb. The slurry, relative to Tube size, could contain anywhere between (300) and (700) Hundred Cubic Centimeters (C C 's).

The **Thistle Tube**, funnel-like on top, also contains a (15) inch long, hollow, plastic tube, that has a Half inch INNER diameter. At the bottom end of the tube is a **THIMBLE-like** cap, which has (15) or (20) holes, uniformly distributed on all sides, with (4) angled outward holes, (**North; East; South; & West**), in the rounded convex bottom of the thimble.

The **Phosphor slurry**, is poured into the top of the funnel, drops down the long plastic pipe and exits the **Thimble-like end**, which thereby disperses the water, much like a shower head. While the Slurry is pouring out, the entire Thistle tube is rotated, continually, **360** degrees, until emptied. This way, you may be assured that the phosphor is uniformly dispersed into the water.

The outer stream of **slurry**, should be directed at a point just before where the top of the water level meets the wall of the Bulb. The phosphor is then allowed, undisturbed, to **"SETTLE"**, (deposit uniformly), on the glass. When settling is completed, it leaves an almost perfectly clear solution, with the Phosphor laying down on the inside face of the Tube. The Settling time is (10) minutes.

Then the table is slowly gently tilted, (**Hydraulically "DECANTED"**), so that the water pours out completely, (taking care not to encourage a GURGLE), { air attempting to enter into the Bulb, while water is attempting to leave the Bulb} If you allow water to pour out and leave enough room for

air to come in to replace the water pouring out, the newly deposited Phosphor will **NOT** be unduly disturbed. Total elapsed Phosphor-coating time, including “settling” time , is about (13) minutes, for a table-load of (8) to (10) Bulbs.

#2 When **ALL** water has left the Bulb , leaving it completely empty, unclamp the Tube from the table (when the neck is pointed to the ground and **do NOT** allow any residual water to flow back onto the screen. Place the tube (neck first), over a thin **Standpipe** which is connected to a mild, **slow-speed**, warm-air dryer (much like a hair dryer), which will dry the wet screen (including the interior of the bulb). Screen-dry time takes about (10) Minutes.

The top of that pipe should be closed-off, so as to **NOT blow** air, directly on the freshly-deposited phosphor. But the **stand-pipe**, **WILL** have holes emanating from all around the sides of the pipe, near the top, but **NOT** directly out of the top. (That would make unwanted marks in the screen)

3 Remove the Bulb from the dryer, gently (while the bulb, is on its side, with the opening in the neck, facing you). Re-wet the phosphor screen, using a **3/8 th** or **1/2**”curved, inner-diameter, polyethylene tube (approx **1/2**”long,), with distilled/de-ionized water), with a solution containing distilled/de-ionized water. The solution contains a **3 %** chemical-binding solution. Do **NOT** unduly disturb the phosphor coating.

NOTE: Do **NOT use** tap water, as this will absolutely contaminate (“poison”) the screen. This contamination will not be readily discernable in the initial stages of manufacture, but after baking (a later step), you will see round colored spots appearing all over the screen, (which would be unacceptable to the viewer).

NOTE: In a later step of manufacture, called “**BAKING**”, an Ultra Violet shining on the tube face, (in broad daylight, would make the screen light up), {**fluoresce**}, would reveal this contamination. It would be as if, the Phosphor Screen were being impacted by the **Electron Beam** while under vacuum. **Green spots** , (like measles), would indicate **COPPER** contamination, whereas **Blue-colored spots**, will indicate **copper contamination** , while **Purple spots** indicate **IRON contamination**.

If the bulb is allowed to continue to completion, eventually, when video information is displayed, **Green, Blue & Purple** spots, (in stationary positions), in **ALL** white display scenes. These colored spots, would make the picture(s) un-acceptable, as was the old straight-Gun, non-aluminized, Black & White Dumont Television Tubes, (**circa 1945**).

PREPARATION FOR ALUMINIZING PROCESS

APPLY A LACQUER COATING TO PROTECT THE PHOSPHOR FROM ALUMINIZING

Introduce water mixed with a **20 %** amount of a fine polymer lacquer gently, onto the same Screen, as you did on the **TILT TABLE**. Place the screen-wet Bulb on a spinning machine, which causes the solution to spread evenly over the entire screen area (by Centrifugal Force). Elapsed time about **(3)** minutes.

#4 Since we do **Not want** residual lacquer to be positioned over the entire inside of the Bulb (we really do **NOT want** it on the Screen either), but it serves an extremely important function, {which will be revealed later} Place the neck of CRT around a flexible plastic pipe on another spinning machine, which dispenses water in a fine non-splashing stream of water, and wash out (trim-away) **ALL** lacquer and water from the interior of the bulb (while spinning), **EXCEPT...** the phosphor Screen.

Start washing the interior of the bulb, (while revolving), starting at about **(3)** inches from the top of the Bulb, from where the Phosphor Screen lies. Elapsed time about **(3)** minutes.

NOTE: This lacquer will be baked out in a later operation, but for now, will protect the Phosphor Screen from the Aluminizing application to be performed next.

NOTE: If the lacquer is not removed properly, then in that case, when the CRT is functioning in a normal T.V. set, it will be reduced to a Gas, where its molecules will interfere with **Electron Beam** and cause a **“Fuzzy”** of **“Blurry”** picture, when in use. More importantly, the Gas molecules will attack the Cathode Coating, by depositing a **BLACK, non-Electron-releasing** substance, which would interfere with and dramatically shorten, the life of the Cathode Coating, hence the Tube.

RE-ACTIVATION/REJUVENATION OF “DEAD” PICTURE TUBES

NOTE, some more: Certain erudite Engineers developed a device, which could apparently re-activate the **electron-creating** Cathode Coating, by removing the black layer of substance, from its surface. The coating underneath was still able to produce **Electrons**, but the black surface coating could not be penetrated. They called this process “**re-activation**” or “**rejuvenation**” of the CRT.

It **REALLY WORKED** and could restore, IMMEDIATELY, the presentation of the picture from a low light output picture to a beautiful high light (normal) picture. In fact some tubes were even better than new, because there was always a slight layer of black deposition from other sources. The terrific positive end-result was because of the way the **reactivation** device worked.

SECRET PROCEDURE EXPLAINED

Here is the secret: A High Voltage, probably as high as **1,000** volts, was placed for **(1)** fraction of a second only, between the cathode and G1 (when normally they **are NOT** interconnected). In fact they had to be separate, for the T.V. Tube/Set to function properly).

That High-Voltage created an ARC, which blasted the unwanted coating away. Because that process also created a great amount of heat, the resultant was observed immediately. Remember, **electrons** are generated from the Cathode Coating, by the heat, **800** Degrees C , as supplied by the Filament.

5 Put the mostly lacquer-free Bulb back on the dryer and dry everything, once again. Elapsed time about **(10)** minutes.

APPLY HIGHLY-CONDUCTIVE (AQUADAG) COATING TO INSIDE OF BULB

6 Place the screened tube on a piece of equipment, which may be rotated, that has a tube holder, and is able to spin the Bulb as slow or as fast as you desire. Using a tiny brush (about **(2)** inches in length and about **3/8ths** “ wide, containing bristles about **1/2** “ long, apply (paint) a black conductive coating (**AQUADAG/Dixonac**), to the entire inside of the bulb.

NOTE: Make sure that the coating completely coats the glass, with the Anode button, (the metal button fused into the bulb), because it is common to the **INSIDE** of the tube as well as providing an electrical path from the **OUTSIDE**.

It now becomes the path for **High Voltage** to come into the **Electron Gun**). You may paint it like hand brush-applying strokes (throughout the entire bulb) or by spinning the bulb, holding the brush still and/or have the spinning machine action cause the paint to be spread, uniformly.

NOTE: Take care, that the coating does **Not splash/impact** onto the Phosphor Screen. Elapsed time to achieve painting about, **(3)** minutes

#7 Place the Bulb neck, around another Screen Dryer to dry the conductive coating painting. Time to dry **Dixonac coating** about **(7)** minutes.

ALUMINIZING PROCESS

8 Remove the tube from the dryer. Place the neck, around an electrode, protruding upward in an **Aluminizing Machine**, up to the “**Yoke**” area, where the seal is made, so that the Tube may be put under Vacuum. The Electrode contains a (Tungsten), heavy-duty-use cycle, coil. Place a pre-measured piece (slug) of **aluminum** (about **3/8** ths long by a **1/4** of an inch thick) in the Coil, which is in a horizontal alignment. Starting the **Aluminizing Machine** up, a Vacuum Pump (part of the machine/operation), draws a vacuum on the enclosed CRT.

When the Vacuum is completed, on command, the Tungsten coil (at about **(12)** Volts, dispensing about **45** to **60** Amps of electricity, causes the **aluminum** slug (pellet), to slowly melt into a liquid ball. It then finally disburse (like a steam cloud), until the whole slug of **Aluminum** has been evaporated, from the Coil, (also called “**SPUTTERING**”).

The resultant cloud of **Aluminum** particles would then have been attached, uniformly, over the entire inside of the Bulb (including the Phosphor Screen AND the Aquadag conductive coating). Elapsed time about **(20)** Minutes.

9 Place the Aluminized tube in a High Temperature Heating Oven and bake at **410** Degrees C. {slightly higher than the regular processing temperature **(400 C)**}, which will be done later, in the evacuating “**PUMPING**”, {vacuum processing procedure}, disclosed. Essentially, this baking cycle will thoroughly dry all material put into the bulb for processing. Most importantly, it will vaporize, (to the atmosphere), the Lacquer put in, [which also covered the Phosphor Screen), via a previous operation]

When that is completed, there is an infinitely small space between the Aluminum and the Phosphor Screen. The aluminum will be held in place by electrostatic action, as well as being solidified aluminum (however thin). Elapsed time about (45) minutes.

SEALING THE ELECTRON GUN INTO THE BULB:

10 First, prepare a tray (5 X 12), of “DRESSED” guns, to be sealed into the neck of the Bulb, so that a vacuum may be achieved only through the tubulation, which is part of the Gun structure. Give a quick check to see if the Filament is in the correct position in the Cathode Cylinder, (2) turns of the “HEATER” {Filament} coil is optimum).

If there are more than (2) turns visible, use a Tweezers (on hand and needed for the sealing operation), and press them in gently, to the required (2) turns. If LESS than (2) turns, gently pull back the connecting links to expose (2) turns.

NOTE: EXTREMELY IMPORTANT. When MORE THAN (2) turns are viewed, the Filament will be located too far away from the inner top of the Cathode Cylinder, which holds the Coating (on the surface of that Cathode Cylinder. That will affect the conversion processing (converting the Coating Oxides into Carbonates).

If the conversion process is not completed when under vacuum, then when the Tube is sealed off from the vacuum system, that process will release additional gas, which will shorten the life of the Cathode (Tube). Also, the Filament being located further away from the Cathode will create a longer WARM-UP time, (more that (10) seconds, which is not desirable, when in the T.V. Set.

If LESS than (2) turns are visible, then that means that the Filament has be squeezed into a much smaller configuration, which would make it compress/enlarge, thereby making it closer to the walls or even pushed against the walls of the Cathode Cylinder. This would cause Electrical leakage, between the (2) Elements { Filament in A. C. and Cathode in D.C.}. Eventually, it would cause a “Short Circuit” and burn out the Filament. If MORE than (2) turns, a tweezers was used to adjust the filament to (2) turns.

Note: When more than (2) turns of the filament are visible, then the end of the filament will be too far away from the cap which contains the coating.

This will cause (2) problems: #1. The cathode-conversion process being done during exhaust, will **NOT be completed**. This may cause the tube to fail earlier in life. #2. The warm-up process in the producing of a viewable raster/ picture would take longer and longer, eventually also causing the tube to fail!.

Next check Grid connection and cathode connection. Make sure they are **NOT touching** other elements or even un-connected. Adjust (**DRESS**) all wires to stay close to the tubulation of the gun. When visually **O.K.**, fit the glass tubulation into a container of glass tubulation-diameter holes, (**60**) of them, for use as needed in the sealing operation.

SEALING THE ELECTRON GUN INTO THE NECK OF THE CRT:

10 Continued: When the Bulb has cooled sufficiently, it is ready for the “**SEALING**” operation. Insert the Electron Gun into the Tube neck, making sure the **SPIDERS** are touching the Aquadag Coating **NOTE:** The **SPIDERS**, because of their spring-like ability, hold the Gun in place before sealing.

Then place the selected to-be-sealed GUN into the selected tube in a small pre-heating Oven-Box, placed **NECK ONLY**, in that preheated (**250** Degrees F), which contains temperature-controlled, **Gas-air** fired, burners. This preheats mostly the neck only, (including the glass wafer of the Electron gun), where work will be done.

The neck (**NOT the entire Bulb**), but including the **Electron Gun**, is placed in the small oven, adjacent to a **SEALING MACHINE**. The Sealing Machine joins the glass **WAFER-LIKE part** of the **Electron gun**, (which contains already-sealed wires), to the glass neck of the Tube, by melting a part of the glass neck, (at a predetermined distance from where the neck joins the Bulb proper), merging/ joining the two, into one piece.

The **Electron Gun** Elements/Structure is also attached to these wires, so as to provide electrical contact to those elements, which will be under vacuum, to the Voltage-providing circuits of the CHASSIS, which are located **OUTSIDE** of the vacuum. Time elapsed in oven pre-heat, approximately (**5**) Minutes..

#11 The **SEALING MACHINE** consists of a number of revolving “heads” (which hold the Tube, in an upright position, neck down), and a fixed-height hollow **STANDPIPE AFFIXED** on a plate which also revolves.

This standpipe arrangement, has removable parts called PINS”, on the top, which may be extracted and other types put in its place. I **do NOT** know why they call them PINS, because they sure do **NOT** like a PIN). These Pins may be exchanged when they wear out, because the tops of them are exposed to **GAS/OXYGEN** fires, in the normal operation of the **SEALING MACHINE**.

The principal reason for Pin exchange, is to accommodate different glass diameters of the tubulations (from Twenty Millimeters (20 MM) to 3/4“ I.D., for multiplicity of different tube sizes. While the heads holding the gunned tubes may rotate about **15** or **20** times a minute, the plate is timed to rotate at only **(1)** POSITION per minute, { of **(6)** positions} or **(6)** minutes to make **(1)** complete revolution).

In each position, there are **(1)** or **(2)** sets of clusters, of individual burners,. They are in fixed positions, but have the ability to be raised or lowered, to effectuate the proper neck-length in the sealing process.

Each tube position on the Plate which slowly revolves has upright stationary fittings, in which the tubulation will be put into. The raising or lowering of the head-fixture supporting the Tube has a screw-like adjustment. Because of the many difference in tube shapes (the tube neck Lengths vary in size, (anywhere between **(3)** to **(7)** inches, dependent on **Deflection Angles**). Measurements, at the time of sealing, are accomplished by a pre-marked/measured (corrugated), cardboard ruler. Any metal used would crack the hot-Glass neck.

In positioning the length and sealing the Glass of the **Electron** Structure to the neck, a space is allocated for the molten bottom part of the neck to drop after sealing, (of at least **(1)** inch, but not more the **(2)** inches). To assist the molten glass of the neck, to be cut away from the Gun, a Tweezers (about **(4)** to **(5)** inches in length), is used in conjunction with air pumped into that area, to pluck away the glass away from the Gun, which is to be discarded.

At that point, air is introduced into the tube itself, thru the Tubulation, as to counter-act the force/pressure of the **Gas/Oxygen** Jets and to **ROUND** out the area which was molten and is now starting to cool and set up. Glass **does NOT** want to have **corners**. It is much stronger when it is rounded out. It also **does NOT like** going quickly from **thick** to thin. **IF** it must be thick for any reason,

then considerable time & care should be allocated to SLOWLY cool (**anneal**) it.

There are at least **(2)** clusters of **Gas-air** positions of PRE-HEATING fires (so the glass does not crack from being too rapidly heated). Next, there are **(2)** sets of clusters of **Gas/Oxygen** fires. These fires do the actual work, (melting the glass of the neck, into that of the glass of the **Electron Gun**), which also contains the Electrical wire for future connections), AND the tubulation, (straw-shaped, with a **3/8"** inner diameter).

It will be used for attachment to the Vacuum Pumps, {the next step}. Then, there are **(2)** positions of clusters of Gas-Air sets of fires (to allow the heated molten glass to slow down in the "cooling" process, of the sealing operation. In glass work, this cooling process is ALWAYS USED and called "**ANNEALING**".

Then the tube is placed in a "**cooling**" oven, annealing procedure, (neck and gun only), which is set at approximately **150** Degrees F, so as to cool the fused glass slowly, for about **(3)** Minutes.. Total elapsed time to seal **(1)** tube with a single-headed machine is approximately **(14)** minutes.

]

NOTE: If a **(2)** headed machine is used, then that time may be reduced to **(7)** Minutes. A **(4)-Headed** machine may reduce the time to **(3)** minutes. High-production machines usually have the ability, and the necessary resources to seal **(1)** Tube, per minute.

PUTTING THE TUBE IN HIGH VACUUM (PUMPING)

12 Now the "**gunned**" bulb is ready for the High Vacuum step and de-gasification, procedure, commonly called "**PUMPING**". The bulb, with the gun sealed in, contains the glass tubulation, as a part of the complete Gun structure, which is used to attach to the **VACUUM-PRODUCING PUMPS**. This is accomplished either of **(2)** ways: When using **Glass-Oil Diffusion Pumps**, a Glass-to -glass joining of the CRT and the vacuum system is made with a **gas/air** torch.

If instead, a **Metal diffusion Pump** is used, then the tubulation is fitted into a "**compression port**", (which is part of the Vacuum arrangement). That compression port is constantly internally water-cooled, as it **IS** in the **heated** oven. The primary, high-speed mechanical vacuum pump is the same in both cases.

The pumps are located **BELOW** the Heating Oven, (**NOT** in the gas-heated portion of the oven), **BUT** are part of the Vacuum System, which **IS** in the **400 Degree C** , (**854 Degree F**, High Temperature Oven. There are **(2)** Vacuum Pumps for each tube to be processed (while, at the same time, they are being baked. The reason for **(2)** Pumps is, because there is **no** single pump which may pull a vacuum at an extremely high speed and achieve a high degree of vacuum at the same time. This arrangement produces an extremely low, gas-containing condition.

HIGH-SPEED MECHANICAL VACUUM PUMPS

A. The High-Speed mechanical vacuum pump, very rapidly **(4)** to **(6)** minutes, (depending on the tube size, in conjunction with the speed of the pump), evacuates the system {which contains a **secondary pump**, called a **(3)** stage "**Oil Diffusion Pump**". That **Diffusion** pump is responsible for achieving very low gas conditions, while being baked, and **ALSO** as gas is liberated from heating the tube, as well as processing the **Electron Gun**.

In the past, **Mercury-Diffusion Pumps** were also used, but have long been discontinued due to **Mercury's** extremely **toxic nature**. The fact that **Liquid Nitrogen** was necessary/**HAD** to be used, for them to function properly, was dangerous to use **AND** was hard to store. Because it had to be kept cool, and was continuing to evaporate, even when **NOT in use**, caused their abandonment. The normal temperature of **Liquid- Nitrogen**, is about **250 Degrees BELOW ZERO**.

HIGH-VACUUM OIL-DIFFUSION PUMPS FOR GAS MOLECULE-REMOVAL FROM SYSTEM

B. The **Oil Diffusion Pumps**, are very effective about pulling gas molecules out of the system, (regardless whether they are **Oxygen**, **Hydrogen**, or of any other Gasses. Many Gasses, whether residual, or being generated at the time of processing, or myriads of gasses were **ADSORBED** (attached to the outside of the parts, materials, used in processing, construction). Other gasses, which were **ABSORBED**, during the **Electron Gun's** Electrodes (parts). The gasses are continually, efficiently, gathered together, transferred to the Mechanical Pumps and then expelled to the atmosphere.

GAS MOLECULES, HAZARDOUS FOR THE LIFE OF THE TUBE AND FOCUS

Gas causes problems, demonstrated by “Fuzzy” pictures. You just can **NOT** get the **clean, clear look**. In high Gaseous conditions, it always looks like the picture is out of focus. That is **BECAUSE**, as the **Electron Beam** tries to go to its assigned position, it encounters molecules of gas and collides with them which causes the **Electron Stream** to be nudged left or right, or up, or down, even in a combination of both/many different directions.

Therefore the Beam impacts different portions of the Phosphor Screen (so many times, each second), that the **AVERAGE** (sum of all the different **ELECTRON-BEAM** landings), video-picture is actually displayed, hence the “**FUZZY**” (BLURRY) look, even though the **Electron Stream** is **OPTIMALLY**, perfectly focused).

Excessive gas guarantees a **SHORT life** for the finished CRT, because the cathode which contains a negative charge attracts **POSITIVELY-CHARGED GAS PARTICLES**. These particles condense/are deposited, on the cathode coating surface. The coating underneath that deposition of Gas Particles, **do NOT** yet contain enough energy to go through that unwanted coating.

Therefore the Cathode **does NOT** emit **Electrons**, and worse yet, inhibits the ability for **Electron-generation** in the good Cathode coating. This then has a smothering effect, thereby causing an ever-slowng **Electron** generation ability, eventually leading to the “**purported**” death of the Cathode/Tube.

“**purported**” ...see next Paragraph!

RENEW THE BRIGHT SHARP PICTURE AND SAVE MONEY, TOO!

NOTE. It was found that even though it appeared that a CRT was “**dead**”, if any Technician could apply about a **1,000** volt (**RE-ACTIVIZATION**), momentary spike, between the Cathode and G 1, the gas-coating deposit(s), could be disintegrated, and the Cathode Coating/Picture Tube, would be able to function properly, for many, many, more years.

HEAT TREATMENT(s) OF THE BULB AND ELECTRON GUN

BAKE TUBE, WHILE UNDER VACUUM, @ 400 DEGREES C /752 DEGREES F.

13 The oven is then heated to **400** Degrees C, {**752** Degrees F}, (in stages of incremental higher heating periods), in about **15** to **25** minutes depending on Tube **size/mass**. It remains at top temperature for (**30**) minutes.

NOTE: Care must be taken to **NOT** exceed this temperature by too much, because at around **450** Degrees C, some thin glass tubes will start to go “**plastic**” and start to **cave-in**.

That is due to the fact, that the bulb interior being in a vacuum, subjects the outside of the tube(s) to the atmospheric pressure of **(14.6)** pounds per square inch, which is exacerbated by the extremely high temperature, and begins to soften AND **cave in**. After the top-temperature time of **(30)** minutes, has been met, the oven is then directed to cool down (again, incrementally).

NOTE: Glass NEVER wants to be heated hurriedly and **ALWAYS** wants to be COOLED, in a longer time, than that which would be normal, if **ALL** heat is suddenly removed (**ANNEALING**). To ignore this rule may cause the glass to crack and **NOT be** able to maintain a vacuum, or even worse yet, “**IMPLODE**”.

Definition of **Implode**: opposite of “**EXPLODE**”, but with just as loud a bang/sound. Further, implosion **can still** hurl broken glass parts/ shards, as far as **(30)** feet away because the pieces rush to, and, **THROUGH** each other (much like the “**crossing point**” phenomena, but with dangerous effects. Time elapsed in baking procedure, about **(1)** hour or so.

PROCESSING THE TUBE AND CATHODE COATING

DE-GAS THE ELECTRON GUN & ASSEMBLY, CONVERT CATHODE COATING
#14. When the Oven temperature is cooled to about **250** Degrees C , (**482** F), the oven doors may be cracked open enough, to connect wires from a D.C. supply unit, to the filaments (only).

Later, Voltages, starting at **6.3** Volts are raised, incrementally, and ultimately, to a **(30)** second “**HOT-SHOT**” (**12** V to **13** Volts). Then incrementally they went back down again, (but never less than **(6)** Volts). Voltage applied time, approximately **30** minutes, while at the same time continuing to open the doors, (incrementally) to accelerate the cooling process!

Simultaneously, with the voltage application and the cooling of the oven, and in addition to de-gassing the **Electron Gun** is another very important part of manufacture namely: Supplying a different source of heat, to the **Electron Gun** itself is accomplished by application of an R. F. source a **BOMBARDER**, the

(DADDY of the microwave oven, in everyone's kitchen). This device was designed and powered specifically, to HEAT-TREAT metal.

NOTE: The KITCHEN MICROWAVE was NOT/SHOULD NOT, be allowed to heat any metal. DANGER (IT COULD CAUSE AN EXPLOSION)!

HEAT-TREAT ELECTRON GUN, WITH "BOMBARDER" TO GENERATE & REMOVE GASSES, & ASSIST IN ACTIVATION OF THE CATHODE COATING

A **Bombarder** is an electrical device, specifically designed, to generate & project Radio-Frequency (R F) Waves into metallic objects. These Electro-magnetic waves, cause ALL molecules, (which have North and South poles, in the metal), to attempt to be aligned in one direction.

Then, the R F wave is reversed, which causes the molecules to re-align themselves, in the opposite direction. It does this, thousands of times per second, such that the molecules rub up each other, creating friction, which as we know creates heat! See next PP, re storing of energy (Kinetic Energy).

This wave-reversal heating phenomena, is then aided & abetted by a process called "Ionic Conduction"! Much of the energy involved, is stored-up in the material under bombardment, (Kinetic Energy), so that under different circumstances, such can actually cause the material to go into a Plasma State. For a complete explanation of Kinetic Energy, (See www.cifaldi.org). Click on "Files", then click on "Ionic Conduction".

"BOMBARDING" THE ELECTRON GUN, WHAT, HOW & WHY? ANOTHER USE OF A BOMBARDER

The Bombarder is so powerful, that it may heat the ANY METAL, to a "White-hot glow. A BOMBARDER is used, by Industry, in many different operations. One that comes to mind is in the manufacture of RAZOR BLADES. A CONTINUOUS BAND OF STEEL, (hundreds of feet long), has to be "HEAT-TREATED", which hardens the metal. This assures that the finished blade, can last for more than one shave.

The band of steel, (much like on a conveyer belt) is run thru a fixed set of coils, which when turned on, projects the Microwave energy into the rapidly-moving

band of Steel. When the STEEL-BAND gets **“RED-HOT”**, it then passes through an **“OIL RESERVOIR**, commonly called **“QUENCHING”**, (forced rapid cooling), Glass wants to cool slowly (annealing), the sudden cooling of **STEEL**, makes the **STEEL**, very **“hard”**.

We do not want the **Electron Gun Electrodes** to get **“White-hot”**, because that much heat would distort the Electrodes and disrupt distance-tolerances, vital for proper functioning of the Electrodes. By switching a micro-switch, **“ON”** and **“OFF”**, (which controls the output of the **Bombarder**), it is possible to maintain just a **“Cherry-red” color**. This then liberates any gases which might have been **“Adsorbed”**, (attached to the surface of the metal).

It also causes **ALL** gasses, which might have been used, in the manufacture of the parts of the electrode and internally **“Absorbed”**, to be liberated from the metal, & then removed from the Tube, (indeed the whole vacuum system), by the **Oil Diffusion Pump**. The **Oil Diffusion Pump** has the ability to take the gasses, pack them together, and send them to the **mechanical vacuum pump**, which is attached and part of the whole vacuum System.

NOTE: Non-metallic parts, contained in the Gun-structure, which might **NOT react** to the **R F** energy, are also heated, to release gasses, because of their proximity to the heated parts.

First, the **BOMBARDER** heats the G 1, along with the Cathode Cylinder and extraneous parts, to a bright-red degree. Each electrode is heated at that red brightness, for **(1) Minute**. This is done for **(2) reasons::**

1 of 2 For de-gassing, as just explained. **NOTE:** Care should be taken **NOT to heat** the **SPIDERS**. If the **Spiders** are heated to that red brightness, then in that case, the **Spiders** will **LOSE their tension** and probably will cause failure of the CRT, at a later date.

When the tube is finished and put into operation, at first, the Tube will function normally. Later, as early as several weeks, because of the heat generated in the normal operation of the T.V. set, the **Spiders** will start to vibrate, **“SING”**, .making a high-pitched ringing sound. The video (PICTURE), **WILL SHOW BLACK HORIZONTAL BARS ACROSS THE SCREEN** and immediately be **NOT** viewable. At that point, the CRT will have to be replaced.

But, if for any reason, the set remains on for longer than a few minutes, after the “singing” commences, the combination of High Voltage and vibrating Spiders “CHATTERING”, will actually cause the glass neck to be “HAMMERED” and crack. The CRT will lose its vacuum and of course , NOT be able to function. If the T.V. Set still is NOT turned off, IRREPARABLE damage will occur to the circuitry of the T.V. set, such that, the entire T.V. set must be discarded.

2 of 2. To assist the Filament-generated heat to aid in conversion of the Triple (3) coating oxides, deposited onto the Cathode Cylinder, (which is encased within G 1), into Carbonates. Then, to start uniform activation of that residual coating, that converted coating, may readily produce Electrons/Ions, when called upon to do so.

NOTE: In the primary manufacture of the Electron Gun, the (3) coatings (in liquid form), are sprayed on by a Paint-sprayer device. Then the deposited coating dries, and is shaped to an EVEN surface, with few, if any irregular (high spots). Then the series of electric voltages applied, rising up, in increments, from 6.3 Volts to a (1) minute “Hot Shot” (12 ½ to 13 Volts), and then incrementally being decreased back to the original 6.3 Volts, completes the conversion and activation of the Coatings.

#15 When the conversion/conditioning of the CRT (Cathode Coating), is completed, the wires attached to the filament are disconnected and the CRT is separated from the Exhaust System, (taking care NOT to allow air to be introduced into the CRT), in any of the following manner(s).

SEPARATING A PROCESSED TUBE FROM THE VACUUM PUMPS (TIPPING OFF)

15a. The old fashion way: With a gas-air torch, heat the area, in which you want the end of the CRT glass tubulation to be. (Do NOT forget to preheat, or the glass may crack, at which point all that time is wasted AND the Electron gun is useless {the cathode Coating is destroyed})

As the glass becomes soft and pliable, the process called (“TIPPING OFF”), [separating the tube from the vacuum system]. Then the atmospheric pressure, coupled with the force of the Gas-Air Torch, causes the tubulation to narrow/start to collapse.

As the tubulation loses diameter and the glass becomes even softer, the CRT is slowly raised upward to make the diameter even less. Continued heating/ lifting the CRT until it comes to a thin thread of string, to a point where the flame severs the CRT glass, from the Vacuum System.

Then, the ideal end-result is like a **“hand-sharpened”** pencil CALLED a **“TIP”** . You must **NOT** just let the glass collapse into a thick **“BLOB”**. If for any reason, you have let it go into a **BLOB** condition, then in that case, you must spend several minutes **“Annealing”** that Blob, or it will surely crack at a later time.

This separating operation requires some strength and certainly skill in maneuvering the torch and lifting procedure simultaneously. See the next Paragraph **“b”** for **another way** of separating the Tube from the Vacuum System.

15 b. In order to reduce the skill [and pay requirement(s)] , certain manufacturers used a ceramic coil, containing a heating element, to be put around the tubulation, in the initial part of attaching the Tube to the Vacuum System. When separation time came, the coil provided the following: **PRE-HEATING** the glass tubulation (it took **(2)** to **(3)** minutes, to bring the tubulation up to softening/melting, then another minute to effectuate the complete closing off (into a **BLOB**), of glass.

Then the coil slowly had voltage reduced, hence producing LESS heat **(ANNEALING)**. This period was about **(2)** of **(3)** minutes. When that was completed, the coil was lowered to the part of the tubulation, still attached to the Vacuum System. With a metal file, (shaped like a knife), a FIRM, QUICK scratch, **“SCORE MARK”** to the middle of the **Blob**, followed by a quick blow to the **blob**, caused the glass to separate, (without breaking vacuum)..

The tube could then be removed for the neat step, called The Oil-diffusion pump was shut off first, for at least One **(1)** minute to allow the Oil to cool from operating temperature. (Most Hi Vacuum Oils used in Diffusion pumps, did not like to be exposed to air at operating temperatures). Then the mechanical pump was also turned off and then air was introduced into the system, ready for yet another pumping operation!.

The remaining piece of Tubulation was then withdrawn and discarded.
Total elapsed time, in the oven, {turn-around time, Two (2) hours}

ATTACHING THE BASE TO THE CRT.

Age” the Cathode Coating

16 a Removing the CRT from the oven, it is put (face-down) on a soft surface, so as not to scratch the face. Wires from the **Electron Gun** are fed thru metallic pins (a part of the base, which will ultimately be used in connecting the CRT to the Television Set), of a Plastic {Bakelite} base It is attached by a Bakelite cement, {with the constituency of peanut-butter}.

Again the filament wires are connected and a series of electric voltages from **6.3** Volts to a Hot Shot of **13** Volts for (1) minute and then back down, incrementally to 6.3 Volts. This is done again for (2) reasons:

16 b : To complete the activation of the Cathode Coating and “age” it so that it may produce enough Electrons in as little as (10) seconds, as well as, to provide a complete viewable picture, for many years.

16 c : To solidify the Bakelite cement, so as to protect the glass Tubulation remnant, from being broken, and to provide a ready, easy electrical access, to the CRT. This normally takes about (30) minutes, concurrently “AGING” the Tube (Cathode Coating). **NOTE:** “AGING” the Tube is necessary, because the Coating has “Hills and Valleys”, (varying portions of Thicknesses) and the thicker parts need more processing than the thinner parts.

A CRT should last many years and **NOT be allowed** to fail, at least for the first (18) months. Generally, there was a One year guarantee given. If the CRT was returned “**under warranty**”, then a new one had to be sent, at **NO CHARGE**, to the consumer, (but at considerable cost to the manufacturer).

LIFE-CYCLE OF THE CATHODE COATING/CRT

- A. Initially the coating is in a non-active state and will **NOT** release **Electrons/Ions**.
- B. As the Coating is heated (in Vacuum condition) it starts to become active.
- C. The coating, (under a microscope), reveals many high spots, [thicker]

mixed in with many low spots, [thinner], parts of coating. Therefore come areas will convert/be activated, sooner than others.

D. When the Cathode Coating is properly-converted and easily producing **Electrons**, it starts out, (on a curve), such that it gets better and better at producing **Electrons**. If for some reason the Cathode is not fully activated, and at or near the bottom of the curve, the coating will **not** continue to improve, but in fact recede to less favorable **electron**-generating conditions.

At that point the tube might be sent back on the production line for additional **“Aging”**. If again, it displays **“unsatisfactory”** readings, then the CRT, would have to be cut open and go through the manufacturing process once again (with the time and the **Electron Gun** wasted).

NOTE: Later on, those **“WASTED” Electron Guns** were themselves rejuvenated by removing the G 1 Structure (containing the entire Cathode Assembly) and replaced it with a BRAND-NEW G1 Assembly {with a new cathode assembly, also}.

NOTE: Failures in the manufacturing are known as **“SHRINKAGE”**. The optimum cathode activation, would be at a point on the curve which is a little before, (but still rising), to a **“Plateau”**, (the next level of activation).

E. When it is producing the maximum amount of **Electrons** it will stay on a plateau producing plentiful **Electrons**, for from **(3)** to **(5)** years, or more.

F. It will then start on the down-slope of the curve, which should be another **(6)** months or so. **NOTE:** When the Cathode Coating is OVER-PROCESSED, you may be well across the plateau or even on the down-slope, even **BEFORE**, the CRT is installed in a consumer’s T.V. This failed CRT, entitles the consumer, to a free replacement **(Warranty)**.

G. Back to a state where **electrons** may **NOT** be generated (coating expended).

ACTUAL AFFIXING OF BASE AND “AGING” OF CATHODE COATING.
The Bakelite cement originally comes as a powder. When mixed with alcohol (a non-contaminating, easily-evaporated material), it is worked to the

consistency of “peanut butter” , which is then called “Bakelite cement”. A 1/4” thick, ring of Bakelite cement is applied inside the Bakelite base. The base also contains hollow metal pins fixed in place. The wires from the **Electron Gun** are threaded thru those metal pins and pulled tight to mount and fix the Bakelite Base and the cement, to the glass of the CRT neck.

This is done where the Glass-like Wafer of the **Electron gun** was melted into the neck. It then serves as protection, (when as a finished tube), for the glass tip. Those wires also hold the base on straight, until the alcohol is evaporated and the Bakelite cement becomes as hard as plastic.

It turned out when tubes were separated in the Blob configuration, it became a good idea to coat the **blob** end with a High-Vacuum red-paint sealant, which was proven to effectively stop minute air intakes remaining in the center of the **blob** (but **NOT** necessary with the hand-separated types), to the CRT.

At the same time of the cement-hardening process, the Filament wires are again connected to a n A C supply, to further age the cathode, (with the obligatory “hot-shot” for (30) seconds), as well as to assist in the evaporation procedure. Depending on the ambient room temperature, sometimes “spot lights” shining on the base may be necessary, to complete the process.

At 6.3 Volts A C, the filament generated approximately 800 Degrees Centigrade of heat, or about 1472 Degrees Fahrenheit,(and higher, as voltages were incrementally advanced, the heat generated so that the Glass in the base area gets hot to the touch. This thereby hardens the Bakelite Cement.

When the Bakelite cement is hardened and the socket called a **BASE**), containing the wires is firmly affixed to the end of the CRT neck, then the wires are snipped off at the top of the pins and lead soldered (so as to assure connections with the pins are securely, permanently made).

Time lapsed about (30) minutes from the last tube connected (usually done in oven-loads or (20) to (30) tubes tied in parallel together, to the A C Power supply. Aging, base-hardening elapsed time approximately (30) minutes.

GETTING RID OF PARTICLES WHICH MAY BE ON THE ELECTRON GUN PARTS

#17 The CRT is placed, (face up, neck down), on a tube holder, and a socket is plugged into the metal strips of the base, in which all pins are joined together by a heavy-duty wire. This other end of the wire is anchored to "GROUND". Another heavy-duty wire is connected (Clipped in) to the Anode. The Anode is fed to a device which produces "HIGH VOLTAGE" { H V.}, ((25) to (35,000) Volts.

When turned on the H.V. disintegrates any material still present on the Electron gun (with the (CRACKLE) sound made by electricity. Larger tubes get the 35,000 volt treatment because the T.V. sets they are placed in, normally deliver more H V, to work properly, than that of the smaller ones. This was commonly called a "SPARK-KNOCKER".

TESTING THE FINISHED PROCESS

VARIOUS VOLTAGES, OF VARYING INTENSITIES, INHERENT IN TEST SET

#18 Testing the finished product was accomplished by connecting the finished product in an T V set-simulating equipment, procedure. All voltages (and current drains, and then some) are available and dial-monitored, by controllable sources. For example: high voltage was supplied from Zero (0) volts, all the way up to (35,000) volts. Other variable voltages available in the TEST-SET were:

Filament voltage from (0 V) to (15 V), w/ automatic current drain (from 200 to 800 Milliamps)

G 1 (0 V) to 80 V

Cathode (-10 V) to (0) V current drain (called "EMISSION", the aggregate of electrons passing from the Cathode though the aperture of G 1), in MICRO AMPS.

NOTE: There is a relationship to the amount of Electrons passing from the Cathode, through G 1 and the amount of voltage necessary to completely halt that action. That also means, that that varying the voltage, according to the signal received from the Transmitting source, may allow varying amounts of Electrons to be sent to impact the Phosphor Screen, thereby drawing the

picture and making the picture darker or lighter.

G 2 (50 V) to 500 V

Focus (0 V) to 450 V

Anode 20,000 V +/-

The TEST SET has the ability to test for “LEAKAGE” between the Cathode (A.C.) and G 1 (D. C.) measured in Micro-amps. Too much leakage (above (10) Micro-amps, would be indicative of the Filament, non-conductive coating was damaged. It should be rejected because, with time/use, it would only get worse. Eventually it would introduce a (60) Cycle “Hum” in the Picture, (un-desirable). (See SEALING the ELECTRON GUN, hereinbefore, to PREVENT leakage).

CRT: CROSSOVER of ELECTRON-BEAM!

In conventional CRT's., the active coatings, (from which the electrons, [and other particles], are generated), reside on the top,(cap), of the cathode cylinder. This cap always has a larger diameter than the aperture [hole], (in G1), situated immediately above the Cathode coating The (G1), controls the amount of electrons, (emanating from the coating), which pass through it !

Therefore, particles (electrons & ions) generated from the coating on the cap, NOT having un-impaired access through the aperture, must be forced to do so. In effect, (for ease of explanation, let's just name ELECTRONS only) this activity basically calls for a “splitting” of the electron stream.

Then as the split-beam is passed through the second controlling grid (G2), of the electron gun, [on its way to impinge on the phosphor screen], the electrons which are crossing through the main stream (beam), attempts to join together, with the electrons which came from the unimpeded part of the electron stream.

But it does join up with the main stream, but the energy (coupled with the inertia contained therein, forces it to continue to go on crossing THROUGH, and beyond, the main stream. In effect, that results in another splitting of the electron stream, until and unless something can bring it back together again.

Now the **beam**, diverging particles, attempting to **split** the **Electron stream** again, enter the anode structure (the **3rd**), main structure of the Gun. They are accelerated, but then encounter a magnetic field, generated by, and called, a **“focus coil”**. This coil is a correcting attempt, (either internal or external), depending on Gun Type, to unify the stream, once again.

Normally the voltages responsible for manipulating this process, **joins** the **Electron Stream**, together again, so that the **Electron stream** in unity, may do its assigned task. Ideally, the re-unification of the **stream** may be fixed to occur directly as it impinges on the Phosphor screen. This action may thereby produce a **clear/sharp** image.

Once again, **too little** focusing voltage causes the united **electron stream** to join together, **BEFORE** it impinges, directly on the screen. Conversely, **too much** **focus** voltage, would affect a **“crossover”** before impinging on the Phosphor screen. The final result, in both cases, [in attempting yet, a **3rd** **“crossover”** effect], would be a **(blurry)** picture.

Note: I never did determine, what effect with having the Cathode Cap, AND the G1 aperture is, if they were both of the **same** diameters! Then, there would **NOT** be a first **“crossover”** point necessary, because **ALL electrons** would have unimpeded access, to go through that G1 electrode., in response to accelerating informational-containing voltages. Hence ? **NO 2nd** , **crossover** needed **NOR** would there be a **3rd crossover** needed/generated !

ASSESSING THE POSSIBLE LIFE OF THE CRT

The Test-set also has the ability to disengage the **“SWEEP”** circuits. This was a valuable tool, in assessing the effectiveness of your manufacturing process, because it enabled you to see a **“PICTURE”** of the surface of the cathode coating, which was called the **“CATHODE IMAGE”**. The actual coating was concealed from visible sight because it was an integral part of the G 1 assembly electrode.

To get a view of the Cathode Coating, first, cut the **Focus Voltage** to Zero Volts. Next, at the touch of a button, the **“SWEEP CIRCUITS”** were automatically dis-engaged, AND the **HIGH VOLTAGE** was cut from **15,000** Volts down to **5,000** Volts.

Physically dialing down a rheostat, lowered the **Focus Voltage**, (which was able to be varied from **450** Volts down to **“0”** Volts), to **“0”** Volts produced the following effect: When the voltage was reduced to **“Zero”**, (**DEFOCUSED**), the **Electron Stream** was precluded from achieving the second **“crossover-point”** point. That action resulted in the **Electron Stream**, continuing it’s **“funnel”** expansion, culminating at the Phosphor Screen, as large as a Silver Dollar.

CAUTION: If you **do not** reduce the Focus Voltage to Zero first, you will ruin the Phosphor Screen in a split second, (instantaneously). When the Sweep circuits are dis-engaged, a tiny focused pinpoint of the **Electron Beam**, (which is supposed to be moving, to **“draw”** the pictures), causes all the **ELECTRONS** to impact one tiny area of the Phosphor Screen and **BURN** a hole in the Screen.

This makes the CRT unacceptable, for viewing. Worse yet, leaving the focused spot ON, for longer than (5) seconds, actually starts to burn a hole in the Glass Bulb itself. Then the whole bulb is useless and must be thrown away.

SOMETHING TO THINK ABOUT:

Let us enlarge the conventional average **“STRAIGHT”** Electron-gun **100** Hundred times. **NO** Container needed, as the Glass Bulb of a CRT. In effect, the Universe will be the Container!

AVERAGE GUN	Extrapolated 100 times larger/stronger
5 Inches	Approx 50 Feet (actually 41.66 feet)
Filament Voltage 6.3 Volts	630 Volts
Filament Current .600 (Milliamps)	60 Amps
G 1 Aperture 0.020 inches	2 Inches
G 1 Grid Voltage Average 40 Volts +	400 Volts +
Anode Voltage 25” C R T 18,000 Volts +	180,000 Volts +

Average **“THROW”** Distance between TOP OF Anode TO Phosphor Screen APPROX 2 feet **200** Feet (Expected Focus Point) From the experience with normal CRT’s, the **“Crossover-Point,”** may be well past the Glass Face of the **25”** C R T, say, conservatively 6 Inches x **100** =’s **50** Feet.

There fore the beam should be effective at, for at least 250 feet/**85** (rounded up from **83.333**) Yards, approx. **3/4** the length of a Football Field. Actual Experience, increased Voltages, can extend the **“Focus-Point”**, even further.

NOTE: Since a “Straight” gun arrangement is envisioned here, the **Electron Beam** shall also include their “heavy-weight” brothers, the **Ions**. The impact of the focused **Electrons Stream**, (**ELECTRONS ALONE**), shows the power, that might be unleashed in a **FOCUSED ELECTRON STREAM (BEAM)**, in a vacuum. Imagine a focused **ELECTRON/ION BEAM**, in a vacuum environment, being propelled by **500 Thousand Volts**, or MORE! ? !

IS N A S A LISTENING ? ! ?

Back to Testing/scanning, the image cast upon the screen (about the size of a silver dollar). It is able to be “**READ**”, like an M D, reads an **X-ray**. To a skilled person, this Cathode Image “**SCAN**”, was remarkably accurate, in culling out tubes which were bound to “**FAIL**”. It also showed others that need additional aging of the Cathode coating. If the processing was done right, in all stages, then **98 %** of all tubes passing the TESTING stage, would last longer than One year.

Each CRT tested was scrutinized for Screen Defects:

- 1) Glass scratches (which were to be removed using grinders in conjunction with Jewelers Rouge”);
- 2) **A10** second warm-up time (for a raster to appear);
- 3) Amount of **Electrons** emanating from the Cathode (which showed up as Current drain in Milliamps);
- 4) **G 1** Voltage necessary to extinguish the **Electron Stream** from view (called **Cut-off Voltage**), having a proper range of **G 1** Voltage, to the amount of emission of **Electrons** from the Cathode;
- 5) The ability to **focus/de-focus** the **Electron stream**,
- 6) the ability to conduct **Spark-knocking**; [Increase/decrease of high voltage]

POLISHING THE FACE OF THE FINISHED CRT “BUFFING”

19 SCRATCH REMOVAL: The face of the finished CRT is carefully scanned for scratches or other blemishes in the Viewing areas. When found, a grinding

Wheel, removes the deep scratches, by creating a number of less-deep scratches. Then, further, a less grainy grinding disc, removes those smaller scratches, with the effect that now the glass is left in a fine haze. Finally, a felt polishing-wheel, assisted by **JEWELERS ROUGE**, **POLISHES** the haze, so that it completely matches that of the rest of the Glass face.

NOTE: This operation, (**BUFFING**), takes a high degree of skill!

MAKING THE CRT “IMPLOSION-PROOF” (LAMINATING).

20 Since there were many accidents because CRT's “**IMPLODED**”, THE public demanded safer CRT's. The “**QUICK-FIX**”, was to provide a system called “**LAMINATION**”. There were several types tried. **ALL** required the use of EPOXY RESINS. Most resins became hard as a rock. The first approach was for Corning Glass and other glass makers to make a “**dish-like**” cover to contour the bulb in question.

The CRT, with the matching face-plate, is heated in a small Oven, to approximately **200** degrees **F**, for several minutes. Then the CRT and the matching plate, are suspended in a Jig, so that there is approx **1/8** of an inch space difference, between them. An appropriate, clear-view, (relatively pliable, when composed), Epoxy Resin, consisting of (**2**) separate fluid components, are mixed together.

This initiates a chemical reaction, which starts to heat up rather quickly, (**2**) to (**3**) minutes. The ever-heating **2-part**, **Epoxy Resin**, is poured, gently, (so as to **NOT** make air bubbles), between the contoured plate and the CRT. The Resin takes about (**3**) minutes to harden, (in the firm, binding, yet pliable state).

Yet other ways, to provide protection against implosions, used different types of metal banding, (including non-resin coating, compression **BANDING**) Still. other types consisted of metal containment, use another type of **2-part** Epoxy Resins, to (Glue), those metal piece to the Glass.

Still another type saw the tube fitted into a metal enclosure. As this also served as a mounting arrangement for the inside of a Television set, the Epoxy was the “**hard as a rock**” variety.

Whatever system was used, they are all **100 %** reliable, because **ALL** the systems hold the glass together, when a blow is delivered with force to the Bulb or when it is accidentally dropped... **ALL, very effective.**

PREPARATION FOR SHIPPING:

SPRAY-PAINT COATING (AQUADAG) ON OUTSIDE OF BULB

#21 The last step before boxing for shipping, was to have a black highly-conductive Electric coating, (**AQUADAG**), sprayed over the entire outer Bulb area { but **NOT** within a **(4)** inch circle of the Anode and at least **(5)** inches from where the neck joins the bulb proper, because that is where the Yoke will reside}

This coating enables the Tube to acquire a *capacitive effect*, (stores **electrons**, which gives a smoother working action, to the picture, in response to fluctuations in voltages, delivered to the TV set, {usually due to external sources}

End of Processing of the CRT.

Extraneous Pieces of the Television Tube Subject Special Manufacturing Steps, Required to Process Metal Tubes, in Addition to the Normal CRT Processing Metal Picture Tubes being used in the **1950's**

SAND-BLASTING

Metal tubes {cones), were received, (without any glass attached), and well-greased to prevent/retard corrosion. First, they had to be cleaned with carbon-tetrachloride to get rid of the grease. Then, the edges, (faceplate side, as well as neck-side), had to be individually "**sand -blasted**".

This was to get rid of any possible corrosion. More importantly, that was done to rough up the smooth metal edges, so as to create, (under a microscope), "**valleys**" and "**pits**" This was a preparatory step to "**marry**" the glass to be attached to the metal cone, overcoming the difference of co-efficients of expansion between the glass & the metal

Differences of co-efficients of Expansion between Glass & Metal

Since metal heats easily and expands very quickly, its marriage to glass, (which heats more slowly and expands more slowly), is a nearly impossible task. **Corning Glass**, perhaps the leader of the whole world in glass/glass working/fabrication, came up to a more amenable solution, to wit!

They invented a powder, which when heated, became a glass-like substance. It did **NOT** heat, **nor** expand as rapidly as metal, but it **did** heat up quicker and expanded more rapidly, than glass. Thus, under the right circumstances/treatment, it became a very successful usable interface.

A pre-fabricated, glass-cone, (including the neck), was placed on a glass-working lathe. It was melted into the frit glass, which was ready to receive it, (in the smaller opening of the metal cone), while the larger portion of the cone was artificially, temporarily closed off, in the lathe.

The neck of the glass, was fitted thereon, such that the lathe operator, could introduce air, on command, so as to properly assure that the glass was properly formed. This counter-acted the driving force of the gas/oxygen fires, being used.

Television-set manufacturers are always concerned with “costs”; “looks”; “weight”; “Greater Deflection angle”; “bulk”; “upgrading”; and last, but not least, with “profits”. A good part of the cost of producing selling and delivery, involved several important considerations, such as **bulk** and **weight**

In order to cut the weight of shipping, they decided to go to the manufacture of **Metal Tubes**, (with a glass faceplate, for viewing). These tubes also were far lighter, [in weight], and as they developed, far less bulky as they were constantly increasing the deflection angle, hence cheaper to ship!

Metal Tubes, being lighter than a then-equivalent-size glass CRT, continued to be developed, such that they got less bulky, still lighter, (as the deflection angle increased, from 60 degrees to 90 degrees). This cut shipping costs for new T.V. sets, as well as for individually-shipped picture tubes themselves.

Following that line of reasoning, the glass-makers, also increased the deflection angle of new GLASS tube types, to as high as 114 degrees! The largest glass picture tube was a 27 inch rectangular monster that weighed about 60 lbs. The largest metal tube was a 30 inch round, which weighed about 65 pounds. NOTE: It was advertised by Dumont, showing it, as a large table, with (4) people sitting around it, sharing drinks!!

Note: In the 1950s, I laminated a 30 inch, round METAL tube, for the United States Navy, under contract with Fairchild Dumont! The Navy used the top of that tube, (plate), plotting different things, in conjunction with radar data, as well as latitude/longitude readings, to chart a course, to and from, their destination.

This was done, *directly on the faceplate*, using a special crayon, called a "China Marker". When needed again, the china-marked-data was simply, cleanly wiped of, and new data was then drawn on the tube (faceplate).

NOTE: In the 1950s, rebuilders charged for the finished tube as well as for the bulb itself. This enabled them to eke out a special profit by taking in used white-face tube, (ex: a 12 inch one). It had definite dark tint, which did NOT look like the original white-face tube, so they credited \$1.00 to the dealer.

Then, by using a special mix of regular phosphor, interspersed with BLACK phosphor, the manufacturer was able to charge \$3.00 for the same bulb, because it had the appearance of the tinted face variety! It looked so good that dealers actually asked for the dark phosphor to be used in metal tubes also, [at the extra cost also]!

Pumping Potpourri:

High vacuum equipment, which I have extensive use of, consisted of round 4-tube stationary ovens, 8-tube stationary units, trolley, 8-tube units and finally 60-position inline units.

All units, (except the 8-tube trolley units), used Dow Corning 704 Silicone Oil in the diffusion pumps, to get the low vacuum necessary to last many years. The 8-tube trolley units used MERCURY, in conjunction with LIQUID OXYGEN, (-320 F) to achieve an extremely low gas condition. (Gas cut the life of the tube, as well as causing a blurry picture!

Sealing Gun into Neck Potpourri:

Sealing the Electron Gun into the neck of the tube Equipment

“Sealing” machines, which I had extensive experience in the use of, consisted of **Single**-headed machines, **4**-headed machines and **8**-headed machines

RE-NECKING the TUBE using a Glass Lathe

I have had extensive experience with glass lathes that used mechanical clamps to hold the tubes being worked on, to lathes which used compressed air to hold the tube in place

Normally, the working fires are a hand-held **Bunson-burner**, **gas-oxygen jets**. For special tubes, (made from **NONEX** glass), **hydrogen/oxygen** jets, **MUST** be used, as the normal oxygen gas jets, are **NOT** up to the requirement. I have had extensive experience with all types of glass lathes, including the different fire sources.

A vertical glass lathe, (which is much more rudimentary), [hence cheaper], has the fire-jets rotating around the neck being worked upon. The usual lathe, a much more expensive unit, has the whole tube revolving. The neck to be added/joined, is also rotating at the same speed, as the neck of the whole tube.

The fire jets may be moved from **left-to-right** and are normally in a fixed prescribed attitude, relative to the work being done. It also has access to compressed air, [at the operator’s request/demand]. This was to counter-act the pushing-in of the pressure exerted by the working jets. If expertly-done, it is almost impossible. to see or feel, where the joint has been made.

Discarding/Replacing the CRT

NOTE: Make sure that you do **NOT** touch the Anode, while the Tube is in operation. It could give you a very bad electrical jolt. It has actually killed people, under certain circumstances.

Before removing the tube, ground the anode to an external source of **GROUND**, or even the metal chassis of the TV set. Otherwise, if you accidentally touched it, it would shock you. The shock would probably **NOT** kill you, but **STARTLE** you. That might cause you to drop the CRT. **THAT... COULD HURT YOU !**