TV and Monitor CRT (Picture Tube) Information

Version 1.92

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Preface

Author and Copyright

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DISCLAIMER

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope of This Document

This document contains a collection of information relating to CRT (picture tube) construction, characteristics, problems, maintenance, troubleshooting, and repair. This was originally from the TV and monitor repair guides of the Sci.Electronics.Repair FAQ but has been moved here due to its being of general interest.
Most new CRT related information originating on the sci.electronics.repair, comp.sys.ibm.pc.hardware.video, or other USENET newsgroups will be included here rather than in those other documents.

Related Documents

The following may be of interest and cover many relavent topics related to CRT based equipment:

- Safety Guidelines for High Voltage and/or Line Powered Equipment.
- Notes on the Troubleshooting and Repair of Computer and Video Monitors.
- Notes on the Troubleshooting and Repair of Television Sets.
- Performance Testing of Computer and Video Monitors.
- Notes on Approaches to using Fixed Frequency Monitors on PCs.
- Notes on Video Conversion.

Additional Information on CRTs

The PC Technology Guide has some information with nice diagrams on both CRT and flat panel displays. This site is well worth visiting to get an idea of the construction, operation, and problems for a variety of display technologies.

(From: David Moisan (dmoisan@shore.net).)
I've seen a few such pictures and I was fortunate enough to find a book on color CRTs that explained quite a few things:

> Color Television Picture Tubes
> Morell, Law, Ramberg, Harold
> ISBN 0-12-022151-0.

I'm not sure if its still in print but you might check out your local university library.)
If you are lucky enough to see "The Secret Life of Machines" on The Learning Channel (or was, last time I saw it), there's an episode on the secret life of the TV. It's excellent! The creator and presenter, Tim Hunkin, has a weird sense of humor but he's very well informed and quite gifted in the way he demonstrates difficult-to-explain concepts. In the opening scene, he showed off a TV that he sawed in half, showing the CRT construction very clearly. (He must have let the air into the tube, then used a diamond saw to cut it; that's the only way it could be done without glass everywhere!)
(Of course, he may not *actually* have cut a TV in half - manufacturers no doubt maintain props of this sort!)

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CRT Safety Issues

Electrical Safety

TVs and computer or video monitors are among the more dangerous of consumer electronic equipment when it comes to servicing. (Microwave ovens are probably the most hazardous due to high voltage at flesh frying and cardiac arresting high power.)
There are two areas which have particularly nasty electrical dangers: the non-isolated line power supply and the CRT high voltage.
Major parts of nearly all modern TVs and many computer monitors are directly connected to the AC line - there is no power transformer to provide the essential barrier for safety and to minimize the risk of equipment damage. In the majority of designs, the live parts of the TV or monitor are limited to the AC input and line filter, degauss circuit, bridge rectifier and main filter capacitor(s), low voltage (B+) regulator (if any), horizontal output transistor and primary side of the flyback (LOPT) transformer, and parts of the startup circuit and standby power supply. The flyback generates most of the other voltages used in the unit and provides an isolation barrier so that the signal circuits are not line connected and safer.
Since a bridge rectifier is generally used in the power supply, both directions of the polarized plug result in dangerous conditions and an isolation transformer really should be used - to protect you, your test equipment, and the TV, from serious damage. Some TVs do not have any isolation barrier whatsoever - the entire chassis is live. These are particularly nasty.
The high voltage to the CRT, while 200 times greater than the line input, is not nearly as dangerous for several reasons. First, it is present in a very limited area of the TV or monitor - from the output of the flyback to the CRT anode via the fat red wire and suction cup connector. If you don't need to remove the mainboard or replace the flyback or CRT, then leave it alone and it should not bite. Furthermore, while the shock from the HV can be quite painful due to the capacitance of the CRT envelope, it is not nearly as likely to be lethal since the current available from the line connected power supply is much greater.

Safe Discharging of Capacitors in TVs and Video Monitors

It is essential - for your safety and to prevent damage to the device under test as well as your test equipment - that large or high voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line operated equipment store a potentially lethal charge. This doesn't mean that every one of the 250 capacitors in your TV need to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found after powering off (or before any testing - some capacitors (like the high voltage of the CRT in a TV or video monitor) will retain a dangerous or at least painful charge for days or longer!)

The technique I recommend is to use a high wattage resistor of about 100 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (not needed for the CRT - discharge is nearly instantaneous even with multi-M ohm resistor). Obviously, make sure that you are well insulated!

- For the main capacitors in a switching power supply which might be 100 uF at 350 V this would mean a 5K 10W resistor. RC=.5 second. 5RC=2.5 seconds. A lower wattage resistor can be used since the total energy in not that great. If you want to be more high tech, you can build the capacitor discharge circuit outlined in the companion document: Capacitor Testing, Safe Discharging, and Other Related Information. This provides a visible indication of remaining charge and polarity.

- For the CRT, use a high wattage (not for power but to hold off the high voltage which could jump across a tiny 1/4 watt job) resistor of a few M ohms discharged to the chassis ground connected to the outside of the CRT - NOT SIGNAL GROUND ON THE MAIN BOARD as you may damage sensitive circuitry. The time constant is very short - a ms or so. However, repeat a few times to be sure. (Using a shorting clip lead may not be a bad idea as well while working on the equipment - there have been too many stories of painful experiences from charge developing for whatever reasons ready to bite when the HV lead is reconnected.) Note that if you are touching the little board on the neck of the CRT, you may want to discharge the HV even if you are not disconnecting the fat red wire - the focus and screen (G2) voltages on that board are derived from the CRT HV.

  WARNING: Most common resistors - even 5 W jobs - are rated for only a few hundred volts and are not suitable for the 25kV or more found in modern TVs and monitors. Alternatives to a long string of regular resistors are a high voltage probe or a known good focus/screen divider network. However, note that the discharge time constant with these may be a few seconds. Also see the section: Additional Information on Discharging CRTs.
  If you are not going to be removing the CRT anode connection, replacing the flyback, or going near the components on the little board on the neck of the CRT, I would just stay away from the fat red wire and what it is connected to including the focus and screen wires. Repeatedly shoving a screwdriver under the anode cap risks scratching the CRT envelope which is something you really do not want to do.

Again, always double check with a reliable voltmeter!T

Reasons to use a resistor and not a screwdriver to discharge capacitors:

1. It will not destroy screwdrivers and capacitor terminals.
2. It will not damage the capacitor (due to the current pulse).
3. It will reduce your spouse's stress level in not having to hear those scary snaps and crackles.

Additional Information on Discharging CRTs

You may hear that it is only safe to discharge from the Ultor to the Dag. So, what the @#$% are they talking about? :-).
BTW, don't wash your CRTs even if the Maid complains about the filth until you have confirmed that your 'Dag isn't water soluble (maybe that's why it has 'aqua' in the name!). It may all come off! Wipe off the dirt and dust with a cloth (and stay away from the HV connector or make sure it is discharged first!).
(From: Asimov (mike.ross@juxta.mnet.pubnix.ten).)
'Dag' is short for Aquadag. It is a type of paint made of a graphite pigment which is conductive. It is painted onto the inside and outside of picture tubes to form the 2 plates of a high voltage filter capacitor using the glass in between as dielectric. This capacitor is between .005uF and .01uF in value. This seems like very little capacity but it can store a substantial charge with 25,000 volts applied.
The outside "dag" is always connected to the circuit chassis ground via a series of springs, clips, and wires around the picture tube. The high voltage or "Ultor" terminal must be discharged to chassis ground before working on the circuit especially with older TV's which didn't use a voltage divider to derive the focus potential or newer TV's with a defective open divider.

Warning about disconnecting CRT neck board

Some manufacturers warn against powering a TV or monitor CRT without the CRT neck board connected. Apparently, without something - anything - to drain the charge resulting from the current flow due to residual gas ions inside the CRT, the shortest path may be through the glass neck of the tube to the yoke or from the pins outside the CRT to whatever is nearby. There aren't many ions in a modern CRT but I suppose a few here, a few there, and eventually they add up to enough to cause a major disaster at least on some CRTs.
This is probably not a problem on small CRTs but for large ones with high high voltages and high deflection angles where the glass of the neck is very thin to allow for maximum deflection sensitivity, the potential does exist for arcing through the glass to the yoke to occur, destroying the CRT.
There is really no way to know which models will self destruct but it should be possible to avoid such a disaster by providing a temporary return path to the DAG ground of the CRT (NOT SIGNAL GROUND!!) via the focus or G2 pins preferably through a high value high voltage rated resistor just in case one of these is shorted.
This probably applies mostly to large direct-view TVs since they use high deflection angle CRTs but it won't hurt to take appropriate precautions with video and computer monitors as well.

CRT Implosion Risk?

Also see the section: Disposing of Dead TVs or Monitors (CRTs and Charged HV Capacitors).
(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
I have checked with our CRT expert and he thinks that any 'normal' type of scratch does not pose any danger. Usual disclaimer applies ... (what is 'normal'?)

The front of the tube is much thicker and stronger than the rear. It has to be, to withstand the air pressure, because the curvature radius is so much larger. You won't break it by throwing a slipper at it. The neck is in fact very easy to break, usually without causing injuries to anyone. Normally, if the tube should implode, the rimband (the tensioned steel band around the rim of all modern CRTs of any size) prevents the glass from flying outward too far. Every tube type has to pass tests in which it is deliberately imploded and it is checked whether any large shrapnel flies too far out.

What *is* very dangerous is a CRT with its rimband missing, or a CRT which never had a decent rimband in the first place (like some dubious Russian-made samples we once saw). Such a tube should not be handled at all. NEVER ever attempt to remove the rimband for and reason!

I just saw a picture tube that was broken due to dropping the (entire) TV on one corner. In the cone (the backside) there are open cracks of some 3 feet length in total. Nevertheless all the glass is still in its original place and it looks as if no glass has flown outward. The faceplate is still intact. So in this case nobody would have got hurt. I remember reading about Americans (who else?) who tried to shoot CRT's with smaller rifles, with little or no success.

Does this comfort you? Get out the shotgun and have a go at it!

Or, perhaps, the following:

(From: Ren Tescher (ren@rap.ucar.edu).)

Our 6 month old 20" SGI color monitor (model GDM-20D11) lost a fight with a fork lift. The case is intact, the CRT probably still has a vacuum, but the outer layer of glass on the screen is shattered.

Picture Tube Implosion IS Possible - But You Really Need To Work at It!

As noted elsewhere in this document, picture tube implosion is a hazard but under normal conditions, quite unlikely. Someone wrote:

> "I heard somewhere that in the early days of TV, the tubes had a tendency to implode at the drop of a hat. (Due to poor design?) In order to prevent flying glass, the sets had a plastic sheet in front of the screen. Obviously, modern sets no longer have this. How safe are modern CRT screens in terms of impact damage etc?"

Well, it isn't quite as simple as that..... However, even if CRT implosion is one of those highly unlikely events, the downside is that should it occur in just the wrong way, the consequences can be disastrous. So, I wouldn't depend on the experiences below to guide you! Treat a CRT about the same way you would an armed nuclear bomb. OK, well maybe just 10 sticks of dynamite. :-)

(From: Dan Evens (dan.evens@hydro.on.ca).)

In high school, our electronics teacher did a demo for each class. He saved out an old black-and-white tube for each class and set up a place to break it. Put the tube on the ground by a brick wall, with a hammer suspended on a wire from the top of the wall. Did it on the driveway so that the glass would be easier to pick up. The tube was placed image-side down. First he pulled the hammer back about 20 feet and just let it go. It bounced off the tube. This was to show that such tubes are pretty tough. Then he pulled the hammer back and gave it a pretty good shove, turning his back to the tube and moving quickly away from it. (Let's face it, the guy could probably have found a safer way to do this.)

Palm sized chunks of glass flew 50 feet. The noise was quite impressive. The thickness of the image plate of the tube was also quite impressive. Kind of looked like a porthole on a submarine. This was from the tube of a small black-and-white TV, about 14 inches or so. One of the larger colour models might be a LOT more violent.

If I was handling these things in such a way as to have the possibility of dropping one, I'd insist on body armor and face protection. And if it involves a picture tube, I insist on competent trained professionals for service.
(From: Matthias Meerwein (Matthias.Meerwein@rt.bosch.de).)
They ARE quite safe. I've got several TVs and computer monitors in for repair that had been dropped. None of them had an imploded CRT. The damage encountered ranged from:

- Broken circuit boards, often around the flyback transformer (the most heavy weight part on the board) - This is quite easily repairable.
- Shadow mask inside the tube knocked out of position (mostly in trinitron tubes due to their heavy aperture grille construction) - this renders the tube (and thus usually the set) a dumpster candidate.
- Neck of tube broken of (usually when the set hit the floor back end first) - obviously junk.

Furthermore, I did some experimentation with junk sets:

- 26 inch color TV with back panel removed placed face-down under a bridge. Dropped a ~10 pound brick from top of the bride (about 10 ft high) into the glass funnel of the tube. Result: Funnel of tube shattered, faceplate intact. All glass shards (most of them rather large) were lying inside the set's cabinet - no flying glass.
- 14 inch B/W computer monitor tube dropped from the second story onto concrete floor, hitting the ground faceplate-first. Result: tube shattered into thousands of small glass particles (the largest ones were about one inch in size), but all debris was located on one heap - none of them traveled farther than about three feet.

Conclusion: According to my experience, spectacular picture tube implosions are something like cars in movies that explode upon roll-over, hitting a tree or driving down the cliffs: an urban legend.
(From: Clifton T. Sharp Jr. (agent150@spambusters.ml.org).)
With today's tubes, that's more or less true (although walking through a picture tube plant can be instructive as you hear the exploding tubes). With older tubes it was a hazard. With pre-1960 tubes it was a big one. My old boss in the TV service, who I trusted not to exaggerate about such things, told me stories of setting a picture tube near a second-floor window, having them fall to the sidewalk and literally blow a hole in the sidewalk. I can tell you factually and first-person that although he took few precautions with other things, when he had to "pop" a picture tube in the dumpster he never ever ever did it without safety glasses, a shield and a six-foot piece of heavy pipe. (I stopped working there around 1973.)

Risks from CRT Scratches?

A really deep long scratch or gouge on the CRT face should be considered a serious safety hazard as it may reduce the structural integrity and increase the risk of implosion. However, you would likely need a hammer and chissel or diamond tipped tool to make scratches that deep. It is very unlikely that such scratches could come from any reasonable normal use. Dropping it from a cliff, deliberate use of a glass cutter, the use of a really really BIG hammer, or 12 gauge shotgun, might perhaps be sufficient.
This is more of a concern for modern CRTs that usually have 'integral implosion protection' - that steel rimband around the outside near the front. Older CRTs used either (1) a separate safety shield - that laminated glass plate in front of your grandmom's TV - or (2) a second contoured glass panel bonded to the actual tube face. In both of these cases, the second panel is protective and cosmetic but is not part of the structure of the CRT. Therefore, any damage

to it does not significantly compromise the tube. In the case of modern CRTs, the steel band in conjunction with the basic tube envelope is used to maintain the integrity of the overall CRT. In addition should implosion occur as a result of catastrophic damage, the rimband will reduce the range and velocity of flying debris.

Also see the section: CRT Implosion Risk?.

BTW, scratches in the CRT have absolutely no effect on X-ray emission. X-rays are blocked long before they come anywhere near the surface and glass has very little effect on their direction. Any scratch deep enough to have any detectable effect on X-ray emission (actually, it would need to be an inch deep gouge) would have caused the tube to implode.

Disposing of Dead TVs or Monitors (CRTs and Charged HV Capacitors)

I don't know what the law says, but for safety, here is my recommendation:

Treat the CRT with respect - the implosion hazard should not be minimized. A large CRT will have over 10 tons of air pressure attempting to crush it. Wear eye protection whenever dealing with the CRT. Handle the CRT by the front - not the neck or thin funnel shaped envelope.

Don't just toss it in the garbage - it is a significant hazard. The vacuum can be safely released (Let out? Sucked in? What does one do with an unwanted vacuum?) without spectacular effects by breaking the glass seal in the center of the CRT socket (may be hidden by the indexing plastic of the socket). Cover the entire CRT with a heavy blanket when doing this for additional protection. Once the vacuum is gone, it is just a big glass bottle though there may be some moderately hazardous materials in the phosphor coatings and of course, the glass and shadow mask will have many sharp edges if it is broken.

In addition, there could be a nice surprise awaiting anyone disconnecting the high voltage wire - that CRT capacitance can hold a charge for quite a while. Since it is being scrapped, a screwdriver under the suction cap HV connector should suffice.

The main power supply filter caps should have discharged on their own after any reasonable length of time (measured in terms of minutes, not days or years).

Of course around here, TVs and monitors (well, wishful thinking as I have yet to see a decent monitor on the curb) are just tossed intact which is fortunate for scavengers like me who would not be happy at all with pre-safed equipment of this type!

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

We have a procedure for disposing of used CRT's. The vacuum must be broken to avoid future implosion, like when it will be crushed by the dumpster truck press. That's NOT funny!

One method is to punch or drill a small hole in the anode contact, which is made of a soft metal. But take care of the electrical discharge of the aquadag capacitance first!!!

The other method is to break the stem in the centre of the socket pins. This is the stem through which the tube was pumped empty during manufacturing. It breaks off easily (after you have removed the plastic part around the pins).

You want to avoid making too large holes, like for example from chopping off the entire neck in one blow with a hammer.

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General CRT Construction and Characteristics

Why is the CRT Still Dominant?

Currently, most TVs and computer monitors are still based on the Cathode Ray Tube (CRT) as the display device. However, many hand-held TVs, portable equipment, laptop computers, and the screens inside video projectors now use flat panel technology, mostly Liquid Crystal

Displays - LCDs. These are a lot less bulky than CRTs, use less power, and have better geometry - but suffer from certain flaws.
First, the picture quality in terms of gray scale, color, and brightness is generally inferior to a decent analog monitor. The number of distinct shades of gray or distinct colors is a lot more limited. They are generally not as responsive as CRTs when it comes to real-time video which is becoming increasingly important with multimedia computers. Brightness is generally not as good as a decent CRT display. And last but not least, the cost is still much much higher due both to the increased complexity of flat panel technology and lower production volumes (though this is certainly increasing dramatically). It is really hard to beat the simplicity of the shadow mask CRT. For example, a decent quality active matrix color LCD panel may add $1000 to the cost of a notebook computer compared to $200 for a VGA monitor. More of these panels go into the dumpster than make it to product do to manufacturing imperfections.
A variety of technologies are currently competing for use in the flat panel displays of the future. Among these are advanced LCD, plasma discharge, and field emission displays. Only time will tell which, if any survives to become **the** picture-on-the-wall or notepad display - at reasonable cost.
At least one company is about to introduce a 42 inch diagonal HDTV format flat plasma panel multisystem color TV/monitor which will accept input from almost any video or computer source. Its price at introduction will be more than that of a typical new automobile - about $15,000! :-) Thus, at first, such sets will find their way into business conference rooms and mansions rather than your home theater but prices will drop over time.
Projection - large screen - TVs and monitors, on the other hand, may be able to take advantage of a novel development in integrated micromachining - the Texas Instruments Inc. Digital Micromirror Device (DMD). This is basically an integrated circuit with a tiltable micromirror for each pixel fabricated on top of a static memory - RAM - cell. This technology would permit nearly any size projection display to be produced and would therefore be applicable to high resolution computer monitors as well as HDTV. Since a reflective medium is used in this device, the light source can be as bright as needed. Commercial products based on the DMD are beginning to appear.

Comparison of CRT Types

> "Could someone please help to elucidate the comparative advantages of each technology? I know how they work but do not know which is advantageous and why."

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
Trinitron is Sony technology. The shadow mask (called the aperture grille) consists of vertical wires under tension. The mask is always straight in the vertical direction and curved in the horizontal direction, thus the shape is a cylinder. The tube surface is also cylindrical, which causes some strange effects, particularly funny mirror reflections of yourself. Because the wires are under a lot of tension, the internal tube structure must be very strong and thus relatively heavy. Because the glass surface is cylindrical instead of spherical, the glass must be thicker and heavier too, to withstand atmospheric pressure.
Heavier always equates to more expensive!
The electron gun construction is also different: there are still 3 guns (not one as some may thing but the 3 guns share one main lens. (The assembly of focusing grids is called a lens, in analogy to the optical principle.) There are still 3 cathodes and 3 G1s, as usual. The large diameter lens has the advantage of less spherical aberration (and thus a sharper spot) but the disadvantage of large physical length which means a deeper cabinet.
In the deflection coil design another compromise is found between spot quality, purity and convergence. As a result horizontal convergence must be helped by an auxiliary dynamic

convergence waveform (on an extra convergence coil?). This adds to cost and can occasionally give an interesting failure of the horizontal convergence.
The best non-Trinitron (or clone) CRTs use a conventional shadow mask made of Invar - originally Matsushita technology; Philips uses it too. The shadow mask is of the standard shape (spherical metal plate with holes in it) but it is made of a special alloy with a 7 times lower coefficient of thermal expansion than regular iron. This allows a brighter picture with less purity errors.
The problem with regular shadow masks is 'doming'. Due to the inherent principle of shadow masks, 2/3 or more of all beam energy is dissipated in the mask. Where static bright objects are displayed, it heats up several hundred degrees. This causes thermal expansion, with local warping of the mask. The holes in the mask move to a different place and the projections of the electron beams will land on the wrong colours: purity errors. The use of invar allows about 3 times more beam current for the same purity errors. See the section: What is Doming?.
Combating purity errors is a necessity due to 2 trends:

- Flatter picture tubes: flatter shadow masks are more sensitive to doming
- Darker (glass) picture tubes: this gives more contrast but more beam current is needed for enough brightness

The trinitron aperture grill shadow mask is inherently insensitive to doming as long as the tension in the wires remains positive. If the wires become too long then they become more sensitive to microphony (try tap the cabinet...). The vertical wires are connected in several places by thin horizontal wires. Some people complain about seeing faint shadows of these wires.
To summarize: Trinitron monitors are probably heavier, larger, more expensive, maybe better on purity, and maybe better on focus than other monitors, with or without invar shadow masks. There are excellent monitors other than Trinitron too... I suppose the Coke-Pepsi comparison is true.

Color CRT Construction

For a couple introductory on-line articles about (mostly) CRTs, see:

- High Tech Tubes, Popular Mechanics, April 1997.
- Display.

All the color CRTs found in TVs and computer and video monitors utilize a shadow mask or aperture grill a fraction of an inch (1/2" typical) behind the phosphor screen to direct the electron beams for the red, green, and blue video signals to the proper phosphor dots. Since the electron beams for the R, G, and B phosphors originate from slightly different positions (individual electron guns for each) and thus arrive at slightly different angles, only the proper phosphors are excited when the purity is properly adjusted and the necessary magnetic field free region is maintained inside the CRT. Note that purity determines that the correct video signal excites the proper color while convergence determines the geometric alignment of the 3 colors. Both are affected by magnetic fields. Bad purity results in mottled or incorrect colors. Bad convergence results in color fringing at edges of characters or graphics.
The shadow mask consists of a thin steel or InVar (a ferrous alloy) with a fine array of holes - one for each trio of phosphor dots - positioned about 1/2 inch behind the surface of the phosphor screen. With some CRTs, the phosphors are arranged in triangular formations called triads with each of the color dots at the apex of the triangle. With many TVs and some

monitors, they are arranged as vertical slots with the phosphors for the 3 colors next to one another.
An aperture grille, used exclusively in Sony Trinitrons (and now their clones as well), replaces the shadow mask with an array of finely tensioned vertical wires. Along with other characteristics of the aperture grille approach, this permits a somewhat higher possible brightness to be achieved and is more immune to other problems like line induced moire and purity changes due to local heating causing distortion (doming) of the shadow mask.
However, there are some disadvantages of the aperture grille design:

- Weight - a heavy support structure must be provided for the tensioned wires (like a piano frame).
- Price (proportional to weight).
- Always a cylindrical screen (this may be considered an advantage depending on your preference.
- Visible stabilizing wires which may be objectionable or unacceptable for certain applications.

Apparently, there is no known way around the need to keep the fine wires from vibrating or changing position due to mechanical shock in high resolution tubes and thus all Trinitron monitors require 1, 2, or 3 stabilizing wires (depending on tube size) across the screen which can be see as very fine lines on bright images. Some people find these wires to be objectionable and for some critical applications, they may be unacceptable (e.g., medical diagnosis).

Assembly of Color CRTs

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
The following is a greatly simplified description of the general process of color (shadow or slot mask) CRT construction. Trinitrons should be basically similar.
The screen and envelope glass pieces are molded separately and then glued (Epoxied?) together as one of the last steps of assembly prior the baking and evacuation. (You will note this seam if you examine the envelope of a color CRT near the front.)
The shadow mask is manufactured through a photo etching process. No, there are no workers responsible for punching all those holes! Since a position error of even a tiny fraction of a mm would result in purity errors, each shadow mask is unique for its faceplate. They are not interchangeable. To facilitate the following steps, it can easily be mounted and removed (essentially clicked in place) during tube production. Registration pins assure precise alignment.

- For each of the phosphor colours (and optional black matrix) one phosphor layer is deposited followed by one photoresist layer.

  At least one manufacturer adds some steps for the Superbright tubes. They put 3 different colour filters between the glass and the phosphor. In terms of contrast that tube is a definite killer.
- The shadow mask for that CRT (unique) is then mounted - clicked in place.
- An intense point source of light is mounted at the location of the effective center of deflection for the electron gun associated with that phosphor.
- The photoresist is exposed to light.

- The shadow mask is removed and the excess resist (not exposed to light) and phosphor is washed away.

These steps are repeated for the red, green, and blue phosphors, and the optional (but very common) black matrix surround.
Using the shadow mask repeatedly in this manner guarantees close registration. How else would you lay down a million individual dots in exactly the right place - paint by numbers? :-).
Then, an aluminum overcoat is deposited over the phosphor/black matrix. This has several functions:

- Provide the return path for the electron beam - connected to the EHT 2nd anode.
- Reduces backscattering or secondary emission. Electrons that bounce back from either the shadow mask or the screen may hit a phosphor elsewhere and thus cause unwanted white light. That reduces contrast and colour purity.
- A side benefit is that it blocks negative ions from residual air molecules from hitting the phosphors. These might result in an unsightly blemish in the center of the screen since they are much heavier (many thousands of times the mass) than electrons and are not deflected very much. (This was a problem in the early days of CRT production but apparently not with present high vacuums and getters to clean up whatever is left.)

The shadow mask is then mounted for a final time and the faceplate, envelope (with its electron gun assembly already fused to it) are mated. At this point, it is ready for the final baking and evacuation.
The tube is evacuated through the thin stem that is located in the middle of the socket. That takes several hours at the vacuum pumps. The stem is then sealed by heating and melting.
The getter - part of the electron gun assembly - is then 'activated' via induction heating from a coil external to the next of the CRT. This vaporizes and deposits a highly active metal on the interior of the glass of the neck. The getter material adsorbs much of any remaining gas molecules left over from the evacuation of the tube. The getter material is normally silvery - if it changes to red or milky white, the tube is probably gassy or up to air.
When the tube is ready it is matched with a deflection coil that provides optimum purity. It takes some ingenuity to get a good match between using a light for exposure which matches the behaviour of the future electron optical system, in order to get good purity.
Amazingly, this basic process has not changed in any fundamental way since the invention of the shadow mask CRT!
However, Computer Aided Design (CAD) has had a major impact on the design of the electron optics. The working of the electron gun and deflection system is now much more predictable thanks to advanced computer simulation. This has reduced the number of active correction circuits for focus, geometry and convergence to almost zero.

CRT Fine Tuning

Once the CRT is sealed, baked, evacuated, etc., the job is not yet done!
(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
They still need to match the finished tube with a deflection coil that will give adequate purity performance and then they need to fiddle with magnets (multipole rings around the neck and sometimes other magnets all over the cone) to improve it further. And even then many tubes need active correction for convergence and/or geometry.
Only after all that correction can you call the yield high. (But you should see their scrap yard, good thing that glass recycles well...)

Northern/Southern Hemisphere Corrections and Adjustments

The vertical component of the earth's magnetic field varies in intensity and polarity (N/S) as one moves from the North pole over the equator and to the South pole. It is maximum at the poles and decreases to zero at the equator. The total strength is not large - after all it is less than the total magnitude of the earth's magnetic field of about .5 Gauss (.00005 Tesla). However, it is enough to affect the trajectory of the electron beam(s) slightly.

For monochrome monitors and B/W TVs, this will result only in a slight shift in position or rotation of the picture depending on the orientation of the CRT with respect to the earth's magnetic field. For the most part such effects will not be significant enough to be objectionable.

However, for high resolution color monitors and even some color TVs, the result of transporting the unit from the hemisphere from which it was manufactured or set up to a location in the opposite hemisphere may be uncorrectable purity problems or excessive sensitivity to local magnetic fields.

Note that is it quite possible that you will never encounter any of these problems. The extent to which your particular monitor or TV is affected depends on many factors - many of which you have no control over.

(From: Bob Myers (myers@fc.hp.com).)

For many monitors - especially the larger sizes, such as 21" - there is a subtle difference in the CRT itself which may mean that a unit with the wrong tube could NOT be adjusted to be within specifications when used in the 'wrong' hemisphere.

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

There are two types of adjustments:

- The passive ones that are done in the picture tube factory and
- The active ones that are done by the setmaker a/o the customer.

In the factory inside the neck of every (Philips) tube a metal ring is permanently magnetized to create a multipole correction field. Then each tube is matched with a deflection yoke to achieve optimum colour purity. It is possible that a couple of yokes must be tried in succession. This matching is done under specific ambient magnetic field conditions. On oriental tubes you will often see little permanent magnets added to achieve further fine correction of landing and/or convergence. When the tube is within landing specification it is shipped to the setmaker.

Depending on the sophistication of the circuitry in the (television or monitor) set, the setmaker can adjust geometry and sometimes convergence (if there is a set of convergence coils present). If there is a rotation coil present then this may also improve the landing a bit. In the 'digital monitors' there are flexible waveform generators to adjust the corrections. There may be further adjustments possible for the uniformity of the colour point and brightness. This gives a place-dependent modulation of the 3 beam currents, it does nothing to improve the landing.

The most expensive monitors (large screen, fine phosphor pitch, very critical on landing) may have active magnetic field compensation in all 3 directions with electronic magnetic field sensors for automatic adjustment. These monitors should be mostly insensitive to the earth magnetic field. (This technology was originally invented for the use of CRT displays on board of jet fighter planes, which tend to turn relative to the earth...)

All other monitors will degrade picture quality when the degaussing is not able to completely compensate for the earth magnetic field. With a tube built for the wrong hemisphere it is possible that the effect of the vertical component of the earth magnetic field will give a residual landing error. This can not be corrected by turning any of the available adjustments, digital or not. Re-alignment might become a very costly job.

Tubes for All Nations

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

CRT Manufacturers actually make different versions of their tubes for TV's for the northern and southern hemisphere, and sometimes a 3rd neutral type. These are so-to-say precorrected for the uncompensated field. (Note that the term 'tube' here includes much of the convergence hardware as well - not just what is inside the glass.)

I remember when we exported projection televisions from Belgium to Australia, a couple of years ago. They all had to be opened on arrival to re-adjust the rotation settings on the convergence panel, due to the different magnetic field in Australia. Projection TV's don't have degaussing (there is nothing to degauss), and the customer can only adjust red and blue shift, not rotation.

Our CRT application group has a "magnetic cage". This is a wooden cube (approx. 2 meter long sides) with copper coils around each of the 6 surfaces. With this they can simulate the earth magnetic field for every place on earth (as indicated on a map on the wall).

During production and adjustment of the tube, the beam landing is optimized for the field condition in which it will be used later. There may be different tube specifications for north, south and equator ("neutral"). If you choose to use it in different conditions then the landing reserve will be diminished and you will suffer sooner from colour purity errors. I'm not so sure if the convergence would be a primary problem, maybe yes.

With a dotted shadow mask, also the horizontal component of the field matters, which is bad because it also depends on which direction you orient the display. This too will eat away from your landing reserve. How critical it all is depends on tube size (bigger is worse) and on dot pitch (smaller is worse). Workstation monitors are most critical.

Using a Helmholtz cage you can test or optimize for a particular place on earth. The most expensive monitors come with their own built-in Helmholtz cage and magnetic sensors to always create a field-free space.

Another interesting bit of trivia:

B&O (Bang & Olufsen of Danmark) use Philips picture tubes in their beautifully designed cabinets. In order to facilitate a more narrow styling they decided to mount the tube upside-down, so they don't need safety clearance for the EHT on top. As a consequence they needed a southern-hemisphere tube for the northern hemisphere! So here is a hint for a solution to you all...

(From the editor).

In light of the above discussion, the following makes perfect sense:

(From: Nigel Morgan (nigel@wycombe.demon.co.uk).

When I was in the TV trade some 20 years ago, I was introduced to a model with a PYE badge on which differed in one significant detail: on all TV sets I'd seen to that date the tube had the blue gun uppermost and the EHT connector at the top of the tube. Thorn TV sets mounted the tube upside-down for some reason so that the EHT connector was at the bottom along with the blue gun, but these PYE sets had the blue gun at the bottom, but the EHT connector was at the top! When I asked about this, I was told that the tubes used in the PYE sets were 'Southern Hemisphere tubes. I never could decide whether this was genuine or BS!

(From: Terry DeWick (dewickt@esper.com).)

The magnetic field for South America is about 0 to -100 mG while the U.S. runs 400 to 500 mG (milli Gauss). For a CRT to set up correctly the gun is offset 1 to 1.5 mm left of center for the 500mG field and 1 mm to the right for 0 mG this way the purity will be centered and the yoke tilt will be centered making setup easy during production. A North American CRT can be set up in South America but there is a chance that it will not set up well with excessive purity correction and or wedging set to the extremes.

So What Does It Mean to Have a Trinitron CRT?

Trinitron is a CRT technology developed by Sony. The patent has recently expired and therefore other manufacturers are free to offer similar CRTs. The CRT uses a set of fine vertical wires called an aperture grill instead of a steel shadow mask to separate the R, G, and B electron beams and force them to strike only the appropriate colored phosphors. This in conjunction with an in-line set of electron guns is supposed to provide a brighter image with simpler convergence and purity adjustments. It should be brighter because the percentage of open space of the aperture grill is higher then that of a shadow mask. Other adjustments should be less critical in the vertical direction. In addition, since there is no imposed structure in the vertical direction, undesirable moire patterns caused by scan line pitch compared with the shadow mask dot pitch should be eliminated.

You can recognize a Trinitron tube by the fact that the picture is made up of fine vertical stripes of red, green, and blue rather than dots or slots. The shadow mask in all other kinds of common CRTs are made up of either dots (nearly all good non-Trinitron computer monitors) or slots (many television sets). The Trinitron equivalent is called an aperture grill and is made of around a thousand vertical wires under tension a fraction of an inch behind the glass faceplate with its phosphor stripes.

Several photos of a disemboweled Trinitron aperture grille can be found at James Sweet's Sony/Trinitron Directory along with some screen shots showing the symptoms resulting from a monitor falling on its face. :(

Since the aperture grill wires run the full height of the tube, there are 1 or 2 stabilizing wires to minimize vibration and distortion of the aperture grill. These may be seen by looking closely 1/3 and/or 2/3 of the way down the tube. The larger size tubes will have 2 while those under 17 inch (I think) will only have a single wire. Many have complained about these or asked if they are defects - no they are apparently needed. You can be sure that Sony would have eliminated them if it were possible.

Another noticeable characteristic of Trinitrons is the nearly cylindrical faceplate. The radius in the vertical direction is very large compared to the horizontal. This is both a requirement and a feature. Since the aperture grill wires are under tension, they cannot follow the curve of the glass as a normal shadow mask may. Therefore, the glass must be flat or nearly flat in the vertical direction. As a selling point, this is also an attractive shape.

In the final analysis, the ultimate image quality on a monitor depends as much on other factors as on the CRT. There are many fine monitors that do not use Trinitrons as well as many not-so-great monitors which do use Trinitron tubes.

Why are There Fine Lines Across My Trinitron Monitor or TV?

These are not a defect - they are a 'feature'. :-)

All Trinitron (or clone) CRTs - tubes that use an aperture grille - require 1, 2, or 3 very fine wires across the screen to stabilize the array of vertical wires in the aperture grille. Without these, the display would be very sensitive to any shock or vibration and result in visible shimmering or rippling. (In fact, even with these stabilizing wires, you can usually see this shimmering if you whack a Trinitron monitor.) The lines you see are the shadows cast by these fine wires.

The number of wires depends on the size of the screen. Below 15" there is usually a single wire; between 15" and 21" there are usually 2 wires; above 21" there may be 3 wires.

Only you can decide if this deficiency is serious enough to avoid the use of a Trinitron based monitor. Some people never get used to the fine lines but many really like the generally high quality of Trinitron based displays and eventually totally ignore them.

Differences between Trinitron and Diamondtron CRTs

(From: Bill Nott (BNott@Bangate.compaq.com).)
Mitsubishi makes the Diamondtron under license from Sony - the subtle differences (according to Mitsubishi) are improvements in the electron gun design for spot uniformity over the CRT face. Also, for the time being, Mitsubishi has tried to introduce Diamondtron tubes in sizes which are not available as Trinitrons - to keep from directly competing, and (ostensibly) to address niches which other sizes can't address.
In order to properly evaluate a monitor, one must consider more than the tube alone - as many readers know, Trinitrons are finding their way into various manufacturer's sets, but they don't all perform the same. In todays market, it's quite possible to find a dot mask design which performs as well as (or better in some cases) the aperture grill design - IMHO every critical monitor purchase should be made by personally examining the monitor to be bought, under the intended application(s).
(BTW, all color tubes use 3 guns, including the Trinitron. Sony used to talk about a "unitized gun", but that only refers to the cathode structure. It's classical use of a misleading term to gain market awareness (looks like it works).)
(From: Someone who wishes to remain anonymous.)
I have found other differences between the Trinitron and Diamondtron tubes. Most noticeable is the grill pitch. The 21" Sony GDM-F520 is 0.22 mm. The 22" Mitsubishi (Cornerstone P1750) is 0.25 mm. For high resolution screens, this makes a difference.
I have also noticed that in a room full of Dell Trinitron monitors, no two monitors have the same color. This is not just a setup issue, the actual tubes have different colors when they are off. The darkness of the black changes.
My gut feeling is that the Dells use a Mitsubishi tube, and that the quality control is not up to Sony's. It is just a feeling, I have not done any research on this.
From what little I know, if you want the very best, you will have to pay for it, (or you get what you pay for).

Some History of In-Line Gun CRTs

(From: Thomas Maggio (staccato@gate.net).)
GE's first set was a 10 or 11 inch " "PortaColor" TV which, to the best of my memory, was introduced in the mid-60s. It was a tube chassis that made use of space saving Compactron multifunction tubes. A solid state version followed some years later I believe. If I remember correctly, the color circuit used a novel method to generate the local 3.58 MHz color signal: it used the recovered color burst to 'ring' a series crystal to produce a continuous carrier. I remember reading about all this in one of the late great "Radio-Electronics" Annual Color TV issues that I looked forward to each year back then as color TVs were dynamically evolving from many US companies.
The GE CRT did indeed use 3 in-line guns aimed at a conventional shadow mask triad phosphor screen. This simplified convergence and the CRT neck components needed. Sony uses one gun with a large common cathode to emit 3 electron beams which focus through a single large electrostatic 'lens' instead of 3 smaller ones like the GE and others used.
One last stroll down memory lane: Does anyone remember the forerunner of the Sony Trinitron? It began as the "Lawrence Tube" (named after its U.S. inventor Dr. Lawrence) then was demonstrated as the "Chromatron" (I think Paramount had some stake in it then). I don't know how the concept became Sony's property so if anyone can corroborate or correct any of my recollections, I would enjoy hearing about it. Thanks.
(From: Andy Cuffe (baltimora@psu.edu).)
I read about Sony's development of the Trinitron. Apparently Sony actually manufactured a 17" TV with a Chromatron CRT in the early 60's. It was only sold in Japan and used a very

unreliable tube chassis. According to the book they all ended up being returned and Sony lost a lot of money on it. Later Sony took ideas from the GE in-line tube and the Cromatron to invent the Trinitron. They used the 3 in-line cathodes of the GE tube with the vertical phosphor stripe screen of the chromatron. The common focusing lens was a way to stay as close as possible to the single electron gun design of the chromatron. The tone of the book suggested that Sony bet the whole company on the success of the Trinitron. Apparently they were very close to licensing the shadow mask design from RCA because of the amount of money they were losing by developing their own color CRT. If anyone is interested I think the title of the book was "Sony Vision". It also had chapters on the Betamax and the development of the first solid state TV.

How Far is the Shadow Mask from the Phosphor Screen?

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
This is simple geometry - similar triangles (at least for a good approximation).
It is easy to do the calculations based on the distance between the electron guns and the horizontal stripe pitch of the CRT (assuming slot mask or Trinitron - just a little more trouble for dot mask to convert the dot pitch).

```
    Dot pitch: 0.3 mm
      | |
 ___________________________________ Phosphor screen
  G B R G B R G B R G B R G B    ^
       \|/                     15 mm
 - ----- ----- ----- ----- --------- Shadow mask
       /|\                       ^
      / | \                      |
     /  |  \                   350 mm
    /   |   \                    |
   /    |    \                   v
  B-gun G-gun R-gun ---------------- Electron guns (center of deflection)
        |     |
        |     |
       Gun pitch: 7 mm
```

(Cool diagram based on efforts of Jeroem Stessen.)
Be aware that both face-plate and shadow-mask are curved and that the radius of curvature is much larger than the distance to the guns. The screen is relatively flat. This too has consequences for the calculation. Oh, heck.
At the center of the screen, we have:

```
          Distance between E-guns (R-G)           Slot pitch (R-G)
     ----------------------------------------  = ------------------
      Distance from deflection center to mask       Mask to screen
```

For a typical 25 inch TV CRT with a .9 mm slot pitch (.3 mm between adjacent stripes) and 7 mm between adjacent guns we have a ratio of about 23:1.
For a distance of 350 mm between the center of deflection and mask, this gives us about 15 mm (~.6 inches) between the mask and the screen.

How is the Shadow Mask Mounted Inside the CRT?

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
The shadow mask is mounted in a diaphragm. The diaphragm is mounted to the inside of the tube with 4 metal springs. In the old days these were bimetal springs. They have an important role for colour purity: they allow the mask to move forward as it expands due to self-heating. Remember: it must dissipate a lot of power and there is no cool air in there...

During production the mask is mounted and removed many times to allow for etching of the phosphors. A point light source is precisely positioned at the deflection center of each gun in-turn to expose the photoresist used in laying down the phosphor dots. (I know, you thought they were painted on one spot at a time! :-)
The mask is never fastened permanently, only clicked in to place just prior to having the envelope glued to the front assembly.
As no two masks are identical, each tube is always paired with its own mask.
(From: David Moisan (dmoisan@shore.net).)
From pictures I've seen, the best way to describe the shadow mask is that it is like a picture inside its frame: The glass face is the frame and the mask is the picture it holds, so to speak. The mask is carefully designed in a frame of its own, with spring clips around the edges, so that it won't distort under the heating it gets from the electron beams (not to mention during manufacturing). There's also a magnetic shield around the inside of the bell in some tubes.

Why is the Shadow Mask or Aperture Grill Made of a Magnetic Material?

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
The question often arises: Well, if magnetization and the need for degauss is a problem, why not make the shadow mask or aperture grille from something that is non-magnetic?
The shadow mask *must* be made of magnetic material! This may seem to be undesirable or counterintuitive but read on:
Together with the internal shielding hood it forms sort of a closed space in which it is attempted to achieve a field-free space. The purpose of degaussing is *not* to demagnetize the metal, but to create a magnetization that compensates for the earth's magnetic field. The *sum* of the two fields must be near zero! Degaussing coils create a strong alternating magnetic field that gradually decays to zero. The effect is that the present earth magnetic field is "frozen" into the magnetic shielding and the field inside the shielding will be (almost) zero. Non-zero field will cause colour purity errors.
Now you will understand why a CRT must be degaussed again after it has been moved relative to the earth's magnetic field. This will also explain why expensive computer monitors on a swivel pedestal have a manual degaussing button, you must press it every time after you have rotated the monitor.
The axial component of the magnetic field is harder to compensate by means of degaussing. Better compensation may be achieved by means of a "rotation coil" (around the neck or around the screen), this requires an adjustment that depends on local magnetic field. CRT's for moving vehicles (like military airplanes) may be equipped with 6 coils to achieve zero magnetic field in all directions. They use magnetic field sensors and active compensation, thus they don't need any degaussing function. This is too expensive for consumer equipment.

Why do CRTs Use Red, Green, and Blue rather than Red, Yellow, Blue?

So you were taught in grade school that any color could be made up of red, yellow, and blue paint. Why are these not used in CRTs?
Nearly any color that we can perceive can be made from some combination of primary colors. There are two types - additive and subtractive.
RGB are primary additive colors - anything that emits light will use these.
The three types of cone (color) recepters in the retina of the human eye have peaks (roughly) sensitive to these primary colors.
Those red, yellow, and blue primaries you used to create your works of art should actually not have been red, yellow, blue but rather magenta, yellow, cyan - close but no cigar. Red, yellow, and blue are approximations good enough for basic painting or printing but are not capable of reproducing the widest range of colors.

CMY (cyan, magenta, yellow) are subtractive colors. Printing processes and color photography use these because layers of ink or dye absorb light. Basically, each of CMY removes a single color from (RGB).

- Cyan = (green+blue) and is the complement of red.
- Magenta = (red+blue) and is the complement of green.
- Yellow = (red+green) and is the complement of blue.

The phosphors used in CRTs are not necessarily optimal - that is why some monitors or TVs may appear to have better color rendition than others.

Purpose of a Separate CRT Faceplate

The surface of the screen you see is most often part of the CRT envelope. In this case, there should be a tensioned steel band - a rimband - around the edge of the CRT near the front. The rimband is essential to assure the structural integrety of the CRT envelope against the emmense forces due to the air pressure attempting to crush it. In the event of a catastrophic event, the rimband will also reduce the range and velocity of any debrie. This is called 'integral implosion protection' by some manufacturers.
Warning: A CRT that is supposed to have a rimband but where it is missing or damaged is a serious hazard since the possibility of implosion is greatly increased and the effects of such an implosion will be more severe. However, such a situation is virtually impossible to occur on its own since the rimband is part of the mounting bracket assembly. Don't be tempted to remove the rimband for any reason unless the vacuum has been let out (in, whatever one does with a vacuum) of the CRT! Spontaneous implosion is even possible. See below for an example.
In some cases, there will be a separate faceplate. Older TVs usually had either a totally separate laminated glass plate in front of the CRT or a contoured glass panel bonded (glued) to the CRT itself. Part of its purpose is protective. It would prevent damage to the CRT in the event of a blow from a thrown object like an ashtray or shoe! In addition, it would contain the debrie in the unlikely event of an implosion resulting from some really catastrophic event. However, the separate or bonded glass plate can also be used for cosmetic purposes to:

- Improve contrast in a bright light by using a tinted glass.
- Reduce reflection by using an anti-reflection coating.
- Iron out the bumps by using a glass plate smoother than the CRT.
- Give the impression of a flatter display by using a glass plate with a larger radius of curvature than the CRT itself.
- Give the impression of a Sony Trinitron by using a cylindrical (plastic) plate in front of a real-flat rear-projection screen.

(From: Joe (rimband@megsinet.net).)
I got my User ID from the metal band. :) Anyway, a friend of mine decided to cut the rimband off a picture tube. I wasn't there, he told me about it. This was a 25" RCA tube he wanted to fit into a Zenith TV (don't ask me why). What happened in the next few seconds after he cut the rimband, the picture tube imploded in his face, embedding the neck and yoke assembly in the ceiling, he came out with a cut about half an inch above his right eye that needed 6 stitches to close. Had that shard of glass been half an inch lower, he would be wearing an eye patch or have a glass eye for the rest of his life.

I told him what an idiot he was, he's lucky he didn't kill himself or blind himself, and also told him NEVER cut the rimband off a picture tube that has vacuum. I just wanted to add that!:)

Leaded Glass and CRT Coatings

> "Is it really true that they put lead in the CRT glass for X-ray shielding? What is the transparent conductive coating on the front of the CRT made of?"

(From: Bob Myers (myers@fc.hp.com).)
First - yes, the glass is leaded (or contains other "impurities") to reduce emissions. In short, it's not just straight sand. :-)
There are various proprietary formulas used to make the faceplate coating, which often acts both as a conductive layer to reduce low-frequency electric fields and as a glare-reduction layer, but one of the most popular materials for making a transparent conductive layer is indium-tin oxide, a.k.a. "ITO". Such transparent conductors are also used in LCDs and other flat-panel technologies - at least the top layer of electrodes (row or column lines) has to be transparent! As conductors go, these things aren't THAT conductive - the age of see-through power lines or Star Trek's "transparent aluminum" is not upon us (and for certain theoretical reasons CAN'T be) - but they get the job done.

Flat Versus Non-Flat CRTs

The long and the short of it is that people would like absolutely flat tubes but there are several electronics and manufacturing problems which make the production of a totally flat (or even almost totally flat) CRT a challenge:

- **Geometry correction:** As the electron beam scans across a flat faceplate, its velocity increased near the edges and corners. Without compensation, the pixels will be stretched significantly in these areas.

- **Brightness uniformity:** Likewise, this means less time on each phosphor dot and lower brightness. In addition, the electron beam hits the screen at an increasingly steep angle which further decreases the brightness for a fixed dot size.

- **Structural integrity:** A totally flat faceplate would have to be much thicker to withstand the force due to the atmosphere with respect to the vacuum inside. So, most "flat" CRTs will still have a slight spherical shape.

Compensation for the geometry and brightness problems becomes much more challenging and it's never perfect. Even a well adjusted CRT will often have a very detectable, if not obvious, variation in brightness from center to edges and corners. Scan linearity and pincushion correction require most complex and carefully adjusted circuits. The thicker faceplate means a heavier CRT and monitor.
The net effect is that for a given screen size, cost will be greater. At a normal viewing distance, the perceived advantages may be minimal. Some people may find (after having gotten used to a moderately spherical CRT) that they actually like a flat one *less* especially if the deficiencies are easily seen. Note that Sony Trinitron (and clone) CRTs are nearly flat in the vertical direction and curved in the horizontal direction. To get used to this geometry may take some time as well.

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Resolution, Dot Pitche, and Other CRT Specifications

Color CRT Resolution - Focus and Dot/Slot/Line Pitch

The ability to display fine detail involves many factors including the resolution of the video source, video bandwidth, sharpness of the electron beam(s), and the dot/slot/line pitch (color only) of the CRT.

The CRT is primarily responsible for the latter two.

The focus or sharpness of the spot or spots that scan across the screen is a function of the design of the electron gun(s) in the CRT and the values of the various voltages which drive them. Focus may be adjustmented but excellent focus everywhere on the screen is generally not possible.

Sharp focus is a difficult objective - the negatively charged electrons repel each other and provide an inherent defocusing action. However, increasingly sharp focus would not be of value beyond a certain point as the ultimate resolution of a color CRT is limited by the spacing - the pitch - of the color phosphor elements. (For monochrome displays and black-and-white TVs, CRT resolution is limited primarily by the electron beam focus.)

One of three approaches are used to ensure that only the proper electron beam strikes each color phosphor. All perform the same function:

1. Dot mask - the phosphor screen consists of triads of R, G, and B, circular dots in a triangular arrangement. The shadow mask is a steel or InVar sheet filled with holes - one for triad. The dot mask has been used since the early days of color TV and is still popular today. The electron guns are also arrange in a triangular configuration.

2. Slot mask - the phosphor screen consists of triples of vertically elongated R, G, and B, stripes (actually, these are usually full vertical stripes interrupted by narrow gaps). The shadow mask is a steel or InVar sheet filled with slots - one for each triple. Ideally, the metal between the slots vertically is as thin as possible to maintain the structural stability of the slot mask sheet. This type of tube seems to be very popular in TVs but also shows up in some computer monitors. The electron guns are in line which makes some of the setup adjustments less critical compared to the dot mask CRT.

3. Aperture grille - the phosphor screen consists of triples of vertical R, G, and B, lines running the full height of the screen. The aperture grille is a series of tensioned steel wires running vertically behind the phosphor stripes - one for each triple. The aperture grille - until recently under patent protection and therefore only available in the Trinitron from Sony - is found in both TVs and monitors. The electron guns are also in line.

The pitch of a color CRT refers to the spacing of phosphor triads or triples. For dot mask CRTs, this parameter is relevant in both the horizontal and vertical direction. For slot mask and aperture grille CRTs, the pitch is only relevant in the horizontal direction.

Dot pitches as small as .22 mm are found in high resolution CRTs. Very inexpensive 14" monitors - often bundled with a 'low ball' PC system - may have a dot pitch as poor as .39 mm. This is useless for any resolution greater than VGA. Common SVGA monitors use a typical dot pitch of .28 mm. TVs due to their lower resolution have pitches (depending on screen size) as high as .75 mm - or more.

Obviously, with smaller screens and higher desired video source resolutions, CRT pitch becomes increasingly important. However, it isn't a simple relationship like the size of a pixel should be larger than the size of a dot triad or triple, for example. Focus is important. All other factors being equal, a smaller pitch is generally preferred and you will likely be disappointed if the pitch is larger than a pixel. As the pixel size approaches the phosphor triad or triple size, Moire becomes more likely. However, the only truly reliable way to determine whether Moire will be a problem with your monitor is to test it at the resolutions you intend to use.

A Discussion of Issues Relating to Monitor and CRT Resolution

Many factors influence the effective resolution of a monitor but the CRT dot or slot mask or aperture grill is the ultimate limit (though it may still be possible to use a monitor at a resolution which exceeds the that of the CRT). However, as the pixel spacing approaches that of the CRT, moire effects are likely to be more of a problem.

(From: Bob Niland (rjn@csn.net).)

Dot pitch is the major component in the actual resolution of the monitor. Most monitor vendors quote the highest resolution signal their monitor will sync to irrespective of whether or not the tube can resolve it. Indeed, it often cannot resolve the highest (and even second highest) claimed display resolution.

(From: Bob Myers (myers@fc.hp.com).)

Very true. On the other hand, things may not be quite as bad as what the numbers appear to say, sometimes.

(From: Bob Niland (rjn@csn.net).)

It's no accident that monitor size is specified in inches, and dot pitch in mm. The vendors don't want to make it easy for you to know what the geometry of their phosphor triads actually is, i.e. how many RGB dot triplets there are across and down the screen."

(From: Bob Myers (myers@fc.hp.com).)

Well, I wouldn't want to accuse the tube industry of deception. Expressing diagonal sizes in inches comes from long-standing tradition. Expressing pitch in millimeters is actually a relatively new practice in comparison, and isn't too unusual when you realize that most tube manufacturers - esp. those in the Far East - actually spec their tube diagonals in metric terms. For instance, Matsushita (Panasonic) has listed their "15 inch visual" color CRTs as "420xxxx" models, 420 being the overall diagonal in mm (16.54")

(From: Bob Niland (rjn@csn.net).)

Here's how to figure it out. You need first to know:

- The diagonal 'active picture" area (APD). If the vendor fails to specify this, subtract 1 inch from the advertised monitor size. I.e. a '21 inch' monitor will usually have about a 20-inch usable diagonal picture area. ('PC Inches' versus 'real inches' is a topic for another time. :-)
- You need the horizontal dot pitch (HDP). The vertical and horizontal are often different (with the vertical being a smaller number). If you have been given only one number, it's probably the diagonal, and is misleading, but it is all we have to work with.

(From: Bob Myers (myers@fc.hp.com).)

Trinitron (aperture grille) tubes will never have the pitch specified as a diagonal measurement, since they have vertical stripes of phosphor. Conventional (flat-square) models will, and probably the safest conversion between diagonal and horizontal for these is to mlutiply by the cosine of 30 degrees (0.866), unless you know for sure the angle to horizontal at which the diagonal measurement was made. (It varies for different tube designs.) See the section: How to Compute Effective Dot Pitch.

(From: Bob Niland (rjn@csn.net).)

- The monitor aspect ratio (AR). This is 4:3 (or 1.33:1) for any CRT you are likely to be using.

To calculate useful horizontal resolution:

- Multiply the APD by .80 (4:3 tube).

  This is the Active Picture Horizontal size (APH) in inches.

- Multiply APH by 25.4.

  This is the APH in mm (APHmm).

- Divide the APHmm by the HDP.

  This is the useful horizontal resolution of the monitor.
  Notice that this number probably does not precisely match any common (640, 800, 1024, 1152, 1280 or 1600) resolution in use, and that it is probably *less* than what the vendor claimed.

I use a Hitachi AccuVue UX4921D (aka HM-4921-D/A-HT01) 21-inch monitor. It is a claimed 1600x1200 monitor, and having a .22 horizontal dot pitch, actually has over 1800 phosphor triads across the screen. This is rare. Most large monitors usually have 1280 or fewer triads across the screen.

(From: Bob Myers (myers@fc.hp.com).)

Here is where some words of explanation are in order.

What many people fail to realize is that the phosphor triads of the screen *do not* correspond to pixels in the image; they are not kept in alignment with the image pixels/lines/whatever, nor is there are reason for them to be. The phosphor dot pitch IS a limiting factor in resolution, but we need to look a little further to determine whether or not a given tube will be usable for a given format (what most people mistakenly call a "resolution".)

The true resolution capabilities of a CRT are limited primarily by the dot pitch AND the spot size. For practically all CRTs and monitors in the PC market, the spot size is considerably larger than the dot pitch - up to 2X or so at the corners, if the tube is at or near its specification limits. This doesn't necessarily cause a problem with the image quality, however, since you aren't really resolving individual "pixels" in any case - what you need to resolve are the *differences* between adjacent pixels, or pixel/line pairs. And, oddly enough, it doesn't take a dot pitch of equal or greater size than a logical pixel to do this to most people's satisfaction. In fact, display types sometimes talk about a 'Resolution/Addressibility Ratio', or RAR, which is in effect the ratio of the actual size of a spot on the display to the size of a "logical" pixel in the image. And for best perceived appearance, this is generally going to be GREATER than 1:1 - say, 1.5:1 or even 2:1. (Too high, and the image is blurred; but too low, and the image takes on a grainy appearance that most people find objectionable.)

Bob is absolutely correct in stating that most displays, when run at the highest support addressibility or format (or, if you insist, "resolution") wind up with the "pixel size" being smaller than the dot pitch. But what is also correct, if somewhat counterintuitive, is that this is OK, and can still result in an image that will be acceptable (and even perceived as 'sharp') to the user.

You can certainly exceed the resolution capabilities of a tube and/or monitor (monitors differ from simple tubes by also having a video amp to worry about!). For instance, you probably won't be really happy with 1600 x 1200 on a 17" 0.28 mm CRT. But 1280 x 1024 on an 0.31 mm 20-21" tube can look very good, even though the numbers don't appear to work out.

(From: Bob Niland (rjn@csn.net).)

While not stated above, I would speculate that this is due to various human visual system factors, particularly that humans have more visual acuity in luminance (B&W) than in chrominance (color). If a CRT can actually illuminate less than a full phosphor triad, its luminance resolution can exceed the dot pitch. There will be some color fringing, but the eye may not notice.

(From: Bob Myers (myers@fc.hp.com).)

That's a good bit of it. Whether or not you're going to be satisfied with a given dot pitch versus addressibility ("resolution") basically has to do with what you think "resolve" means. The fact that we don't generally have the same spatial acuity for color - in other words, you won't really see small details based on differences in color alone, there has to be a difference in brightness - is a big part of this. And you will be able to see such variations acceptably even when the size of the logical pixel is somewhat under the dot pitch size. When this occurs, you don't get constant color pixels - you don't even get constant *luminance* pixels - but you do perceive acceptable levels of detail to call the image 'sharp'.

About the Quality of Monitor Focus

> "I have 2 identical monitors. One is razor sharp from edge to edge. The other is blurred at the corners- not from convergence problems, but just plain out of focus. In this monitor, the focus adjustment on the flyback can improve the focus at the edges, but then the center of the screen becomes worse..My question is : Is this a problem in the electronics and presumably a fixable flaw or is it caused by variance in the picture tube itself and not correctable ? Or is it some other issue?"

(From: Bob Myers (myers@fc.hp.com).)
The adjustment on the flyback sets the "static" focus voltage, which is a DC voltage applied to the focus electrode in the CRT. However, a single fixed focus voltage will not give you the best focus across the whole CRT screen, for the simple reason that the distance from the gun to the screen is different at the screen center than it is in the corners. (The beam SHAPE is basically different in the corners, too, since the beam strikes the screen at an angle there, but that's another story.) To compensate for this, most monitors include at least some form of "dynamic" focus, which varies the focus voltage as the image is scanned. The controls for the dynamic focus adjustment will be located elsewhere in the monitor, and will probably have at LEAST three adjustments which may to some degree interact with one another. Your best bet, short of having a service tech adjust it for you, would be to get the service manual for the unit in question.
It is also possible that the dynamic focus circuitry has failed, leaving only the static focus adjust.
As always, DO NOT attempt any servicing of a CRT display unless you are familiar with the correct procedures for SAFELY working on high-voltage equipment. The voltages in even the smallest CRT monitor can be lethal.

How to Compute Effective Dot Pitch

We always see CRTs specififed in terms of dot pitch but what does this mean with respect to actual useful horizontal and vertical dot pitch?
The usual arrangement of phoshpor dots on the screen of a dot mask type CRT is shown below:

```
 B R G B R G B R G B R G B R                        R --- G --- B --- R
R G B R G B R G B R G B R G B   Magnified ->             / |
 B R G B R G B R G B R G B R                          /    |
R G B R G B R G B R G B R G B                   G --- B -+- R --- G --- B
```

(Portions from: Jac Jamar (jamar@comp.snads.philips.nl).)
For a dot mask type CRT, normally the nominal pitch (also called the Hexagonal Pitch or HexP) is defined as the distance between one phosphor dot to the next same colored one in the 'hexagonal' direction (i.e. in the direction 30 degrees above the horizontal).
The calculations below follow from simple geometry:

- The Vertical Dot Pitch (VDP) will be equal to: HexP * 1/2.
- The Same Color Horizontal Dot Pitch (SCHDP) will be:
- `SCHDP = HexP * sqrt(3) (sqrt(3) = 1.732 or 2 * cos(30 degrees))`
  This is the distance between one phosphor dot and the next dot of the same color on the same horizontal line.
- The Horizontal Dot Pitch (HDP) is the distance between adjacent columns of same color dots. This is equal to: SCHDP * 1/2.
- The distance between adjacent dots of different colors or Closest Dot Spacing (CDS) is equal to: SCHDP * 1/3. A landing error of this magnitude (due to improper manufacture, adjustment, inadequate degauss, external fields, or doming) may completely shift the color from what it is supposed to be to one of the other primary colors.

So, for a 0.28 mm dot pitch CRT, VDP = .14 mm, SCHDP = .485 mm, HDP = .242 mm, and CDS = .16 mm.

Dot Pitch of TV CRTs

Computer monitor specifications always include the dot pitch of the CRT. However, this information is rarely available for TVs. Why? The quick answer is that since TVs are always used at the same scan rate (except for multisystem international TVs), this information is not nearly as important for TVs as for high resolution multiscan computer monitors.
In general, the dot/slot/line pitch of TV CRTs is very large compared to even mediocre computer monitors. Here are some typical values which I measured very precisely (!!) by putting a machinest's scale against the screen. These are all slot mask type CRTs:

- 13 inch GE - .60 mm.
- 19 inch Samsung - .75 mm.
- 25 inch RCA - .9 mm.

Therefore, you can forget about trying to use one of these CRTs for your 1280x1024 high resolution PC or workstation. The dot/stripe pitch needed for 1280 pixels on a 25" tube would be about .3-.4 mm maximum. The pixels are about .35 mm. Typical high resolution CRTs for high resolution computer monitors have a dot/stripe pitch of .25 to .28 mm (I have heard of numbers as low as .22 mm in commercially available monitors).

CRT Aspect Ratio

Nearly all modern CRTs have a 4:3 aspect ratio (H:V). Of course, with HDTV, 16:9 will probably become standard but CRTs may be obsolete by then!
(From: Bob Myers (myers@fc.hp.com).)
The physical shape of the tubes themselves came through this evolution, but the aspect ratio assumed for the original transmission format specs WAS 4:3, as driven by Hollywood. Where did you think the shape of the masks came from?
The desired 4:3 aspect ratio standard was known right from the start, and the early TV designers DID realize that the use of round tubes to display this was a literal case of a "square peg in a round hole". Rectangular CRTs for TV use had been developed as early as 1939, with the first American rectangular tube to enter production in late 1949.
(See Peter Keller's very excellent "The Cathode Ray Tube: Technology, History, and Applications" for all the details.)

CRT Deflection Angle

What does this mean? What is the difference between a 110 degree tube and a 90 degree tube? This is the maximum angle the beam makes with respect to the gun axis to fill the screen.

- All other factors being equal, a 110 degree tube is shorter than a 90 degree tube. This is the principle advantage of higher deflection angle CRTs.
- High deflection angles means higher deflection power for a given accelerating (2nd anode) voltage.
- Higher deflection angle CRTs are more difficult to converge and maintain focus, purity, and uniform brightness across the screen. Reducing geometric errors is more challenging. Yoke design is also trickier.

In the early days, 60 degrees was considered high tech. 110 degrees is about the practical limit for TV CRTs now. Give me a 90 degree CRT any day. Monitor tubes are usually 90 degrees.

CRT Contrast Ratio

(From: Don Stauffer (stauffer@htc.honeywell.com).)
Apparently CRTs have made quite an increase lately. Years ago when I looked into it, CRTs were not much better than about 20:1. Now, folks are claiming well over 40:1.
One thing to watch, though. The phosphor has two decay curves, a rapid one followed by a slow one. A change in scene can lower contrast ratio of a bar chart that appears in a region that was a large white area.
(From: Steve Eckhardt (skeckhardt@mmm.com).)
This comment makes me curious about the claims made by manufacturers of video projectors. Visually, their images have lots of resolution but mediocre contrast at large scale. A video monitor looks a lot better in contrast. The manufacturers, however, claim contrast ratios of 100:1 or better.
Are the numbers simply marketing hyperbole or have I missed something interesting?
There are several methods for arriving at the advertised numbers for contrast. One is to simply advertise the number for the imager and ignore the degradation due to the rest of the system. Another is to measure the illuminance of a white screen compared to a black screen. The best way is to use the ANSI method and advertise ANSI contrast, which is the practice at 3M. We really do sell projectors that achieve 100:1 contrast when measured by the ANSI standard. This is, however, a relatively recent achievement. LCD projectors are improving at a rapid rate.
CRT projectors are an alternate technology that I know little about, but they have characteristics that allow them to produce very high localized contrast. This can make displays and projectors based on CRT's look superior to anything an LCD can produce.
(From: Don Stauffer (stauffer@htc.honeywell.com).)
One big problem with LCD displays, projection or otherwise, is view angle. In order to cut off the light completely, polarization needs to be controlled to a couple of degrees. The LCD works by affecting the rotation, so many degrees per unit distance through the crystal. But the total path through the crystal depends on view angle. So max contrast may be only over a small field angle. Now, games can be played with this in projection optics, but it is hard.

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Effects of External Magnetic Fields on CRTs

Magnetic Interference and Shielding

When color CRTs must be operated in areas where the magnetic field causes unacceptable purity errors or distortion (either static or dynamic depending on whether the source is constant (as with the magnet in an MRI scanner or MegaBase(tm) loudspeaker) or changing (as with nearby motors, transformers, or even other monitors), there are several options (besides relocating):

- Passive shielding - soft magnetic materials (those that are easily magnetized and don't retain their magnetism) can effectively block modest strength magnetic fields. The best known of these for shielding purposes is called 'Mu-metal', an alloy of 76% nickel, 17% iron, 5% copper, and 2% chromium. (from Nelson and Parker, A.L.Physics).

  Advantages: simple (at least in priniple), doesn't care if conditions change (within specified field strength limits). Mu-metal can be very effective if used properly - but see below.
  Disadvantages: expensive and often ugly. The cost of a complete functional but not aesthetic enclosure for use of a color monitor near an MRI scanner was about $2,000 a couple of years ago when we needed to provide this for one of our customers. Check out MuShield specifically under "Monitor Enclosures" if you're curious. Less EMF, Inc. sells Mu-metal foil by the foot but what they have listed is rather thin - I don't know how well it would work for CRT shielding.

- Active compensation - a set of coils is energized with exactly the correct currents to cancel the effects of the interfering fields.

  Advantages: can be built inside the monitor using small coils in some cases.
  Disadvantages: must be engineered for each situation. Change almsot anything and it will no longer be effective even if feedback is used. Complex in practice since interfering field geometry is often not well behaved.

- Shielding can also sometimes be introduced at the source. See the section: Comments on Speaker Shielding.

  Advantages: will reduce interference for all monitors in the vicinity.
  Disadvantages: shielding location may not be readily accessible. Geometry offending device may not lend itself to a reasonable size or shape shield.

(From: Tony Williams (tonyw@ledelec.demon.co.uk).)
You can buy commercial Mu-metal screening cans and yes they are a complete enclosure, with small holes for the I/O wires.
Mu-metal is very expensive and not easy to work but will solder, especially with acid flux.
I suggest you try a dummy run first with some mild steel to get the design sorted and to test if it looks worth it.
You never know your luck, mild steel may do the job anyway and you may not want to deal with mu-metal (--- sam):

> "Just got my 10' sheet of mu-metal delivered today. It came very well packaged sandwiched between two pieces of wood so that it would not bend during shipment."

(From: James P. Meyer (jimbob@acpub.duke.edu).)
One of the reasons it came so well packaged was the fact that the magnetic properties are degraded if the material is bent or stressed in any way. Once you fabricate anything out of the mu-metal, you have to go through a high temperature annealing process to remove the stress

and restore its full magnetic properties. If you don't do that, you are no better off with Mu-metal than you would be with tin-can stock.

Comments on Speaker Shielding

When loudspeakers - even those little speakers that came with your PC - are near TVs or monitors, there may be problems with the fringe fields of the powerful magnets affecting color purity, convergence, or geometry. Speakers designed to be used with PCs in close proximity to their monitor will likely include some internal shielding. This may even be effective. However, the large powerful loudspeakers used with high performance stereo systems will likely not have such shielding. The best solution where display problems have been traced to the loudspeakers is to move them further away from the TV or monitor (and then degauss the CRT to remove the residual magnetism). Where this is not possible, consider the special speakers designed to be used in closer proximity to CRTs. These have (or should have) specially shielded magnet structures or an additional magnet with its field set up to cancel the main magnet's fringe field which will minimize these effects.

Shielding of conventional speakers may also be possible:

(From: Lionel Wagner (ck508@freenet.carleton.ca).)

Put a Tin can over the magnet. This will reduce the external field by about 50%. If more shielding is desired, put additional cans over the first, in layers, like Russian dolls. (Note: a Tin can is actually made nearly entirely of steel - the term 'Tin' is historical. --- sam)

(From: Nicholas Bodley (nbodley@tiac.net).)

While both electrostatic and electromagnetic (E/M) fields can affect the paths of the electron beams in a CRT, only E/M fields are likely to be strong enough to be a problem.

Magnetic shields have existed for about a century at least. Some decades ago, a tradenamed alloy called Mu-Metal became famous, but it lost its effectiveness when bent or otherwise stressed. Restoring it to usefulness required hydrogen annealing, something rarely done in a home shop (maybe one or two in the USA).

More-recent alloys are much less fussy; tradenames are Netic and Co-Netic.

Magnetic shields don't block lines of force; they have high permeability, vastly more than air, and they guide the magnetism around what they are shielding; they make it bypass the protected items.

I have been around some shielded speakers recently, but never saw any disassembled. They looked conventional, must have had the "giant thick washer" (my term) magnet, and seemed to have a larger front polepiece than usual.

They had a shielding can around the magnet; there was a gap between the front edge of the can and the polepiece. I suspect that a second internal magnet was placed between the rear of the main magnet and the rear (bottom) of the can, so there would be minimal flux at the gap between the can and the front polepiece. Holding pieces of steel close to the gap between the can and the polepiece showed very little flux there.

Modern magnets are not easy to demagnetize, in general.

(From: Dave Roberts (dave@aasl.demon.co.uk).)

The *good* so-called magnetically screened speakers rely on two means of controlling stray flux. The static field from the magnet on the speaker (which would cause colour purity problems) is minimized by the design of the magnet. This is often at the expense of gap field linearity, leading to greater distortion - not that most users seem to worry about that...

The mains varying field is minimized by use of a toroidal mains transformer, but the more recent mains powered speakers seem to be coming with *plug top* PSUs, which take the problem further away.

Why Magnetic Fields May Cause the Picture to Rotate

One might think that the result of the Earth's or stray magnetic fields would only be for the picture to shift position slightly. Why isn't this the case?
Magnetic fields don't really 'pull' on charged particles, they result in a force at right angles to the field lines with a direction dependent on the charge (negative for electrons, positive for protons) and field (North or South). The magnitude of the effect also depends on the energy/speed of the particles and their mass. For the case of a CRT:

- If the field is horizontal with respect to the screen, the picture will mostly shift up or down.
- If the field is vertical with respect to the screen, the picture will mostly shift left or right.
- If the field is in the direction of the tube axis, electrons going toward the right will experience a shift in the opposite direction as those going toward the left (as the beam is deflected). Presto: The picture will rotate.

The actual direction of the Earth's magnetic field experienced by the CRT depends on the latitude and includes both horizontal and vertical components - horizontal at the equator and becoming progressively angled toward the poles (with opposite polarities - N or S - depending on which hemisphere it is in). This is the main reason that TVs and monitors really need to be set up slightly differently depending on location (hemisphere and latitude). And, of course, local magnetic conditions also affect this including geologic formations and other equipment and wiring which produce magnetic fields.
The rotation knob or setting ion some TVs and monitors varies the current in a coil wrapped around the CRT bell just beyond the neck which has its axis parallel to the CRT's axis and adds a magnetic field to counteract the component of the ambient field along that direction.

Best Direction to Face a Monitor?

One would think that the magnetic field of the earth is inconsequential compared to what is used to drive a CRT. While the reasons this is not true should be obvious from other sections of this document, some would still call worrying about such issues as the direction of the monitor nonsense.
(From: Bob Myers (myers@fc.hp.com).)
No, it's not nonsense. The fields generated by the deflection coils, etc., ARE much greater in magnitude than the Earth's field, but they're AC fields. The DC offset of these fields is relatively small, and the Earth's field (also DC) IS sufficient to cause a visible shift in the position of the raster and affect the beam landing, etc.. This is why, for instance, there ARE often problems when trying to use a "Northern hemisphere" monitor in the Southern hemisphere.
Having said that, however, this isn't really something the average user needs to worry about. In the detailed specs for any monitor, there generally ARE a set of specific ambient conditions under which certain performance specs are intended to be checked. These usually include the ambient magnetic fields (which also tells you what magnetic environment was used at the factory for adjustment), and the orientation of the monitor within those fields. For the vast majority of monitors, the specified ambient conditions simulate average magnetic fields in the U.S. or Europe (which are very similar), and the monitor is specified as facing east or west within those fields. Strictly speaking, one has to establish those conditions (and so match the factory adjustment environment) in order to evaluate the monitor for compliance with these specifications.
Monitors are aligned in whatever field the manufacturer (or large OEM customer) SPECIFIES. This USUALLY involves an east or west alignment, as this results in no field

component in the CRT's Z-axis (the axis "down the throat" of the CRT, perpendicular to the center of the screen).
However, this doesn't necessarily mean that optimum performance at YOUR location will be obtained with the unit facing east or west, as local fields can vary considerably from the specified nominal field. The field identified in the specs is just that - it is part of the conditions under which those specifications are to be checked.
But the *specific* conditions for a given installation can vary considerably from the nominal, and so the only advice I can give the individual user is that if you're happy with the performance, don't worry about it. If you DO think that a local DC field (the Earth's field or any other) is causing a problem, THEN try to move or rotate the unit to see if you can find a better orientation or location. Of course, *AC* fields, such as those from a nearby power line or electrical equipment, are something else entirely.

Ways Around North/South or Other Sensitivity to Magnetic Fields?

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
They use magnetic field compensation for the professional types. This is too expensive for us mortals, so we get a CRT that has been optimized for one field condition only: North, South or Neutral. Not all displays are CRTs. LCDs for instance are not sensitive to the earth magnetic field. And not all CRTs use a shadow mask for colour selection. For instance, in Tektronix colour oscilloscope they use a white CRT with a colour LCD shutter in front of it. That too would not be affected too much by the earth magnetic field.
You see, plenty of ways out for aircraft, ships, and the Space Shuttle.

Additional Comments/Summary on Northern/Southern Hemisphere Issues

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)

- The vertical component of the earth magnetic field varies as a function of latitude, particularly between hemispheres a vertical magnetic field will influence the color purity of a CRT.
- The magnetic shielding of a CRT will, after degaussing, not provide complete compensation for the vertical field, especially for the space between shadow mask and screen.
- That's why manufacturers produce different displays for different hemispheres: northern, southern and neutral. They do this by adjusting for optimum purity in a simulated magnetic field.

Where you have a TV or monitor that was manufactured for a different location, your options (apart from tossing it) are:

- Re-adjust the purity, this involves moving the deflection coil, adjustment magnets, adding more magnets, etcetera. This is a big job and success would not be guaranteed.
- Simulate a southern hemisphere location by creating a vertical magnetic field around the TV, put two big multi-turn wire loops (Helmholtz coils) above and below the TV and run a DC current through them. Might be expensive and certainly would provide a 'different' look!
- Replace the picture tube with a northern hemishpere type, this is very expensive.
- Mount the picture tube upside-down inside the TV cabinet. Then reverse the wires for the line (H) and field (V) deflection to put the picture correct side up again.

For this case, you might have some problems with:

- The mounting nuts for the tube are hard to reach and may have left thread (look carefully before turning!
- The wires to the inverted picture tube panel being too short, they can probably be easily extended.
- The distance between high-voltage anode connection and the chassis (circuits) being too short (safety!)
- Condensation dripping into the anode contact.

Bang & Olufsen once made a compact style television where they wanted the anode contact to be away from the top of the cabinet, so the back cover could fit tighter. So they mounted the tube upside-down. Consequently they had to order southern hemisphere tubes for a northern hemisphere TV set. That works, of course.

Orientation Considerations for Projection TVs

Projection TVs do have have CRTs with shadow masks or aperture grills but nonetheless can be affected by magnetic fields. In fact, it is possible that degaussing could even be needed if a strong magnet were somehow placed near the set - but how would THAT happen? :-)

> "Any truth to the rumor that how you position a projection TV in a room (N,E,S,W) can affect the image quality? Does the Earth's magnetic field truly have that much of an effect."

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
Yes, it is true.
It makes a difference whether you talk about a front or rear projector. Front projectors are expensive and critical enough that they will be converged after installation, so that takes care of any convergence errors. Purity errors are of course no issue with 3 separate CRTs...
Rear projectors are converged in the factory, the customer does only the static convergence (4 pots) after he has decided which direction the set will face. This takes care of problems due to the horizontal component of the earth agnetic field.
In a rear projector the CRTs are mounted almost vertically. The vertical component of the earth magnetic field causes a rotation error. Normally this is not an issue because that component does not depend on the orientation of the set and it is more or less constant over the entire continent.
It makes a biiiig difference though if you manufacture PTVs in Belgium and then export them to Australia... That means opening the cabinet and re-adjusting for rotation.
A front projector has its tubes mounted horizontally. The rotation error will depend on the direction the set is facing. This is easily adjusted through the convergence.

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Picture Quality and Appearance Issues

Why Does the Intensity Appear So Non-Uniform in Bright Areas?

Actually, the intensity variation is likely to be even worse than you might think - possibly as much as 2:1 from the center to the corners. In most cases you do not notice it. With large deflection angle tubes, fewer electrons make it to phosphor dots near the edge of the screen. It is simple geometry.

(From: Bob Myers (myers@fc.hp.com).)
It is extremely difficult for any CRT display to maintain perfect brightness and color uniformity across the entire image. Just the geometry of the thing - the change distance from the gun to the screen as the beam is scanned, the changing spot size and shape, etc. - makes this nearly impossible, and there can also be variations in the phosphor screen, the thickness of the faceplate, etc.. Typical brightness-uniformity specs are that the brightness won't drop to less than 70% or so of the center value (usually the brightest spot on the screen).
On color tubes, the lack of perfect brightness uniformity is aggravated by the lack of perfect *color* uniformity and purity. What appear to be "dark spots" on a solid gray image may actually be beam mislanding (color purity) problems, which may to some degree be remedied by degaussing the monitor.
Again, *some* variation is normal; if you think you're seeing too much, you can try degaussing the thing and seeing if that helps. If it doesn't, then the question is whether or not the product meets its published specs, and that is something you'll have to discuss with the manufacturer or distributor.

Comments On Color Purity, Set Orientation, and Doming

> "The problem with my TV is that bright parts of the picture change color. For example, white areas may shift towards yellow or blue depending on the orientation of the set.
>
> What are the possible causes of doming? I have noticed that the magnitude of the doming effect varies with TV orientation even after degaussing several times at the new orientation. Does this help identify the cause of the doming in my case?"

(Portions from: Jeroen Stessen (Jeroen.Stessen@philips.com).)
The problem with regular shadow masks is 'doming'. Due to the inherent principle of shadow masks, 2/3 or more of all beam energy is dissipated in the mask. Where static bright objects are displayed, it heats up several hundred degrees. This causes thermal expansion, with local warping of the mask. The holes in the mask move to a different place and the projections of the electron beams will land on the wrong colours: purity errors. The use of invar allows about 3 times more beam current for the same purity errors.
Both local doming and magnetic fields compete for the remaining landing reserve. Due to improper degaussing, the doming problem may be more visible. And applying a tube designed for the wrong hemisphere may very well increase the doming complaints. It is possible to deliberately offset the nominal landing in order to get more doming reserve (the shift due to doming is always to the outside of the tube). You would do this using spoiler magnets put in the right places.
Permanently setting the contrast lower is not a real cure because the customer might not like such a dark picture. A better picture tube (Invar shadow mask) *is* a good cure (in most cases) but there is the cost price increase. (This is mainly due to the fact that Invar metal is harder to etch.)
Also see the section: What is Doming?.

Difference in Color Rendition Between CRTs

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
There can be several reasons why primary colours (especially red) may look different between picture tube brands:

1. Different phosphor composition. In the beginning everybody was looking for the phosphors with the highest luminous efficiency. Nowadays with the trend to avoid

heavy metals, particularly cadmium, in consumer products the composition had to be changed. This shifts the colour point.

2. Back scattering. Not all electrons that hit the shadow mask are absorbed. In fact, a quite high percentage is scattered back into the empty space between gun and mask. If they bounce back again from internal metal parts, then they may find their way to the screen and activate an arbitrary phosphor element. This increases the black level and reduces saturation of the primary colours. Red turns a bit towards orange. Even with good phosphors, large area colours will be less than perfect. Triple-CRT projection TVs do not have this problem, fantastic red!

3. Colour filters. Toshiba has developed a process where they put individual colour filters between glass and phosphor. This makes the black much better and also improves the colour points when unwanted spectral lines are suppressed.

4. There can also be differences with respect to the NTSC system, like wrong matrix from YUV to RGB. The definition in the Japanese NTSC system differs from the USA NTSC system and the signal processing should take that into account.

Contour Lines on High Resolution Monitors - Moire

These fall into the category of wavey lines, contour lines, or light and dark bands even in areas of constant brightness. (Some people may refer to this phenomenon as "focus or Newton's rings".) These may be almost as fine as the dot pitch on the CRT or 1 or 2 cm or larger and changing across the screen. If they are more or less fixed on the screen and stable, then they are not likely to be outside interference or internal power supply problems. (However, if the patterns are locked to the image, then there could be a problem with the video board.)

One cause of these lines is moire (interference patterns) between the raster and the dot structure of the CRT. Ironically, the better the focus on the tube, the worse this is likely to be. Trinitrons, which do not have a vertical dot structure should be immune to interference of this sort from the raster lines (but not from the horizontal pixel structure).

You can test for moire by slowly adjusting the vertical size. If it is moire, you should see the pattern change in location and spatial frequency as slight changes are made to size. Changes to vertical position will move the patterns without altering their structure - but they will not remain locked to the moving image.

If they are due to the raster line structure - your focus is too good - the patterns will remain essentially fixed in position on the face of the CRT for horizontal size and position adjustments - the patterns will remain fixed under the changing image.

How to eliminate it? If moire is your problem, then there may be no easy answer. For a given resolution and size, it will either be a problem or not. You can try changing size and resolution - moire is a function of geometry. Ironically, I have a monitor which is nicer in this respect at 1024x768 interlaced than at 800x600 non-interlaced.

Some monitors have a 'Moire Reduction Mode' switch, control, or mode. This may or may not be of help. One way to do this is - you guessed it - reduce the sharpness of the beam spot and make the picture fuzzier! You might find the cure worse than the disease.

Another cause of similar problems is bad video cable termination creating reflections and ghosting which under certain conditions can be so severe as to mimic Moire effects. This is unlikely to occur in all colors with a VGA display since the termination is internal to the monitor and individual resistors are used for each color (RGB).

I think it is ironic that some people will end up returning otherwise superb monitors because of moire - when in many cases this is an indication of most excellent focus - something many people strive for! You can always get rid of it - the converse is not necessarily true!

Moire and Shadow Mask Dot Pitch

(From: myers@fc.hp.com (Bob Myers).)

The density of the holes in the shadow mask set an upper limit on the resolution supported by that monitor. Lower resolutions work just fine; there is no need to have the logical pixels in the image line up with the physical holes in the mask (nor is there any mechanism to make this happen), and so you can think of this as the "larger pixels" of the lower-res image simply covering more than one hole or slot in the mask.

As the effective size of the pixels in the image approach the spacing of the mask holes, individual pixels are no longer guaranteed to cover enough phosphor dots on the screen to ensure that they are constant color or constant luminance, but an image will still be displayed which ON AVERAGE (over a reasonably large area) looks OK. Actually, the specified "top end" format ("resolution") for most monitors usually is at or slightly beyond this point - the effective pixel size is somewhat UNDER the dot pitch.

Isolated Spots on Display

These could be a problem with the video source - bad pixels in the video card's frame buffer or bad spots on a camcorder's CCD, for example. Or, they could be dirt or dead phosphor areas in the CRT. Except for problems with the on-screen character generator, it is unlikely that the monitor's circuitry would be generating isolated spots.

You can easily distinguish between video problems and CRT problems - missing pixels due to the video source will move on the screen as you change raster position. CRT defects will remain stationary relative to the screen and will generally be much more sharply delineated as well.

There is a specification for the number and size of acceptable CRT blemishes so you may have to whine a bit to convince the vendor to provide a replacement monitor under warranty.

Purple Blob - or Worse

Have you tried demagnetizing it? Try powering it off for a half hour, then on. Repeat a couple of times. This should activate the internal degausser. See the section: Degaussing (Demagnetizing) a CRT.

Is there any chance that someone waved a magnet hear the tube? Remove it and/or move any items like monster speakers away from the set.

Was your kid experimenting with nuclear explosives - an EMP would magnetize the CRT. Nearby lightning strikes may have a similar effect.

If demagnetizing does not help, then it is possible that something shifted on the CRT - there are a variety of little magnets that are stuck on at the time of manufacture to adjust purity. There are also service adjustments but it is unlikely (though not impossible) that these would have shifted suddenly. This may be a task for a service shop but you can try your hand at it if you get the Sams' Photofact or service manual - don't attempt purity adjustments without one.

If the monitor or TV was dropped, then the internal shadow mask of the CRT may have become distorted or popped loose and you now have a hundred pound paper weight. If the discoloration is slight, some carefully placed 'refrigerator' magnets around the periphery of the tube might help. See the section: Magnet Fix for Purity Problems - If Duct Tape Works, Use It!.

It is even possible that this is a 'feature' complements of the manufacturer. If certain components like transformers and loudspeakers are of inferior design and/or are located too close to the CRT, they could have an effect on purity. Even if you did not notice the problem when the set was new, it might always have been marginal and now a discoloration is visible due to slight changes or movement of components over time.

Magnet Fix for Purity Problems - If Duct Tape Works, Use It!

The approach below will work for slight discoloration that cannot be eliminated through degaussing. However, performing the standard purity adjustments would be the preferred solution. On the other hand, the magnets may be quick and easy. And, where CRT has suffered internal distortion or dislocation of the shadow mask, adjustments may not be enough.

In any case, first, relocate those megablaster loudspeakers and that MRI scanner with the superconducting magnets.

The addition of some moderate strength magnets carefully placed to reduce or eliminate purity problems due to a distorted or dislocated shadow mask may be enough to make the TV usable - if not perfect. The type of magnets you want are sold as 'refrigerator magnets' and the like for sticking up notes on steel surfaces. These will be made of ferrite material (without any steel) and will be disks or rectangles. Experiment with placement using masking tape to hold them in place temporarily. Degauss periodically to evaluate the status of your efforts. Then, make the 'repair' permanent using duct tape or silicone sealer or other household adhesive.

Depending on the severity of the purity problem, you may need quite a few magnets! However, don't get carried away and use BIG speaker or magnetron magnets - you will make the problems worse.

Also note that unless the magnets are placed near the front of the CRT, very significant geometric distortion of the picture will occur - which may be a cure worse than the disease.

WARNING: Don't get carried away while positioning the magnets - you will be near some pretty nasty voltages!

(From: Mr. Caldwell (jcaldwel@iquest.net).)

I ended up with the old 'stuck on a desert island trick':

I duck taped 2 Radio Shack magnets on the case, in such a way as to pull the beam back.!!!!

A $2 solution to a $200 problem. My friend is happy as heck.

RCA sells magnets to correct corner convergence, they are shaped like chevrons and you stick them in the 'right' spot on the rear of the CRT.

How Much Tilt is Acceptable?

This was in reply to a concern that a 1 degree tilt on a 27" TV was a problem. Yes, you may not like it, but unless there is a user tilt adjustment, the laws of physics prevail!

(From: David Kuhajda (dkuhajda@mail.locl.net).)

A 1 degree tilt given the effect of the earth's magnetic field is well within tolerance for a 27" TV set. The larger the picture tube, the more the tilt effect of the earth's magnetic field is noticeable. Even a shielded speaker may have just enough magnetic field to cause some slight tilt. 1 degree, however, is anything but a serious problem. Probably you would notice it you turned the TV 180 degrees on its axis that the tilt would then be going the other was. Factory standard is to have the picture straight when the back of the TV set is facing magnetic north. The actual measured tilt we have seen is as much as 3 degrees on a 36" tv set. This is why the higher-end larger TV sets have an adjustment for picture tilt.

What is Doming?

The shadow or slot mask inside the CRT is a thin sheet of steel or InVar positioned a half an inch or so behind the phosphor screen. The flatter the screen, the more susceptible it will be to thermal expansion effects: With individual phosphor dots spaced as as little as .13 mm apart (for a .22 mm dot pitch CRT), it doesn't take much inaccuracy in their position to result in a

noticeable effect. (See the section: How to Compute Effective Dot Pitch.) As a result, high resolution CRTs tend to be more susceptible to doming problems.
(Portions from: Jac Jamar (jamar@comp.snads.philips.com).)

1. Doming is a deformation of the shadow mask or its support structure caused by heating and subsequent expansion in bright (high beam current) areas of the picture. This causes a shift in position of the finely spaced holes or slots in the mask. The result will be color purity problems - discoloration and brightness variations. For a .28 mm dot pitch CRT, a change of only .14 mm in the position of a hole or slot can totally shift the display from one of the primary colors to another.

2. InVar shadow masks can sustain a significantly higher current density than steel shadow masks (by as much as 3:1) without noticeable problems.

   Trinitrons are more resistant to local doming effects as long as the wires are under enough tension. However, expansion of the suspension components can still result in doming with an overall bright picture.
3. The onset and disappearance of color purity problems will generally lag the cause due to the thermal mass of the affected components. For local heating resulting from picture highlights, this will be only a few seconds since the thermal mass of a small area of the mask is not that great. However, for effects having to do with expeansion of the suspension or support structure, it may take up to 30 minutes to reach equilibrium.

4. The orientation of the TV or monitor with respect to the earth's magnetic field and even whether the CRT was set up for the Northern or Southern hemispheres may affect the resulting color shift. Thus, the picture may tend toward yellow while the monitor is facing one way and blue when rotated 180 degrees on its base (even if degaussed at each position).

5. Reducing the brightness/contrast or setting the brightness limiter will prevent doming but may result in an unacceptably dark picture.

6. Shadow mask doming in itself is not something that becomes defective and has to be repaired. It is a characteristic of the CRT assembly. However, shifts in the position of purity adjustments can results in increased sensitivity to slight doming.

Purity problems resulting in discolouration and/or brightness variations are due to mislanding of the microscopic electron beams (the electron beams after the mask) on the red/green/blue phosphor stripes or dots. The mislanding is in general caused by:

- Influences of ambient magnetic fields (such as the earth magnetic field).
- Shadow mask doming.
- Tolerances occurring in the production of CRTs.
- Less than optimal setup of the purity adjustments (yoke position, rings on CRT neck, etc.

Only when the sum of these influences exceeds the 'guardband' provided in the CRT design, discolouration (or brightness variations) becomes visible.
If discolouration complaints arise, this will normally not be due to changes in doming behaviour, but to changes in shielding against magnetic fields.

The ambient magnetic fields are shielded by means of iron components inside (or sometimes outside) the tube, which have to be 'degaussed' to give good shielding. For this in a set degaussing coils and circuits are provided. A discolouration complaint will thus often be due to insufficient degaussing.

- TV sets and monitors which are kept in 'stand-by' mode for a long time may never be degaussed adequately because the degaussing circuit may only operate for a short time after the unit is switched on from cold - whether this is so with your unit depends on the design). In this case, they can pick up magnetic fields from magnets moved nearby or other equipment.

  The solution in this case is to switch the TV or monitor completely off or pull the plug if in doubt, let it cool down for half an hour or longer and switch it on again. If necessary this procedure can be repeated a few times (I had to do this at home once when my children had been playing with magnets). For monitors with degauss buttons, you can usually hear a hum when the degauss is activated.
- Similarly, if the orientation of a unit with respect to the earth's magnetic field is changed, it requires degaussing. So if you put your TV in another corner of the room or rotate your computer monitor on its tilt-swivel base, you have to activate its degauss circuitry (by letting it cool down or in the case of a high-end monitor, using its degauss button) or degauss it manually (see the section: Degaussing (Demagnetizing) a CRT).
- The PTC resistor (thermistor or posistor) in the degaussing circuit can become defective. This prevents proper degaussing after switch-on.

Since lower resolution CRTs are used for most TVs compared to similar size computer monitors, doming would not be nearly as much of a problem if they were both run at similar brightness (energy density) levels. However, TVs are very often used at higher brightness levels resulting in more of a thermal load on the mask which offsets the lower resolution.

Afterglow - Phantom Patterns on CRT After Shutoff

Why is there a splotch of colored light at the center of the CRT after I kill power to my TV? Why does this not happen if the plug is pulled instead? It seems to last for hours (well maybe minutes at least).
(Portions of the following from a video engineer at Philips.)
A broad diffused glow (not a distinct spot in the middle of the screen) that lasts for a few seconds to minutes is called 'afterglow' and may be considered 'normal' for your model. The warm CRT cathodes continue to emit electrons due to the high voltage that is still present even though the signal circuits may have ceased to operate.
For more sharply defined spots there are two phenomena:

1. Thermal emission from a cathode that has not yet cooled off (and this could take several minutes) gives a more or less circular spot near the centre. It is actually 3 spots from the 3 cathodes, we at Philips call them 'Christmas balls'.
2. Field emission from sharp whiskers on any electron gun part gives a much sharper spot, sometimes with a moon-shaped halo around it. Even with the filament off, there may be some electron emission from these sharp points on the cold cathode(s) due to the strong high voltage (HV) electric fields in the electron gun. I do not know how likely this is or why this is so.

The shape of the spot is an inverted image of the shape of the emitting area(s) on the electron guns cathodes.

The visibility of both effects depends in the same way on the decay time of the high voltage (HV/EHT) on the anode.
When turned off with the remote or front panel button, you are not actually killing AC power but are probably switching off the deflection and signal circuits. This leaves the HV to decay over a few minutes or longer as it is drained by the current needed to feed the phantom spot or blob.
When you pull the plug, however, you are killing AC input and all the voltages decay together and in particular, the video signal may be present for long enough to keep the brightness (and beam current) up and drain the HV quickly. Whether this actually happens depends on many factors - often not dealt with by the designers of the set.
A proper design (who knows, yours may simply have been broken from day 1 or simply be typical of your model) would ensure that the HV is drained quickly or that the other bias voltages on the CRT are clamped to values that would blank the CRT once the set is off. If the problem developed suddenly, then this circuitry may have failed. On the other hand, if it has been gradually getting more pronounced, then the characteristics of the CRT or other circuitry may have changed with age.
In most sets it is left to chance whether the picture tube capacitance will be discharged by beam current at switch-off. It may simply be due to the behaviour of the video control IC when its supply voltage drops that causes the cathodes to be driven to white and this may not be formally specified by the manufacturer of the IC. Some of of the latest sets have an explicit circuit to discharge the EHT at shutdown.
As noted in the section: "Safety guidelines" the HV charge on the CRT capacitance can be present for a long time. A service technician should be very aware of that before touching HV parts!
Interestingly, most sets for the Asian Pacific market have a bleeder resistor built in that will discharge the EHT without the need for a white flash at switch-off. These will in fact drive the beam to black at switch-off via a negative voltage to the CRT G1 electrode. The AP market is very sensitive to proper set behaviour, they don't like a white flash.
In short, it all depends on the demands of the particular market, the chance of the picture tube producing a spot/blob, and the mood of the designer.
So, it may not be worth doing anything to 'fix' this unless the splotch is so bright (more so than normal video and for an extended time) that CRT phosphor damage could result. This is usually not a problem with direct view TVs but would definitely be a concern with high intensity projection tubes.
On the other hand, your phantom blob may provide for some interesting conversation at your next party!

Discussion on the causes of color flare

On the right side of high intensity colors, some CRTs will exhibit a flare - the color will appear to be stuck at its highest level. This often occurs with older CRTs even at modest drive but can usually be forced to happen with any CRT if the drive level is turned up very high.
(From: Andy Cuffe (baltimora@psu.edu).)
I think it's due to the electron gun clipping when it's overdriven. Even a new CRT will bleed if it's driven hard enough, but most TVs are designed so you can't turn up the contrast that much. Once the CRT goes into clipping, it must take a short time to start working normally again after the drive level falls below clipping. The same thing happens when certain problems develop in the video amp.
All CRTs do it when they get weak enough. Samsung seem to be worse than most. In general, all CRT manufacturers have been cutting costs. A larger percentage or 8 year old or newer TVs that I see have bad CRTs than ones that are more than about 16 years old. I just picked

up a heavily used 1982 Zenith from the side of the road and it has a better looking CRT than most new TVs.

(From: Michael Shell (mikes1987@yahoo.com).)

I suspect that you may be right. I used to work a lot on older tube color televisions and I don't recall the bleeding problem. The first time I remember seeing it was on a 1978 Sampo. I have seen it EVERYWHERE since then. Has anybody seen the problem on a, say 1970, tube type set with good video drivers and correct CRT voltages (so you know it to be the CRT).

(From: Andy.)

My theory is that a weak CRT (or a good one with reduced G2) represents a higher impedance load to the video output transistor. The biasing of the video outputs would have to be designed for the load created by a good CRT. When the output load impedance goes high enough, the voltage can go high enough to saturate the transistor (the CRT isn't pulling enough current to keep the C-E voltage from going close to 0).

tubes, being like FETs (in that they are majority carrier devices) which are used in high speed digital circuits because don't have any delay in getting out of saturation.

(From: Michael.)

I think we may have a winner. A scope on the cathode should be able to confirm it.

(From: JURB6006 (jurb6006@aol.com).)

Hmm, that's one of most technical questions I've heard in a while.

First of all, realize that most sets do this with a lowered G2 voltage. While on the surface, lowering the G2 seems to mimic a weak CRT, this is not the case. Only in some ways it does, apparently.

Some sets have an unusual resistance, and others seem to have an unusual propensity to "bleed" (we call it flaring at my shop).

I was around before ICs, and have had an opportunity to study the design of the video output circuit(s) of TVs without ICs. I do understand circuit design, and have reached the following conclusion (this completely excludes sets with AKB):

It depends on how the video output transistors are driven. It seems that if there is a path for current feedback, the set will flare. This is the worst in sets that drive the emitters of the outputs.

Other sets, which could be designated as "voltage drive sets" either have such solid drive to the emitters that CRT load doesn't affect it or they just drive the base(s) of the outputs.

Engineering-wise, I think it basically boils down to the output impedance of the video output stage, and on a single ended stage, as most are and were, this impedance is different for negative and positive going slopes in the waveform.

There are other theories, this is only one. I speak of this because the flaring effect was almost always noticed on some chassis, back when all the CRTs were interchangeable. It followed the set, not the CRT.

(From: Michael.)

OK, I agree with what you are getting at here. Consider what happens when a transistor is overdriven. There are so many excess carriers in the device that it takes a long time for recombination to occur. This delay will result in the transistor taking a longer than normal time to switch off.

As noted above, often bad video driver circuitry/designs can cause bleeding (flaring) too. These cases could be caused by overdriven transistors (see above), feedback loops, or some type of ringing effect. I am interested in this as well, but my real fascination is when the CRT is the trouble maker.

Unlike a semiconductor, a CRT is a pure majority carrier device - no holes, just electrons flying around in there.

What bothers me is this: Say we have a test pattern consisting of a solid red square in the middle of an otherwise black screen. We turn up the saturation/contrast (and have a weak CRT), we will see bleeding to the right of the square. Instinctively, we FEEL we know what is going on. But think about it. The instant the electron beam leaves the square, the voltages on the CRT grid/cathodes are such (or should be) that the red gun should be shut off. (It is only like a nanosecond from the gun to the screen.) If the CRT cathode is weak, or the G2 voltage is too low, then I would expect the beam to cutoff even faster! Yet, the phosphors in the bleed DO see electrons exciting them! So, what is happening here? Did charge somehow build up somewhere in the tube? OR has the tube changed properties in such a way to cause trouble for the video output stages in a manner which would cause problems like Jurb6006 suggested? In the later case, it should be possible to design or modify the output stages to be resistant or immune to this problem. (I am not suggesting it would be worth it though).
The thing I really despise is that it seems to happen on CRTs that still have perfectly acceptable brightness.
(From: JURB6006.)
When they flare, yet the CRT isn't weak, it is usually due to a low collector Supply voltage to the vid outs. Unfortunately there is no way to tell on a normal scope whether the effect is being driven to the CRT or if the effect is IN the CRT.
Actually on what I call "voltage driven" units, you CAN see some type of clipping when either the CRT is weak or the G2 is low, but let's say on an older Sony, it seems like the clipping is omnidirectional.
Yet when this happens, the purity is not extremely affected.
On the sets that flare profusely, is it possible that the designers stumbled on a rudimentary form of AKB?
(From: Asimov (warpcastgate@dynip.com.)
It's analogous to how speakers and amps distort when the clip. When the clipping occurs in the CRT it's bandwidth falls to zero and you see then a type of ringing or smear. It's like the beam gets cutoff then saturates repeatedly very fast at a video rate. Also the electrostatic voltages which set the convergence get all thrown out of whack when this happens. This last is why a CRT with weak emission will also show poor purity, bad convergence, and a loss of tracking.
(From: Andy.)
I wonder if it would be possible to modify the video output circuit to eliminate the bleeding in a TV with a weak CRT that's not too far gone to be usable?
(From: Michael.)
I plan to try this in the next month or so. If I have any luck, I will post the results. In order to do this, voltages are gonna have to climb to keep that transistor out of saturation. This is going to result in more heat. Could it be possible that energy conservation mandates from the government resulted in flaring? If so, the same thing that causes my CRTs to flare also causes my toilet and shower to lose power.
From the point of view of the cathode, the CRT is a current controlled device like a BJT. From the point of view of the grid, it is a voltage controlled device, like a MOSFET. I can't remember why the video drive is applied to the cathodes rather than the grids, but I know there was/is a good reason.
So, barring a radical change, such as CRT grid drive, I think we want to use BJTs, but we need total control over Ik, regardless of how Mr. CRT feels. So, we would drive the CRT cathode with the NPN BJT collector, and have a fairly large Vce - which implies a bigger transistor with more heat sinking. I had thought of an alternative - using a transistor that comes out of saturation faster, but as you mentioned before, we lose detail in saturation and

thus would still not like the resulting picture. Another simple solution would be to "tweak a few V's".
Instinctively, I feel we can do this. Then why haven't the OEMs?
I thought up some humorous explanations for flaring during the course of this discussion. Maybe somebody will get a laugh:

1. A crust spot on the cathode, which only emits at high drive levels, causes the electrons that pass through it to have a reduced velocity - by a factor of a 10000. These delayed electrons form the flare.

2. The front of the cathode starts to wear out. Under high drive levels, electrons are emitted from the BACK of the cathode. The G2 voltage then pulls them around, but the result is a corkscrew spiral path to the screen whose total linear length is on the order of a 1000 feet. Hence the delay. Purity is not affected due to "circular symmetry".

3. A crust forms on the cathode. Under high drive levels, electrons are trapped within the layers of this crust. Even when the video drive cuts off current to the cathode, the trapped electrons continue to leak to the surface resulting in a flare. This is known as the "cathode becomes a capacitor" theory.

4. The phosphor of old CRTs become "flaky". When hit by electrons, ionic radiation is emitted radially outward. This radiation makes other adjacent phosphors super sensitive to future electron exposure. Hence, we are able to see a nearly zero electron beam which results in the flare.

And finally:

5. It's all in your head. Buying a new TV raises endorphens in the human brain, fixing the problem for a couple years. This also explains why more expensive, feature rich TVs have the problem less often. The CRT restorer should be applied to the USER not the TV. In skillful hands, it can also cure one of "color vision" allowing the use of much more inexpensive B/W sets.

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Magnetic Fields and Degaussing

Degaussing (Demagnetizing) a CRT

Degaussing may be required if there are color purity problems with the display. On rare occasions, there may be geometric distortion caused by magnetic fields as well without color problems. The CRT can get magnetized:

- if the TV or monitor is moved or even just rotated.

- if there has been a lightning strike nearby. A friend of mine had a lightning strike near his house which produced all of the effects of the EMP from a nuclear bomb.

- If a permanent magnet was brought near the screen (e.g., kid's magnet or megawatt stereo speakers).

- If some piece of electrical or electronic equipment with unshielded magnetic fields is in the vicinity of the TV or monitor.

Degaussing should be the first thing attempted whenever color purity problems are detected. As noted below, first try the internal degauss circuits of the TV or monitor by power cycling a few times (on for a minute, off for at least 20 minutes, on for a minute, etc.) If this does not help or does not completely cure the problem, then you can try manually degaussing.
Note: Some monitors have a degauss button, and monitors and TVs that are microprocessor controlled may degauss automatically upon power-on (but may require pulling the plug to do a hard reset) regardless of the amount of off time. However, repeated use of these 'features' in rapid succession may result in overheating of the degauss coil or other components. The 20 minutes off/1 minute on precedure is guaranteed to be safe. (Some others may degauss upon power-on as long as the previous degauss was not done within some predetermined amount of time - they keep track with an internal timer.)
Commercial CRT Degaussers are available from parts distributors like MCM Electronics and consist of a hundred or so turns of magnet wire in a 6-12 inch coil. They include a line cord and momentary switch. You flip on the switch, and bring the coil to within several inches of the screen face. Then you slowly draw the center of the coil toward one edge of the screen and trace the perimeter of the screen face. Then return to the original position of the coil being flat against the center of the screen. Next, slowly decrease the field to zero by backing straight up across the room as you hold the coil. When you are farther than 5 feet away you can release the line switch.
The key word here is ** slow **. Go too fast and you will freeze the instantaneous intensity of the 50/60 Hz AC magnetic field variation into the ferrous components of the CRT and may make the problem worse.
WARNING: Don't attempt to degauss inside or in the back of the set (near the CRT neck. This can demagnetize the relatively weak purity and convergence magnets which may turn a simple repair into a feature length extravaganza!
It looks really cool to do this while the CRT is powered. The kids will love the color effects.
Bulk tape erasers, tape head degaussers, open frame transformers, and the "butt-end" of a weller soldering gun can be used as CRT demagnetizers but it just takes a little longer. (Be careful not to scratch the screen face with anything sharp. For the Weller, the tip needs to be in place to get enough magnetic field.) It is imperative to have the CRT running when using these whimpier approaches, so that you can see where there are still impurities. Never release the power switch until you're 4 or 5 feet away from the screen or you'll have to start over.
I've never known of anything being damaged by excess manual degaussing as long as you don't attempt to degauss *inside* or the back of the TV or monitor - it is possible to demagnetize geometry correction, purity, and static converence magnets in the process! However, I would recommend keeping really powerful bulk tape erasers-turned-degaussers a couple of inches from the CRT.
If an AC degaussing coil or substitute is unavailable, I have even done degaussed with a permanent magnet but this is not recommended since it is more likely to make the problem worse than better. However, if the display is unusable as is, then using a small magnet can do no harm. (Don't use a 20 pound speaker or magnetron magnet as you may rip the shadow mask right out of the CRT - well at least distort it beyond repair. What I have in mind is something about as powerful as a refrigerator magnet.) Also see the juggler's technique, below. :-)
Keep degaussing fields away from magnetic media. It is a good idea to avoid degaussing in a room with floppies or back-up tapes. When removing media from a room remember to check desk drawers and manuals for stray floppies, too.
It is unlikely that you could actually affect magnetic media but better safe than sorry. Of the devices mentioned above, only a bulk eraser or strong permanent magnet are likely to have

any effect - and then only when at extremely close range (direct contact with media container).
All color CRTs include a built-in degaussing coil wrapped around the perimeter of the CRT face. These are activated each time the CRT is powered up cold by a 3 terminal thermister device or other control circuitry. This is why it is often suggested that color purity problems may go away "in a few days". It isn't a matter of time; it's the number of cold power ups that causes it. It takes about 15 minutes of the power being off for each cool down cycle. These built-in coils with thermal control are never as effective as external coils.
Note that while the monochrome CRTs used in B/W and projection TVs and mono monitors don't have anything inside to get magnetized, the chassis or other cabinet parts of the equipment may still need degaussing. While this isn't likely from normal use or even after being moved or reoriented, a powerful magnet (like that from a large speaker) could leave iron, steel, or other ferrous parts with enough residual magnetism to cause a noticeable problem.
If you try the 'technique' below, make sure you don't smash the TV or your spouse!
(From: Mike Champion (mchampfl@gdi.net).)
I replaced the magnetron in my microwave and ripped apart the old one with my kids to 'see how it works'. Boy, there are some mother magnets in there! The kids and I had fun with them. You know - push me pull you; the paper clip boat; which Easter egg has the metal and which has the wood; etc. Dnough with this kid stuff - 'wanna see something really cool?', says I. Having been around monitors for a long time in the computer business, i showed them what what a REALLY powerful magnet will do to an electron beam in a cathode ray tube - my sharp 19" color TV. "Wow, dad!", "psychodelic!" "it looks like all the colors are flushing down the toilet!" Boy, was I DAD or what? The problem was that my experience with magnets and monitors were in the monochrome days! so the price I paid for such esteem in the eyes of my children were purple faces and green legs on my sharp 19" color TV! Uh-oh! well, maybe it will be allright by tomorrow. Well it wasn't. Now I'm getting worried! I used to do computer support at a television station so I called an old engineer friend there for help. He just hee-hawed! As he was drying his eyes, he suggested that I had probably just magnetized the mask and he'd loan me a degausser. I offered to buy him lunch for the favor. This was Friday and because of my friend's diagnosis T was able to relax about the problem enough to think about it. Hmmmm. degausser = alternating magnetic field... Strong magnetron magnet... Alternating... So I got this great idea! I took the ring magnet I used to mess it up, tied a string to it, suspended it on the string and spun it as fast as i could. I put it up to the CRT and brought it away slowly! Eureka! On Monday I called my smart-alek friend and cancelled the lunch!

How Often to Degauss

Some monitor manufacturers specifically warn about excessive use of degauss, most likely as a result of overstressing components in the degauss circuitry which are designed (cheaply) for only infrequent use. In particular, there is often a thermister that dissipates significant power for the second or two that the degauss is active. Also, the large coil around the CRT is not rated for continuous operation and may overheat.
If one or two activations of the degauss button do not clear up the color problems, manual degaussing using an external coil may be needed or the monitor may need internal purity/color adjustments. Or, you may have just installed your megawatt stereo speakers next to the monitor!
You should only need to degauss if you see color purity problems on your CRT. Otherwise it is unnecessary. The reasons it only works the first time is that the degauss timing is controlled

by a termister which heats up and cuts off the current. If you push the button twice in a row, that thermister is still hot and so little happens.
One word of clarification: In order for the degauss operation to be effective, the AC current in the coil must approach zero before the circuit cuts out. The circuit to accomplish this often involves a thermister to gradually decrease the current (over a matter of several seconds), and in better monitors, a relay to totally cut off the current after a certain delay. If the current was turned off suddenly, you would likely be left with a more magnetized CRT. There are time delay elements involved which prevent multiple degauss operations in succession. Whether this is by design or accident, it does prevent the degauss coil - which is usually grossly undersized for continuous operation - to cool.

Ultra Cheap Degaussing Coil

Pack Rat Trick #457384:
Next time you scrap a computer monitor (or tv), save the degaussing coil (coil of wire, usually wrapped in black tap or plastic) mounted around the front of the tube. To adapt it for degaussing sets, wrap it into a smaller coil, maybe 4"-6". To limit the current to something reasonable, put it in series with a light bulb (60 to 100 W, maybe as high as 200 W but keep a finger on the temperature of the coil!). You need AC current to degauss, so just put the bulb in series with the coil and use the your local 120 VAC outlet. BE VERY CAREFUL that you actually wired it in series, and that everything is properly insulated before you plug it in (A fuse would be a real good idea too!!)
A few circles over the affected area will usually do it. Note that it will also make your screen go crazy for a little bit, but this will fade out within a minute or so.
Just a couple of points for emphasis:

1. The coil as removed from the TV is not designed for continuous operation across the line as indicated above. In fact, it will go up in a mass of smoke without the light bulb to limit the current. The poor TV from which this organ was salvaged included additional circuitry to ramp the current to 0 in a few seconds after power is turned on.

2. Reducing the coil size by a factor of 2 or 3 will increase the intensity of the magnetic field which is important since we are limiting the current with the light bulb to a value lower than the TV used. You don't need to unwind all the magnet wire, just bend the entire assembly into a smaller coil. Just make sure that the current is always flowing in the same direction (clockwise or counterclockwise) around the coil.

3. Insulate everything very thoroughly with electrical tape. A pushbutton momentary switch rated for 2 amps at 115 volts AC would be useful so that you do not need to depend on the wall plug to turn it on and off.

(From: Larry Sabo (sabo@storm.ca).)
I've been using a couple of degaussing coils from "parts" monitors, connected n series. The combined resistance is about 27 ohms, for a current of around 4 to 5 amps. Sorry, I don't know the wire size, but it's very substantial, not like some of the thin, flimsy stuff I see. Works great!

Bob Myers' Notes on Degaussing

A couple of comments: first of all, it makes no difference whatsoever if the display is on while it's being degaussed. (Oh, some people DO like to watch the psychodelic light show, but it really doesn't help anything for it to be on.) Actually, there is a very minor case to be made for degaussing while OFF, at least for the Trinitron and similar tubes. (The field of an external degauss coil CAN cause the grille wires to move slightly, and they're a bit more flexible when hot - so it is conceivable, although certainly unlikely, that you're running a higher risk of causing the grille wires to touch or cross and become damaged.)

Secondly, a good practice for degaussing is to slowly back away from the monitor after giving the screen a good going over. Once you're about 5-6' away, turn the coil so it's a right angles to the CRT faceplate (which minimizes the field the monitor is seeing), and THEN turn to coil off. This is to reduce the possibility of the field transient caused by switching the coil off from leaving you once again with a magnetized monitor.

The last point is to make sure that you DON'T leave the coil on too long. These things are basically just big coils of wire with a line cord attached, and are not designed to be left on for extended periods of time - they can overheat. (I like the kind with the pushbutton "on" switch, which turns off as soon as I release the button. That way, I can never go off and leave the coil energized.)

Oh, one more thing - make sure your wallet is in a safe place. You know all those credit cards and things with the nice magnetic stripe on them? :-)

(Actually, I've got a good story about that last. I was teaching a group of field service engineers how to do this once, and being the "Big Deal Out of Town Expert", made VERY sure to place my wallet on a shelf far away from the action. Unfortunately, Mr. Big Deal Out of Town Expert was staying in a hotel which used those neat little magnetic-card gadgets instead of a "real" key. Ever try to explain to a desk clerk how it was that, not only would your keycard NOT let you into your room, it was no longer anything that their system would even recognize as a key? :-))

Degaussing after lightning strike

Sometimes a nearby lightning strike may produce effects which mimic those of a nuclear explosion, at least in terms of EMP induced magnetization. This may be take the form rainbow patterns or purity blotches that the internal degaussing coil or even an typical external degauss won't cure.

(From: JURB6006 (jurb6006@aol.com).)

A lightning strike produces a VERY high magnetic field, something the degausser can't handle. Somehow connect a good, like 10 amp Variac straight to the degaussing coil(s) and turn it all the way up and down, fairly quickly. You might do better to get ready, flip the switch on and turn it down from the top, but DON'T blow the fuse, that might make things worse. Turn it down quick, but it is the top end that gets the job done. Thing is those coils can only stand it for a second or two, but that is way longer than it takes. You can also do this with it running, but you risk damaging the vertical circuit. However you can try different levels and see if less than max is enough to do it. At extremely high levels you risk damaging the shadow mask, that is if it is not already damaged.

I almost scrapped a 36" Sony for this, same thing, near a lightning strike. The colors were seriously FUBARed. The coil to the variac trick did it. What happens is I think the purity shield itself gets magnetized, despite it's low coercivity. It takes a bit more than the standard degausser in the set to do the trick.

Degaussing Humor - If it Works, Use It!

Note: If you are forced to use this stunt, sorry, approach, make sure you don't end up smashing something important! :)

(From: Mike Champion (mchampfl@gdi.net).)

I replaced the magnetron in my microwave and ripped apart the old one with my kids to 'see how it works'. Boy, there are some mother magnets in there! me and the kids had fun with them. you know - push me pull you; the paper clip boat; which easter egg has the metal and which has the wood; etc. enough with this kid stuff - 'wanna see something really cool?' Says I. Having been around monitors for a long time in the computer business, I showed them what

what a REALLY powerful magnet will do to an electron beam in a cathode ray tube - my sharp 19" color TV. "Wow, dad! psychodelic! It looks like all the colors are flushing down the toilet!" Boy, was I DAD or what? The problem was that my experience with magnets and monitors were in the monochrome days! So the price I paid for such esteem in the eyes of my children were purple faces and green legs on my sharp 19" color TV! Uh-oh! Well, maybe it will be all right by tomorrow. Well it wasn't.
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Can a Really Strong Magnet Permanently Damage the CRT?

Even a magnet that can suspend your weight may still not have much range as they usually have metal pole pieces that concentrate the flux and work well only with a matching flat steel plate.
The only thing in the guts of a TV or monitor (that is accessible from outside the cabinet) that can be damaged permanently is the shadow or slot mask of the CRT. If the magnet is strong enough to distort it, the CRT will be ruined. Even manual degaussing with a similarly powerful degaussing coil will then not totally clear up color purity problems. The shadow or slot mask is a very thin perforated steel or InVar sheet about 1/2 inch behind the glass of the CRT screen - which is itself about 1 inch thick or more. So, even up against the screen, your magnet is still at least 1-1/2 inches from the shadow mask. It would take a mighty powerful magnet to distort it.
For Trinitron (or clone) CRTs with aperture grilles - tensioned fine wires in place of a shadow or slot mask, the force required would be even greater.
No way to know without trying it :-(.
(From: Jeff Mangas (jeff@edldisplays.com).)
I work in a small monitor factory and some time ago we were using some very strong degaussing wands to remove magnetism from some of our chassis. We found that this caused a weakening of the shadow mask and it would take only a small shock/vibration to break the mask loose. We are not 100% sure that it was the degaussing that caused the problem but we only used these strong wands for a short time (lost several tubes while using them) and have not had any problems before or since.

WARNING about degaussing late model Sony Trinitron CRTs

The following has been confirmed by others.
(From: David Kuhajda (dkuhajda@locl.net).)
You should NEVER use a big degauss coil on ANY SONY WEGA tube, or ANY SONY 27" or larger CRT made after 1997. Sony deliberately put a small amount of magnetic field into the strapping and aperture grill to compensate and improve the convergence. A BIG degauss will remove this and make the tube look very bad.
A BIG manual degauss coil from about 3 feet away should have a low enough field to be safe. (Note: should) I NEVER use the large degauss coils on the Sony tubes after seeing the Sony video of how CRTs have been damaged. I USE a smaller degauss coil and work it on a Variac at a lowered AC voltage, and bring the voltage up each successive pass to degauss the CRT until it is cleared up.

If the internal degauss is not taking care of the problem, you have other things to look at. Has the yoke or yoke purity rings been moved? Have the TV or monitor been dropped? Are all the connections good on the degauss thermister? If it is a three leg thermister it still may be bad as those leave a small current flowing on the older Sony coils. Have any of the extra purity magnets fallen off the yoke or CRT?
Note that Sony tubes do NOT have shadow masks, but they have aperture grills which are an array of incredibly fine wires under tension. A BIG degauss coil can also rip the aperture grill away from the stabilization wires.

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CRT Related Adjustments

Principles of Purity and Convergence Adjustment

Purity involves bending all 3 of the beams so that they cross the space between shadow mask and screen at the proper angle and will land at a different place on the phosphors.
Convergence involves adjusting the aim of 1 or 2 of the beams at a different angle so that they all land at the same place on the screen.
Dynamic convergence circuitry is now virtually non-existent, except in high resolution monitor tubes and in Sony Trinitron tubes (they require a very basic horizontal convergence). All other tubes have the convergence correction built into the design of the tube and the coil. Sony has chosen a different trade-off between price and performance (which includes also sharpness).
Most CRTs have a series - usually 3 pairs - of ring magnets mounted on the neck near the socket end. These are used for part of the purity adjustment and static convergence. (Coarse purity is set by the position of the yoke and dynamic convergence is set by the tilt of the yoke.) These rings consist of multi-pole magnets which due to their field configuration are able to affect the electron beams from the 3 guns in different ways.
(Some CRTs employ internal structures that are premagnetized at the factory and cannot be adjusted in the field - though perhaps auxiliary magnet rings could be added if the original magnetization were lost for reasons we won't go into :-). This type of CRT will be obvious as there will be no adjustable rings to mess screw up!)
The relative orientation of the rings in a pair affect the strength of the effect.
In a nutshell, the electron guns in most modern CRTs are arranged in-line. For example: GRB. Some of the ring adjustments are designed to affect them all while others pretty much leave the center gun's beam alone and only affect the outer ones. Various options then exist depending on the magnetic field configuration.
The three sets of ring magnets are shown below along with the position of the red (R), green (G), and blue (B) electron beams passing through them. Each is actually a pair of rings which may be moved relative to one-another to control the strength of the magnetic field. When the tabs are adjacent, the fields from the two rings nearly cancel and the rings then have no effect.
Two typical orientations are shown (N and S are the poles of the ring magnets):
Orientation 1:

```
                          S            S   N

     N  R G B  S      N  R G B  N    N  R G B  S

                          S            S   N

      2-pole            4-pole          6-pole
     (purity)         (red-blue)    (red/blue-green)
```

Orientation 2:

```
 0 Degrees        0 Degrees         0 Degrees

     N             N       S            S
                                    N       N
   R G B             R G B            R G B
                                    S       S
     S             S       N            N

  2-pole            4-pole            6-pole
 (purity)         (red-blue)    (red/blue-green)
90 Degrees        45 Degrees        30 Degrees
```

(My apologies if I have the direction of deflection reversed - I can never remember the right hand rule for electrons moving in magnetic fields!)

- The 2-pole purity rings move the set of RGB beams more or less together to fine tune the position of the center of deflection.

  The field lines go generally across (at the orientation shown) between the N and S poles.
  Orientation 1, the RGB beams will be raised.
  Orientation 2, the RGB beams will be moved to the right.

- The 4-pole red-blue rings move the R and B beams relative to the G beam but leave the G beam alone.

  The field lines go generally between adjacent N and S poles. On opposite sides of the rings, the polarity/direction of the lines oppose and thus tend to move the R and B beams in opposite directions. The G beam in the center does not experience any deflection from the 4-pole ring magnets since all the fields tend to cancel.
  Orientation 1: The R beam will move up and the B beam will move down relative to G.
  Orientation 2: The R beam will move up and to the right and the B beam will move down and to the left relative to G.

- The 6-pole red/blue-green rings move the RB beams with relative to the G beam but leave the G beam alone.

  The field lines go generally between adjacent N and S poles. On opposite sides of the rings, the polarity/direction of the lines are the same and thus tend to affect the R and B beams in the same direction. The G beam in the center does not experience any deflection from the 6-pole ring magnets since all the fields tend to cancel.
  Orientation 1: The R and B beams will move up relative to G.
  Orientation 2: The R and B beams will move up and to the right relative to G.

For purity to be perfect (or as good as possible), the electron beams must originate from the same effective center of deflection as used in originally laying down the phosphors. Moving the yoke forward and backward on the neck of the CRT can precisely set the deflection center along the axis of the neck. However, slight transverse errors may still exist due to imperfections in the yoke windings or positions of the electron guns. This is affected slightly by the earth's magnetic field as well. The purity magnet rings are those closest to the yoke and provide the means for moving the electron beams very slightly to compensate.

The adjustment procedures generally use the red gun for the setting purity. Intuitively, one would think this should be the center (green) gun. However, since the red beam current is the highest (red phosphor is least sensitive), problems are likely to show up first with the red purity so it is used for the adjustment. In any case, it is a good idea to check all three guns for proper purity and tweak if needed before moving on to convergence.

In an in-line gun, the green gun is always in the middle. The only reason for adjusting purity with the red beam is because it gives the greatest sensitivity:
(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

- The red beam current usually has the largest amplitude.
- A landing error of the red beam gives the best visible discoloration (much better than green, better than blue).
- This makes the landing of the red beam the most critical.

Detailed Purity and Static Convergence Adjustment Procedure

Also see the adjustment information in the documents: Notes on the Troubleshooting and Repair of Computer and Video Monitors or Notes on the Troubleshooting and Repair of Television Sets.
(From: Alan McKinnon (alan.mck@pixie.co.za).)
The rearmost pair of magnets (seem from the service position behind the set in other words furthest from you nearest the front of the tube) affects purity. More on this later. The middle and front magnets are for convergence and work on pairs of colours. The effects can most easily be seen on a cross hatch test pattern (10 or so horizotal lines, 15 or so vertical lines).
But first, purity:
Without getting into the details of what happens inside the guns, I assume you need to know how to do the adjustments. You need some means of generating an evenly red screen. An (expensive) pattern generator is the preferred method. Fiddle the rear purity rings to distort the screen by bringing green and blue blobs into it. You will note that the magnets can be adjusted by moving both together, and moving them aart relative to each other. The best advice here is: adjust slowly and observe what happens. Once you have the screen evenly red, move on to convergence, which is the trick of getting the red green and blue beams to coincide on the screen to produce white, with the minimum of colour shadowing.
With a cross hatch pattern on screen, you can see easily how convergence works, and how the magnets affect the picture. Each tube type is different in exactly how this is done, but the general idea is that one set of magnets affects two specific colours only, moving them apart and bringing them nearer, while leaving the third colour alone. The other set of magnets takes the colours affected by the other set, and moves them together relative to the third colour. Also, moving a pair of magnets together adjusts the colours in one direction (vert or horiz) while moving the magents apart adjusts the other direction. With all things in life, there is some overlap, so you need to look carefully and see what happens mostly - the adjustments are not cut and dried. Oh, and they are interactive to some degree. Keep checking purity after you do convergence. All of this is best shown with a picture, the colours are arbitrary, you may well find the details do not apply to your tv, but the basic principles will. These initial converence adjustments apply only to the centre of the screen by the way, the edges are done elsewhere:
Rotating one set of magnets together might move red and blue together till they coincide vertically:

```
| |   |         | | |         |  |
| |   | -----> | | | -----> |  |
| |   |         | | |         |  |
R G   B         G R B         G R&B
```

And moving them apart relative to each other might move red and blue together horizontally:

```
R -----
               R --------        R&B---------
G ----- -----> G -------- -----> G ---------
               B --------
```

```
       B -----
```

Moving the other set of magnets together might take the red and blue pair and move them to coincide with the green, vertically:

```
       |  |         | |          |
       |  | -----> | | ------> |
       |  |         | |          |
       G R&B       G R&B      R&G&B (=white)
```

And moving them apart relative to each other might move the red and blue pair and move them to coincide with green horizontally:

```
    R&B -------
                         R&B -------
                ----->                 ----> ------- R&G&B
                           G -------                (=white)
      G -------
```

Once the convergence is perfect in the centre of the screen (called static convergence) it's time to handle the edges and corners (called dynamic convergence for historical reasons). This is done by physically moving the entire yoke that is clamped around the tube neck with the deflection coild on it. It is anchored in place by a collar on the tube neck, loosen this slightly, butnot enough so that the yoke can move backwards. It is also held in place by rubber wedges glued or taped down. Take the wedges out. By gripping the yoke and levering it up and down, left and right, you will change he convergence in the corners. The effects don't work as you might at first suppose - moving the yoke left affects the lower right corner, this type of thing. Get the dynamic convergence right and stuff the wedges back under the yoke to hold it precisely in place and glue them back down. The recheck purity.

There you have it. Easy as pie. Some folk would have you believe no-one in their right minds adjusts these things. Well, balls. Someone did it at the factory, and they did it the way I just described. All you need is the right tools (pattern generator), patience, and time.

Tony's Notes on Setting Convergence on Older Delta Gun CRTs

(From: ard12@eng.cam.ac.uk (A.R. Duell))

The older delta-gun tubes (3 guns in a triangle, not in a line) can give **excellent** pictures, with very good convergence, provided:

1. You've set those 20-or-so presets correctly - a right pain as they interact to some extent.

2. The CRT is set up in the final position - this type of tube is more sensitive to external fields than the PIL type.

Both my delta-gun sets (a B&O 3200 chassis and a Barco CDCT2/51) have very clearly set out and labeled convergence panels, and you don't need a service manual to do them. The instructions in the Barco manual are something like:

"Apply crosshatch, and adjust the controls on the convergence board in the numbered order to converge the picture. The diagrams by each control show the effect".

Here's a very quick guide to delta gun convergence where the settings are done using various adjustments on the neck of the CRT (if you don't have a service manual but do know what each control does, and where they all are - otherwise, follow the instructions in the service manual --- sam):

1. Apply a white crosshatch or dot pattern to the set. Don't try and converge on anything else - you'll go insane. It's useful to be able to switch between those 2 patterns.

2. Before you start, set the height, width, linearity, pincushion, etc. They will interact with the convergence. Also check PSU voltages, and the EHT voltage if it's adjustable. That's where you do need a service manual, I guess.
3. Turn off the blue gun using the A1 switch, and use the red and green static radial controls to get a yellow croshatch in the middle of the screen. These controls may be electrical presets, or may be movable magnets on the radial convergence yoke (the Y-shaped think behind the deflection yoke).
4. Turn on the blue gun and use the 2 blue static controls (radial and lateral) to align the blue and yellow crosshatches at the center of the screen. Some manufacturers recommend turning off the green gun when doing this, and aligning red with blue (using *only* the blue controls, of course), but I prefer to align blue with yellow, as it gives a check on the overall convergence of the tube.
5. Turn off the blue gun again. Now the fun starts - dynamic convergence. The first adjustments align the red and green crosshatches near the edges - I normally do the top and bottom first. There will be 2 controls for this, either a top and a bottom, or a shift and a linearity. The second type is a *pain* to do, as it's not uncommon for it to affect the static convergence.
6. Getting the red and green verticals aligned near the edges is a similar process.
7. You now have (hopefully) a yellow crosshatch over the entire screen.
8. Now to align the blue. This is a lot worse, although the principle is the same. Turn on the blue gun again, and check the static (center) convergence
9. To align the blue lines with the yellow ones, you'll find not only shift controls, but also slope controls. Use the shift controls to align the centers of the lines and the slope controls to get the endpoints right. These interact to some extent. You'll need to fiddle with the controls for a bit to work out what they do, even if you have the manual.

The convergence over the entire screen should now be good....
A word of warning here... The purity is set by ring magnets on almost all colour CRTs, but on PIL tubes, there are other ring magnets as well - like static convergence. Make sure you know what you are adjusting.

Jerry's Comments on Convergence and Other Advanced Adjustments

(From: Jerry G. (jerryg@total.net).)
Convergence alignment is not something you can do yourself unless you have the proper calibration instruments and skills. It takes lots of experience and time. There are published specs for most of the good monitors. Most of the time they are as follows:
There is the 'A area', 'B area', and 'C area'. On a 15 inch monitor the A area would be a diameter of about 4 inches. The B area would be about 7.5 inches. The C area would be the outside areas including the corners. These numbers are approximate. There are actually standard specs for these areas. They are expressed in percentage of screen viewing area. Therefore the inches would vary with the CRT size.
The higher the price (quality) of the monitor CRT, yoke, and scanning control circuits, the tighter the convergence can be aligned by the technician. For the A area on a good monitor, the maximum error should not exceed 0.1 mm. For the B area it should not exceed more than about 0.25 mm. And for the C area, it can be allowed up to about 0.3 mm. Most of the monitors that I have repaired, seen, and used did not meet these specs unless they were rather

expensive. With these specs there would not be any real visible misconvergence unless you put your nose very close to the screen... A lot of the ones in the medium price range they were about 0.15 mm error in the A area, about 0.4 in the B and greater than in the C area. This also annoys me because I am very critical.

If one has the skills and test gear he or she can do a better job on most monitors. It is a question of the time involved. To see the convergence errors a grating or crosshatch pattern is used. A full raster color generator is required for the purity adjustments as well. This is necessary to align the landing points of the CRT guns. The exact center reference and purity adjustments are done with the ring magnets on the CRT neck. The yoke position angle adjustments are also done for the side and top-bottom skewing as well. Everything interacts! The corners are done with various sorts of slip or edge magnets. As for corner convergence skewing, button magnets are used. The color purity will be effected as you go, and must be also corrected. These adjustments interact on one another, and the processes continues until the convergence and purity are good at the same time...!

I don't recommend the amateur or hobbiest, or even the do-it-yourselfer to attempt this alignment procedure. The test gear would exceed the cost of a really good monitor anyways...!!! And without the proper skills required, he or she would only make it worse anyways...

As for purity specs, the color change from any corner to any corner must not exceed an error of more than 200 degrees Kelvin. The error in the B area should not exceed 300 degrees kelvin. This applies to a white raster. Most of the monitors I see don't get better than about 300 degrees Kelvin. And some are even 1000 out! The purity errors are best checked with a full Red raster using 100 % saturation. Then the other color vector angles are checked with cyan, and then magenta. The color temperature stability should be the same in all aspects.

A color spectrometer should be used to judge this error factor. As far as the eye is concerned, it will see a purity error of more than about 500 degrees Kelvin if the person knows what to look for...

When changing the CRT, this alignment must be done completely. Most shops do not even employ people who are skilled to a proper alignment, or don't even own the instruments to do it right, and the poor customer get back a monitor that is not in specs...!

CRTs with No Purity or Static Convergence Rings

I have a late model TV with a 13 inch tube with no static purity or convergence rings. I don't get to see that many modern tubes so this was a bit of a surprise or maybe I just hadn't noticed before on small CRTs if they didn't have purity/convergence problems. I do see it has wrapping of a rubber-ferrite-permalloy type material where the ring assembly would go. I assume that this is magnetized selectively at the factory to adjust purity/convergence? The yoke has the usual position and tilt adjustments. This one was an RCA/GE CRT.

What this means is that if you were to accidentally bring a strong permanent magnet near the base of the CRT or a strong degaussing coil, there is a slight possibility of totally messing up this compensation requiring replacement of the CRT. I don't know how possible this is without really working at it!

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)

Since eternity, Philips CRTs have not had external multipole magnet rings around the neck. There is an iron ring inside the neck, at the end of the electron gun assembly. This ring is permanently magnetized in the factory by a strong outside magnetic field at a later stage of the production. Further responsibility for purity, convergence and geometry is in the design of the coil windings distribution and some metal parts. Final purity adjustment is achieved by matching a tube with a coil and then shifting and tilting the coil slightly. This explains why

Philips CRTs are always sold as a matched combination of tube and coil, contrary to some other brands.

Projection Set Convergence Adjustment Principles

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
CRT projection displays require much convergence correction, especially since the 3 tubes aim at the screen under different angles. Generally the green Horizontal convergence coil is not driven because that is a geometry correction which is taken care of by the horizontal deflection circuit. The 3 vertical convergence coils usually also take care of vertical geometry correction (N-S corrrection) because the vertical deflection circuit is generally a standard direct-view type. Add to that a severe keystone correction for the Red and Blue tubes.
The convergence waveforms used to be generated from an analog polynomial generator. The components are then weighted and summed to form a Taylor polynomial. Consider the adjustment of horizontal convergence, then typical polynomial components are:

1 (shift),
x (amplitude),
x^2 (linearity),
y (rotation or tilt),
y^2 (bow),
x*y (keystone),
x^2*y (dunno if it's used).
x*y^2 (pin-cushion),
x^3 (side linearity).
x*y^4 (corner pin-cushion)

Adjusting convergence is a highly iterative (read: costly) process because each potentiometer tends to influence the whole screen. Also, this method is not easily extendible to higher order adjustments for more accuracy. That's why better waveform generators have been designed, like digital look-up tables with D/A converters (which are quite expensive) and spline-like waveform generators (which are cheap and easy to adjust, the Philips design is called Convergence Spline Processor, it's digital too).

Monitor Tune-Up?

(The following from: Bob Myers (myers@fc.hp.com).)
Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.
The only "tuneup" that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a "tuneup" or adjustment.

A Discussion on Correction Magnets

(From Ludwig (eastcomp@gmx.de).)
When repairing and recalibrating color monitors of different brands, one experiences those "dirty little tricks" called correction magnets, which have different forms, sizes and magnet strength, and which are attached at different locations somewhere near the electronic beams at the neck of the tube. These magnets are used to correct bad edge geometry/convergence and problems with color convergence at various locations on the screen.

Depending on the quality (i.e., magnetic geometry) of the tube and the deflection coils/fields there are monitors, which have only few (or even none) of these correction magnet, while others (some brands are "famous" for this) are really clustered with these magnets.
The magnets can have different forms and sizes:

1. Most often there are used small and thin, weak magnets, which are glued to the end of a plastic stripe. These stripes are inserted into the small gap between the tube and the deflection coils (ferrite coil) and the fixed by glue, silicon or plaster. This magnets are weak and therefore have to be positioned very near to the electron beam at the neck of the tube. They usually are intended to correct bad convergence at the corners and edges of the picture.

2. Plastisized magnets (e.g., 4x4x1 mm, 3x10x1 mm, or 10x10x0.2mm), which have a much bigger magnetic strength, are either glued to the the edges of the plastic case of the deflection coils or - if the magnet is not so strong - to the tube itself. These types of magnets often are used to correct larger deficiencies in geometry - and to a lesser extent - in convergence.

Those are my observations, but what I'd like to know is this:

- Why aren't such magnets demagnetized during the power-on degaussing?

- Aren't such magnets demagnetized, if one uses an extra demagnetizing coil for removing undesired magnetic fields at the tube? Are those demagnetizing coils harmful to the different correction magnets on/at the neck of the coil?

  What type of magnets are used for those correction magnets ? (barium titanate, other types of ferrites?).

(From: Sam.)
The answers to both (1) and (2) is that if using the internal degauss coil and/or properly positioned (front of CRT only) external coil, the strength of the field is (hopefully) insufficient to affect the correction magnets. That is why one should NEVER attempt to degauss in the rear of the TV or monitor or inside the case!
I don't believe the magnets are made of anything special - they appear to be similar to your typical refrigerator (note holding) magnets in composition and strength.
(From: Ludwig.)
By the way: Almost any monitor, which is older than 1-2 years has developed deficiencies in convergence, geometry and sharpness, and has to be recalibrated, if you'd prefer an optimal picture (and being careful with one's eyes). It's not quite easy to do fine recalibration of convergence and geometry (even modern monitors allow only to correct coarse via OSD menus), because during recalibration the monitor has to be at power-on state, i.e. high voltages are at every edge of the monitor. I successfully used household rubber/plastics gloves to do the recalibration by repositioning the above mentioned magnets while the monitor is powered on. Using household rubber/plastics gloves is also a valuable means to prevent beginners from electric shock, and therefore should be recommended for every job to do with the monitor case open and power on (even just for monitoring electronic signals with an oscilloscope).

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CRT and CRT Related Maintenance and Repair

Preventive Maintenance - Care and Cleaning

Preventive maintenance for a TV or monitor is pretty simple - just keep the case clean and free of obstructions. Clean the CRT screen with a soft cloth just dampened with water and mild detergent or isopropyl alcohol. This will avoid damage to normal as well as antireflection coated glass. DO NOT use anything so wet that liquid may seep inside of the monitor around the edge of the CRT. You could end up with a very expensive repair bill when the liquid decides to short out the main circuit board lurking just below. Then dry thoroughly. Use the CRT sprays sold in computer stores if you like but again, make sure none can seep inside. If you have not cleaned the screen for quite a while, you will be amazed at the amount of black grime that collects due to the static buildup from the CRT high voltage supply.
There is some dispute as to what cleaners are safe for CRTs with antireflective coatings (not the etched or frosted variety). Water, mild detergent, and isopropyl alcohol should be safe. Definitely avoid the use of anything with abrasives for any type of monitor screen. And some warn against products with ammonia (which may include Windex, Top-Job, and other popular cleaners, as this may damage/remove some types of antireflective coatings. To be doubly sure, test a small spot in corner of the screen.
In really dusty situations, periodically vacuuming inside the case and the use of contact cleaner for the controls might be a good idea but realistically, you will not do this so don't worry about it.
(From: Bob Myers (myers@fc.hp.com).)
Windex is perfectly fine for the OCLI HEA coating or equivalents; OCLI's coating is pretty tough and chemical-resistant stuff. There may be alternative (er..cheaper) coatings in use which could be damaged by various commercial cleaners, (For what it's worth, OCLI also sells their own brand of glass cleaner under the name "TFC", for "Thin Film Cleaner".)
I have cleaned monitors of various brands with both Windex and the OCLI-brand cleaner, with no ill results. But then, I'm usually pretty sure what sort of coating I'm dealing with...:-)
Monitor coatings are always changing; besides the basic "OCLI type" quarter-wave coatings and their conductive versions developed to address E-field issues, just about every tube manufacturer has their own brew or three of antiglare/antistatic coatings. There are also still SOME tubes that aren't really coated at all, but instead are using mechanically or chemically etched faceplates as a cheap "anti-glare" (actually, glare-diffusing) treatment.
In general, look in the user guide/owner's manual and see what your monitor's manufacturer recommends in the way of cleaning supplies.

Shorts in a CRT

Occasionally, small conductive flakes or whiskers present since the day of manufacture manage to make their way into a location where they short out adjacent elements in the CRT electron guns. Symptoms may be intermittent or only show up when the TV or monitor is cold or warm or in-between. Some possible locations are listed below:

- Heater to cathode (H-K). The cathode for the affected gun will be pulled to the heater (filament) bias voltage - most often 0 V (signal ground). In this case, one color will be full on with retrace lines. Where the heater is biased at some other voltage, other symptoms are possible like reduced brightness and/or contrast for that color. This is probably the most common location for a short to occur.

- Cathode to control grid (K-G1). Since the G1 electrodes for all the guns are connected together, this will affect not only the color of the guilty cathode but the others as well. The result may be a very bright overloaded *negative* picture with little, none, or messed up colors.

- Control grid to screen (G1-G2). Depending on circuitry can result in any degree of washed out or dark picture.

- Screen to focus (G2-F). Screen (G2) and focus voltage will be the same and the controls on the flyback will interact. Result will be a fuzzy white raster with retrace lines and little or very low contrast picture. Symptoms will be similar to those of a flyback with breakdown in the focus/screen divider network.
- Focus to high voltage (F-HV). High voltage will be pulled down - probably arcing at the focus spark gaps/other protective devices. Line fuse and/or HOT may blow.
- Other locations between electron gun elements as feed wires.

Replacing the CRT may be required but there are a variety of 'techniques' that can often be used to salvage a TV that would otherwise end up in the dump since replacing a CRT is rarely cost effective:

1. Isolation - this will usually work for H-K shorts as long as only one gun is involved.
2. Blowing out the short with a capacitor - depending on what is causing the short, this may be successful but will require some experimentation.
3. Placing the CRT (TV or monitor) face down on a soft blanket and gently tapping the neck to dislodge the contamination. Depending on the location of the short, one side or the other might be better as well.

A combination of (2) and (3) may be required for intermittent shorts which don't appear until under power. See the sections below for additional details. However, for shorts involving the focus and high voltage elements, even a sharp edge can result in arcing even if there is no actual short. There is no remedy for these types of faults.

Providing Isolation for a CRT H-K Short

This procedure will substitute a winding of your own for the one that is built in to the flyback to isolate the shorted filament from the ground or voltage reference. Note that if you have a schematic and can determine where to disconnect the ground or voltage reference connection to the filament winding, try this instead.

The flyback is the thing with the fat red wire coming out of it (and perhaps a couple of others going to the CRT board or it is near this component if your set has a separate tripler) and may have a couple of controls for focus and screen. It should have some exposed parts with a ferrite core about 1/2-3/4" diameter.

The filament of the CRT is the internal heater for each gun - it is what glows orange when the set is on. What has happened is that a part of the fine wire of the bad color's filament (assuming this is indeed your problem) has shorted to the cathode - the part that actually emits the electrons. Normally, the heater circuit is grounded or tied to a reference voltage so when it shorts to the cathode, the cathode voltage level is pulled to ground or this reference.

You will need some well insulated wire, fairly thick (say #18-22). Find a spot on the flyback where you can stick this around the core. Wrap two turns around the core and solder to the CRT filament pins after cutting the connections to the original filament source (scribe the traces on the board to break them). Make sure you do not accidentally disconnect anything else.

This winding should cause the filaments to glow about the same brightness as before but now isolated from ground. If they are too dim, put another turn on the flyback to boost the voltage. (Don't go overboard as you may blow the filament totally if you put too many turns on the core - you then toss the TV or monitor.)

Route the wires so that there is no chance of them getting near the high voltage or any sharp metal edges etc. Your picture quality may be a tad lower than it was before because of the added stray capacitance of the filament wiring being attached to the the (formerly bad) video signal, but hey, something is better than nothing.

Rescuing a Shorted CRT

If the short is filament-cathode (H-K), you don't want to use the following approach since you may blow out the filament in the process. If this is the case, you may be able to float the filament and live with the short (see the document: Notes on the Troubleshooting and Repair of Television Sets.

Shorts in the CRT that are between directly accessible electrodes can be dealt with in a more direct way than for H-K shorts. At this point you have nothing to loose. A shorted CRT is not terribly useful.

If the short is between two directly accessible electrodes like cathode-grid, then as a last resort, you might try zapping it with a charged capacitor.

Unplug the CRT socket!

Start with a relatively small capacitor - say a few uF at a couple hundred volts. Check to see if the short is blown after each zap - few may be needed. Increase the capacitance if you feel lucky but have had little success with the small capacitor.

If the fault is intermittent, you will, of course, need to catch the CRT with the socket disconnected and the short still present. Try some gentle tapping if necessary. If you do this with the charged capacitor across the suspect electrode, you **will** know when the short occurs!

(From: Terry DeWick (dewickt@esper.com).)

I have seen this problem many times, shorted CRT red cathode, tap neck of CRT (not hard enough to brake, but close) or hit with a Tesla coil, we use one in shop, remove CRT board, run coil around pins for about 10 seconds, would you believe there is a service bulletin from Philips on this and focus shorts - I do not have a copy - I just helped write it - demonstrated use of coil to the service engineer and fixed 2 bad tubes in process.

Determining if Your CRT is up to Air

> "I have a Compuadd monitor that's completely blank.The high voltage is very low and there's flashing inside the neck of the picture tube. I believe there may be a small hairline crack in the neck of the picture tube. I suspect that a crack has compromised the vacuum in the tube and that's what is causing the flashing and the low voltage. Is that possible, and if so, is there anything that can be done other than junking it?"

If there is a crack, then everything else is possible. However, these rarely develop on their own.

Look around the neck of the CRT for a coating - the getter. If it has turned white or red, your CRT is history. If it is still silver, the vacuum is intact and your arcing may be due to a bad flyback putting excessive voltage on the screen or focus electrode or a CRT that is bad in other ways. There are supposed to be external protection spark gaps, etc. for this but may not always work.

Sorry, junking it is probably the only realistic solution. Unless you find a cheap used CRT, the expense is not worth it. Even then, adjustments may be quite involved.

Scratches or Other Damage to the CRT Face

It is generally difficult to accidentally scratch the face of the screen but accidents do happen. The way the manufacturer would repair it is to replace the CRT. If the scratch is the result of shipping damage, file a claim with the shipping company. If it is a factory defect, get it repaired or replaced under warranty.

Barely visible scratches can be removed with jeweler's rouge or similar ultra-fine abrasive unless the CRT has an antireflective or textured surface.
Jeweler's rouge is the same stuff that is used in the final polishing of lenses and mirrors so it makes for a fine finish. However, any kind of scratch deep enough to be felt will not yield to this approach.
For larger scratches, one would normally start out with a coarser abrasive like 300 grit and work toward successively finer sizes - 600, 1200, etc. - with the final polishing being done with the rouge. However, realistically, this isn't really a viable approach for a CRT faceplate. It takes a lot of grinding to remove enough material to smooth out a scratch and you are more likely to mess things up than to improve matters.
If the CRT has an antireflective coating or textured surface, it will almost certainly be best to leave the scratch alone. Any type of polishing *will* remove affect the appearance in the vicinity and leave you with a big unsightly blob. This will be much more objectionable than a slight scratch.
The types of fillers sold in auto parts stores for repairing auto windshields may reduce the visibility of any scratches but DO NOT restore the integrity of the glass.
I don't quite know whether this is better or worse than the disease but it might be worth trying: (From: Cooper@Hub.ofthe.NET).

> "I may have come across an easy fix for those who have scratched glass on the monitor face. I am currently using window film as an adhering material to cover and conceal the scratches. This looks much better and enables me to continue usage of the monitor without the aggravating distortion."

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CRT Degradation

CRT Aging - Effects on Electrical Characteristics and Performance

(From: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
Specifications for Philips CRTs can be found in the regular series of data books from Philips Components. Companies and universities usually have them. Usually the data sheets show typical Ik/Vk characteristics. They also list the spread on cutoff voltage and cathode gain, and this spread is quite large even on new CRTs. They also list phosphor sensitivity (Lum/Ik), this too has a large spread. But they almost never list anything about the aging process.
Here are some of the effects:

- Phosphor ages due to burn-in, particularly on static pictures, this is immediately obvious on visual inspection. If the aging is even (no pattern) then at least the efficiency is reduced.
- Cathodes age due to loss of emission material, particularly for oxide cathodes. The central part of the cathode surface has carried the most current density and will wear out first. The surrounding area takes over, this will lead to an unsharp picture. Adjusting the focus voltage will not really improve it. The tube is worn out.
- Also poisoning of cathode surface may occur. This can be cured temporarily by short-time overheating ("re-conditioning").

- The cathode that wears out first (often the red one) also loses gain, so the white point of the image will shift (to cyan). The white point can be re-adjusted with the gain potentiometers and the contrast, but peak brightness will not be as high as new.
- The cutoff voltages of all cathodes will drift. Common drift is adjusted by the user by controlling the brightness. Different drift leads to a coloration of the black background level. In extreme cases vertical flyback lines will appear. Cutoff voltage can be adjusted with potentiometers, or there is automatic stabilisation. Still, the VG2 (screen) may need periodic adjustment too.
- Leakage currents may disturb VG2 and focus voltage, re-adjustment has only a temporary effect.
- VG2 and focus potentiometers may wear out due to electromigration etc. A hole may form under the wiper, re-adjustment is then impossible.
- Some types of cathode wear (according to a friend in Philips Semiconductors) can cause the Ik/Vk transfer characteristic to divert so much from an ideal gamma function that no adjustment can compensate for it. Then the tube is really worn out.

I hope that this helps you to distinguish between a really worn out tube and one that still has some life in it after re-adjustment.

CRT Age Resulting in Dark Picture

Where circuit problems have been ruled out:
(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
Most probably the cathodes have worn out. The emission material on the surface slowly becomes inactive. Usually you see one colour go first, then the others. At the same time you will observe a loss in sharpness, because a larger cathode area is being used, giving a bigger spot.
Rejuvenating is done by applying a (too) high filament voltage, in order to bring new emission material to the surface. It will not work for long and there is the risk of burning the filament wire for good. It may be worth a try, though.
Other wear mechanisms are:

- Glass browning (generally only for projection tubes).
- Phosphor aging (life time is defined by efficiency < 50%).
- Vacuum leaks (generally cause EHT flashover, audible).

Then again, it may also be that for some mysterious reason your VG2 voltage has dropped below spec. A too high VG2 voltage will cause a smaller cathode area to be used, leading to a sharper picture but accelerated cathode wear.

Brightening an Old CRT

If performing adjustments of the internal background and/or screen controls still results in a dark picture even after a long warmup period (and the controls are having an effect - they are not faulty), the CRT may simply be near the end of its useful life. In the old days of TVs with short lived CRTs, the CRT brightener was a common item (sold in every corner drugstore, it seemed!).
First confirm that the filaments are running at the correct voltage - there could be a marginal connection or bad resistor or capacitor in the filament power supply. Since this is usually derived from the flyback, it may not be possible to measure the (pulsed high frequency)

voltage with a DMM but a service manual will probably have a waveform or other test. A visual examination is not a bad way to determine if the filaments are hot enough. They should be a fairly bright orange to yellow color. A dim red or almost dark filament is probably not getting its quota of electrons. It is not be the CRT since all three filaments are wired in parallel and for all three to be defective is very unlikely.

If possible, confirm that the video output levels are correct. For cathode driven CRTs, too high a bias voltage will result in a darker than normal picture.

CRT brighteners are available from parts suppliers like MCM Electronics. Some of these are designed as isolation transformers as well to deal with heater-to-cathode shorts.

You can try a making a brightener. Caution: this may shorten the life of the CRT - possibly quite dramatically (like it will blow in a couple of seconds or minutes). However, if the monitor or TV is otherwise destined for the scrap heap, it is worth a try.

The approach is simple: you are going to increase the voltage to the filaments of the electron guns making them run hotter. Hopefully, just hotter enough to increase the brightness without blowing them out.

Voltage for the CRT filament is usually obtained from a couple of turns on the flyback transformer. Adding an extra turn will increase the voltage and thus the current making the filaments run hotter. This will also shorten the CRT life - perhaps rather drastically. However, if the monitor was headed for the dumpster anyhow, you have nothing to lose. You can just add a turn to an existing winding or make your own separate filament winding as outlined in the section: Providing Isolation for a CRT H-K short.

In some monitors, there is a separate filament supply on the mainboard - this should be obvious once you trace the filament wires from the video driver board). In this case, it still may be possible to increase this output or substitute another supply but a schematic will be required.

There are also commercial CRT rejuvenators that supposedly zap the cathodes of the electron guns. A TV or monitor service center may be able to provide this service, though it is, at best, a short term fix.

Checking the Age of the CRT

So you have this great deal on a used TV or monitor. How can you tell if the picture tube is about to die on you?

(From: Andy Cuffe (baltimora@psu.edu).)

The best way to tell is to look at the picture quality. There is no way to tell the exact number of hours. Also, the life of CRTs varies quite a bit. some will go down hill much faster than others.

- It should be sharply focused over the entire screen and all 3 colors should be equally sharp.
- Set the picture brightness and color to maximum. If you see any bleeding or smearing to the right of bright objects don't buy it.
- When you first turn it on the picture should look normal in well under a minute. If it is dim, tinted, or blurry for more than a minute or two the CRT is getting weak.
- A B/W picture should not be tinted.
- The picture should have decent brightness with the picture at about mid range.

Apart form that, if the overall picture is good the CRT is fine. CRTs usually fail very slowly. Even if it's starting to show it's age it probably has several years left.

(Portions from: Jerry G. (jerryg50@hotmail.com).)

You cannot tell the hours used by just looking or even measuring a tube. A tube can go at any time. There are no hour counters!
Turn on the unit and see if there is any unusual bleeding of the image in the picture at high contrast levels. When turning the brightness up and down, the color temperature should not change, only the brightness. When turning the contrast up and down, the focus at the center should also be very stable. It may change only a little bit. When turning on the set, the color temperature should be stable within about 3 to 5 minutes.
Look at the colors in the corners to see if the purity is good. Bad purity can be attributed to a miss-adjusted yoke assembly, to a bad shadow mask.
To know the manufacture date of the unit, it us usually on the back with the model and serial number. Most TV sets are on about 5 to 8 hours a day if it is a family TV. If it is a bedroom TV the hours may be 1/2 that amount. Monitors may be on 24 hours a day - or much less.
A good way to know if the emission of the CRT is up to specs is to get a CRT analyzer and measure the gun emission. Some service centers own one.

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CRT Rejuvenation

What is CRT Rejuvenation?

Where one or more electron guns in the CRT have deteriorated due to wear and tear, it is sometimes possible to give them a new, but possibly, temporary lease on life through rejuvenation using a special piece of CRT service equipment.
There may be some schematics for commercial CRT rejuvenators accessible from the Sencore Service Page.
(From: Gary Klechowitz (klechowi@execpc.com).)
When I rejuvenate a tube I inform the customer that there is no warranty on the job. Rejuvenating a CRT is like when Clatuu was brought back to life by Gort in "The Day The Earth Stood Still". When asked "How long will you live"? he replied: "no one knows".
I use a Sencore Beam Builder. If your tube is just moderately dim and blurry but still shows good cut off threshold, I would just use the auto restore mode on the beam builder rather than using the restore button. If the tube is really bad with little or no cutoff threshold, then the rejuvenator is needed but that has less than a 50% chance of fixing the tube and in many cases the tube gets worse to trashed in the process.

CRT Degradation and Rejuvenation

> "As I understand it, when a CRT ages, its filament looses material. It ejects fewer electrons, and this accounts for the need to crank up the cutoff. Is the focusing problem caused by the high cutoff voltage accelerating the electrons too fast for the focusing assembly to work? And what would explain the shadowing problem?"

Replies from: Jeroen H. Stessen (Jeroen.Stessen@philips.com) and another engineer at Philips who we shall call Tom.
Tom:
Yes, the cathode surface is losing the Barium/Strontium oxide slowly and hence the working voltage to free the electrons is rising. In itself, this will not change the cut-off voltage needed for proper operation. This stays the same, only there are fewer electrons left that can be drawn towards the screen at a certain drive voltage. The focusing problem occurs at the moment that the TV-set tries to establish a certain beam current and finds out that a higher driver voltage is

needed to give this current. Consequently, a larger cathode area is used to get enough electrons out of it. This larger cathode area will be imaged onto the screen and give a larger spot size.
Another point is the drift of leakage current, leading in a practical TV-set with high impedance focus circuit (this allows voltage drop) to a focus voltage at the CRT focus pin that is lower than it should be and this again leads to a bad focus performance.
Jeroen:
Readjustment of the focus voltage will be only a temporary solution.
Addressing each of the effects and CRT rejuvenation:

1. Why is poor focus sometimes a symptom of a failing CRT?

Tom:
Normally only the emission from the centre of the cathode adds to the electron beam. If the emission material in the centre is exhausted then the outer area comes in. This is a larger surface, the electron lens projects this into a larger spot. It is not that the focus is bad, the lens works OK. It is that a larger object is projected onto a larger image.
Jeroen:
This applies mainly to oxide cathodes. Impregnated cathodes are much more robust. They can be applied at a higher cutoff voltage and thus deliver a smaller spot without premature wear. They are more sensitive to a too high heater temperature, however, because they are operated at a higher temperature to begin with. They do evaporate more metal during their lifetime. At one time there was fear that they would deposit too much metal on the glass around the electrodes, leading to leakage currents. These can cause drift of focus and screen voltages and can disturb the cutoff current measurement. Those can influence the picture too.
Tom:
Impregnated cathodes contain a lot of emission material that moves more easily towards the cathode surface as time passes. Oxide cathodes have the problem that the Ba/Sr-oxide is positioned too deep to be very effective. Hence, the life time of an I-cathode should be longer than that of an oxide cathode but indeed the sensitivity to correct heater voltage is higher. Second, an impregnated cathode, being highly conductive compared to an oxide cathode which is a semi-conductor, can handle a much higher peak current since the cathode material is not locally heated up by this peak current. An oxide cathode can be destroyed by a too high peak beam current !
Jeroen:
Oxide cathodes are typically operated at cutoff voltages between 100 and 130 V. Impregnated cathodes are typically operated at cutoff voltages between 130 V and 200 V. Hence they can provide a much sharper spot, but it is also much more difficult to design a video output amplifier with sufficient bandwidth at the required large drive voltage (like 120 V peak-peak).

2. Why is horizontal streaking sometimes another symptom?

Jeroen:
Two symptoms, both related to the cutoff voltage being higher than what the video output amplifier(s) can deliver. The cutoff voltage is proportional to the VG2 (second grid voltage). The higher VG2 is the higher the cutoff voltage VK - VG1 must be to blank the beam. The video amplifier delivers VK. VG1 is fixed. Remember: cathode drive is negative, e.g. +130V = black, +30V = white.
If the video amplifier clips before cutoff is reached then the beam will not be blanked completely and you will see a lighted background with slanted retrace lines. Some class-B video amps will also show a bad recovery time from clipping to black, this may lead to black streaks after black images. Class-A amps should not have this problem. (In my experience this is more common with clipping to white, usually leading to red or yellow streaks.)

If the cutoff voltage rises (due to some unexplained wear) or because VG2 rises (due to drift or due to owner intervention: turning the Screen potmeter) then the user may compensate for the increased (background) brightness by lowering the brightness control of the set. Some televisions automatically lower the brightness of each channel because they have automatic cutoff control. Either way, the cathode voltages rise and clipping may occur with retrace lines as a result.
Tom:
Well, as said earlier, in principle the cut-off doesn't change due to cathode wear-out. The fewer electrons still need the same voltage to prevent them from reaching the accellerating lens. I have heard of cut- off drift due to distance drift between G1 and G2 for which it is very sensitive. However, this is not something that gets worse over time.

3. And finally, what is the real story on CRT restorers/rejuvenators?

Jeroen:
Some of the possible 'remedies' include:

- Excess heater temperature may bring some new emission material to the surface of the cathode. This is done by putting 9-10 V (?) on a 6.3 V heater. There is not emission material much left, so this will be a temporary solution at best. I don't think it is needed or recommended with I-cathodes (impregnated).

  Tom:
  This also helps for poisoned cathodes. Cathodes that have been operated too long on a too low heater voltage get poisoned, meaning that the Ba/Sr-oxide gets chemically binded, leading to a higher working voltage. Indeed, only oxide cathodes can be rejuvenated this way. Impregnated cathodes have a more sudden death mechanism and can not be regenerated in this way.
  There is also the risk of burning out a heater filament for good.

- Some type of electrode shorts may be removed by high currents.

- The vacuum may be improved by activating the getter electrode using an induction heater or RF source to heat the ring shaped getter electrode to red/orange temperature. (This probably only applies and then only in a limited way if the getter spot has faded - turned red or milky from its normal silvery appearance --- sam.)

  Tom:

- Further: burning metal whiskers off the electrodes can help reducing a leakage current problem.

  Jeroen:
  This is done by running high (flash) currents between electrodes. A similar procedure is performed on new picture tubes in the factory.

Also see the sections starting with: "Brightening an old CRT".

More Comments on CRT Rejuvenation

(From: Ren Tescher (ren@rap.ucar.edu).)
Reduced emission (dim picture) can occur when the cathode/filament has used up most of the electrons it can emit to the screen. Or, a 'crust' may have formed on the thoriated emitter material that can be 'boiled off' to expose more electrons.
A rejuvenator or restorer generally hits the cathode/filament with a higher than normal current to accomplish this.
But, while a rejuvenator gives the cathode/filament a 'blast' of power, a restorer can slowly increase the temperature while monitoring beam current on one of the grids.

So generally a rejuvenator was a 'do or die' unit and a restorer could give only what was needed to accomplish increased emission. But these definitions have always been blurred by advertising hype.

The early restorers, such as my REM, had the operator watch the grid current on a meter(s) to determine when emission was sufficient. I suppose newer units have a PIC chip or some other logic to do the job.

(From: Terry DeWick (dewickt@esper.com).)

I use a hand held Tesla coil to all pins for about 5 seconds. Then, follow up with rejuvenator for a quick check and cleanup if needed. Tesla coil is type the neon sign people use for testing. 95% or better luck - saved a lot of out of warranty Zeniths from big repair bills or junk pile.

Home-Made CRT Rejuvenator 1

(From: Tony Duell (ard@p850ug1.demon.co.uk).)

I've read some articles in 'Television' which describe home-brew CRT rejuvenators. I've not tried any of the circuits yet...

It appears that you overrun the heater by up to 50% (for a 6V heater, try 7.5V and 9V, say). Don't blame me if it burns out ;-)

You then apply about 300V, current limited to say 50 or 60mA between cathode and 1st grid.

One of the older designs used the UK 240V mains, a single diode as a half-wave rectifier, and a 15W light bulb in series for this PSU. I don't like unisolated equipment, so I'm not going to try it.

Some designs apply that voltage continuously, and you watch the emission current rising (or the bulb getting brighter...). With others you apply it for a few seconds, and then check the emission using, e.g. a 12V supply and a microammeter between cathode and grid.

One old article suggested that if you get no improvement, switch off the heater supply with the 300V still connected. As the cathode cools down, you get quite violent stripping of the cathode - observable as sparks from the electron gun area of the CRT. On the other hand, it is claimed that this can completely ruin the cathode, or even cause short-circuits to occur in the CRT.

Home-Made CRT Rejuvenator 2

I have no comments one way or another with respect to this device. Please contact the author for further information.

(From: Mario Di Stefano (mario.distefano@siemens.it).)

Here is the 'gadget' I use to rejuvenate 'tired' CRT's:

```
               T1
o---+--------+    +------------------------------>
    |        )||(
M   |        )||(
A   |        )||( 6.3 or 12 Vac                 To Filament
I   |        )||( Secondary                     CRT Tube
N   |        )||(                               (no Polarity)
S   |        )||(
    |        )||(
o---|-----+--+    +------------------------------>
    |     |
    |     ----------------------------------------> CRT Cathode
    |
    |                 +-----+     _|_
    ------------------| LP1 |-----o o------------> CRT 1st Grid
                      +-----+     P1
```

Where:

- T1 is a standard mains AC transformer.
- LP1 is a standard FILAMENT LAMP (60 - 100 W) working voltage according to mains.
- P1 Hand Pushbutton.

Other things needed (not shown):

- Mains switch (best if with overload protection or with fuse)
- 4 ISOLATED clips like the ones used in electronics to make contacts with the pins of ICs. These isolated clips ARE IMPORTANT. You don't have to touch any connection during the cleaning.

I think this circuit works better if the mains voltage is 220 Vac.
How to use it:
First we have an tired CRT (BW or colour is the same). We have poor image contrast, 'strange' brightness, also strange colours. Next we have to remove (if present) the CRT socket to its circuitry (beware to disconnect mains voltage FIRST!!!!!). At this point could be useful to discharge the HV using an isolated wire FIRST connected to CRT grey body and then to the make the contact UNDER the suction gummy which carries EHT. to the tube. It is not a dangerous voltage, but could be better not to discharge it over the body!
Now we have to identify the filament pins. Usually on the schematic circuitry of the Monitor/TV it is clearly written. If the schematic is not available, using an ohmmeter we should find the two contacts which gives a few ohms. These contacts usually are put aside each other) have to be connected to the transformer secondary of the circuit above. The Cathode and 1st grids can be found looking very closely into the tube glass (use lens and good light if necessary). Keep in mind the way the CRT electron sources are built. These usually follows this:

```
                   Cathode
                   |                  (B/W CRT tube)
                   V
         O------+  |  |
                +  |  | <- 1st Grid
      Filament  +  |  |
                +  |**| <-Spark (read text below)
         O------+  |  |
                   |  |
                   |  |
Cathode  O---------+  |
Connection            |
                      |
1st Grid O------------+                 (Damn'd ASCII graphics!)
Connection
```

Try to connect and turn on the transformer. The Filament in the CRT should turn on in a not-so-bright red (if it is a colour tube, we have 3 filaments on).
Now turn off the transformer again. Connect the Cathode wire to the cathode pin of the CRT Tube. Connect the 1st grid accordingly.
Turn on the transformer. FIRE button P1. If there is dust (due to aging) between the cathode and 1st grid, the circuit will blow-up it. If this happens, you could (but not always) even see the LP1 turn on and off randomly (a good cleaning gives a lamp OFF) and some sparks inside the tube. The tube collar glass now becomes hot: it is normal. You can even 'force' better

sparks if you 'ting' your finger against the CRT glass (not so strong, of course). If it is a Colour CRT, you have 3 Cathodes, 3 1st grids a anyway 1 filament. Useless to say that the procedure have to be carried out for all these electrodes. A good cleaning, gives a LP1 steady OFF. If it is a steady bright or dim, means that a 'bridge' has been formed between the electrodes and there is no way to recover the tube. Turn off the mains, remove the connections, and re-apply the original socket. That's all. I'm not tired to say: BEWARE OF THE MAINS VOLTAGE: IT CAN KILL!! If you are not so skilled, don't try to do this procedure. I used this circuit lots of times. It worked almost anyway. I recovered lot of thrown away PC monitors, and now are working well....

Home-Made CRT Rejuvenator 3

Here's another circuit found on the Web:

- CRT Rejuvenator Description
- CRT Rejuvenator Schematic

And, some comments:
(From: Chris F.
I recently built a homemade CRT tester & rejuvenator from plans I got these plans. The test mode works quite well, providing a good indication of the CRT emissions and showing the presence of H-K or K-G shorts. But the restore mode often doesn't help very much, though it has done a half-decent job on at least a few old CRTs. Anyway, I've been told that Sencores "Beam Builder" applies 450 Volts cathode to grid for a short time to restore the emissions. Now I have some old 450-volt transformers from really old TVs and I wondered if I could modify this design to use 450 VAC between cathode and grid (during restoration only). How long would the restoration process take at this voltage, would this work, and how dangerous would it be? I've heard horror stories of all kinds about CRTs during handling, rejuvenation, and so on, and I don't like taking chances with these things.
But I'd rather give this a try than spend the $2000 Cdn it would cost me for a Sencore unit.

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Items of Interest

Lifespans of Monitors

(From: Bob Myers (myers@fc.hp.com).)
Most manufacturers will quote an MTBF (Mean Time Before Failure) of somewhere in the 30,000 to 60,000 hour range, EXCLUSIVE OF the CRT. The typical CRT, without an extended-life cathode, is usually good for 10,000 to 15,000 hours before it reaches half of its initial brightness. Note that, if you leave your monitor on all the time, a year is just about 8,000 hours.
The only 'tune-up that a monitor should need, exclusive of adjustments needed following replacement of a failed component, would be video amplifier and/or CRT biasing adjustments to compensate for the aging of the tube. These are usually done only if you're using the thing in an application where exact color/brightness matching is important. Regular degaussing of the unit may be needed, of course, but I'm not considering that a tune-up or adjustment.

Monitor Life, Energy Conservation, and Laziness

A common misconception about the care and feeding of computer monitors is that they should be left on all the time. While there are some advantages to this, there are many more disadvantages:

1. CRT Life: The life of a monitor is determined by the life of the CRT. The CRT is by far the most expensive single part and it is usually not worth repairing a monitor in which the CRT requires replacement. The brightness half-life of a CRT is usually about 10-15 K hours of on time independent of what is being displayed on the screen. 10 K hours is only a little more than a year. By not turning the monitor off at night, you are reducing the life of the monitor by a factor of 2-3. Screen savers do not make any substantial difference especially with modern displays using X-Windows or MS Windows where the screen layout is not fixed. With video display terminals, the text always came up in the same position and eventually burned impressions into the screen phosphor. With modern CRTs, the filaments can be left to minimize the time needed for a picture to appear since this doesn't affect CRT life very much.

2. Component life: The heat generated inside a monitor tends to dry out parts like electrolytic capacitors thus shortening their life. These effects are particularly severe at night during the summer when the air conditioning may be off but it is still a consideration year around.

3. Safety: While electronic equipment designed and manufactured in accordance with the National Electrical Codes is very safe, there is always a small risk of catastrophic failure resulting in a fire. With no one around, even with sprinklers and smoke alarms, such an failure could be much more disastrous.

4. Energy use: While modern monitors use a lot less energy than their older cousins, the aggregate energy usage is not something to be ignored. A typical monitor uses between 60 and 200 Watts. Thus at a $.10 per kWH electric rate such a monitor will cost between $48 and $160 a year for electricity. During the night, 1/2 to 2/3 of this is wasted for every monitor that is left on. If air conditioning is on during the night, then there is the additional energy usage needed to remove this heat as well - probably about half the cost of the electricity to run the monitor.

The popular rationalization for what is most often just laziness is that power-on is a stressful time for any electronic device and reducing the number of power cycles will prolong the life of the monitor. With a properly designed monitor, this is rarely an issue. Can you recall the last time a monitor blew up when it was turned on? The other argument, which has more basis in reality is that the thermal cycling resulting from turning a monitor on and off will shorten its life. It is true that such thermal stress can contribute to various kinds of failures due to bad solder connections. However, these can be easily repaired and do not effect the monitor's heart - the CRT. You wouldn't leave your TV on 24 hours a day, would you? Full power saving where virtually everything including the CRT filaments is turned off is really best but the delay before a picture appears may be 20 seconds or more.
Also see the section: Thernal Cycling and Component Life.
Some of the newest ('green') monitors have energy conserving capabilities. However, it is necessary for the software to trigger these power reduction or power down modes. Few monitors in actual use and fewer workstations or PCs are set up to support these features. If you have such a monitor and computer to support it, by all means set up the necessary power off/power down timers. However, using the power saving modes of a 'green' PC with an older monitor can potentially cause damage since some of the modes disable the sync signals. A

'green' monitor which can detect a blank screen and and use this as a trigger can easily be used with a screen saver which can be set to display a blank screen - on any PC or workstation. Even if the monitor does not support power saving modes, a blank screen or dark picture will reduce stress on the CRT and power supply. Electronic components will run cooler and last longer.
Please make it a habit to turn your monitors off at night. This will extend the life of the monitor (and your investment) and is good for the environment as well. For workstations, there are good reasons to leave the system unit on all the time. However, the monitor should be turned off using its power switch. For PCs, my recommendation is that the entire unit be turned off at night since the boot process is very quick and PCs are generally not required to be accessible over a network 24 hours a day.

Thernal Cycling and Component Life

(From: Bob Myers (myers@fc.hp.com).)
In a CRT monitor, the shortest-lived component BY FAR is the CRT itself, and it ages (more properly, the cathode is aging) as long as the heater is on and the tube is under bias. Most monitors don't get around to turning the heater down or off until they enter the DPMS "suspend" or "off" modes. (And no, screen-savers do NOT help here - the tube is still on and the cathode is aging.)
Other factors - simply having the circuits hot and powered up in general means that they're aging. Clearly, they're NOT aging when they're off. This needs to be balanced against the thermal-cycling sort of stresses that you mention which happen during power cycling, and this is why I recommend shutting off only when you're going to be away for an extended period, such as overnight. This is, of course, most important for those components which have clear heat-related aging, but most do to some extent. Esp. vulnerable are things like electrolytic caps, for obvious reasons.
The bottom line is that nothing is ever going to last forever, and trying to maximize the life of the product is an exercise in making tradeoffs between various aging/failure mechanisms.

Expected Life of TV CRTs

(From: David (dakuhajda@aol.com).)
The "unofficial" designed life is 10,000 hours on the guns used in most Thomson manufactured sets. I got this from a Thomson engineer. They are no longer plating the guns but dipping them.
Given the number of hours most people watch TV these days, take 6 hours a day on average 365 days a year and you get 4.5 years. Also note that the 10,000 hours is at the preset way too high brightness and contrast settings that the set comes with from the factory. Since most people never adjust from these expect 5 years. We do the contract repair service for all the hospitals and hotels in our area. The sets bought in 1993 in one hospital are now coming in with complaint of green picture or bad focus at edges. All due to the picture tubes being worn out.
Zenith on the other hand has a company expected life of 3 years on new sets. Plus the hard short failures they have been having on all "L" and "M" line sets.
Thomson does have a "better" line of picture tubes for the higher end sets. They are actually plating the guns the way they use to.
Final note: we see 7 and 8 year old sets come in all the time with crappy picture tubes, and a few with really good looking pictures.

Why are Prices of Video Monitors So High Compared to Similarly Size TVs?

How come I can buy a 32" Sony Trinitron TV set for $800, but when it comes to buying a monitor for my PC, $1400 only gets me a no-name 20" tube?

Why can't a giant like Sony produce a PC monitor anywhere close in cost to an equivalently sized TV set?
(Some of this from: Mike Stewart (mstewart@whale.st.usm.edu).)
There are several significant factors being overlooked here:

1. Economy of scale. There are still *many* more TV sets being sold than computer monitors. Manufacturers order TV chipsets in much larger quantities. This drives down the price.

2. Resolution. NTSC TV signals aren't even VGA resolution. Try getting that 32" Sony Trinitron XBR to give you 1280x1024. A computer monitor has a CRT with a resolution about 2 to 3 times that of a TV of similar size in both horizontal and vertical directions. The beam is also more sharply focused.

3. Refresh rates. NTSC TV signals come at one refresh rate, period. You either watch broadcast NTSC at 59.94Hz (interlaced), or you don't watch it at all. No nice, clean 72Hz NI display on there. (NOTE: This only refers to the 99+% of TV playback equipment that contains no line- doubling circuitry. That's fair, as you'll pay a good bit more for a non-interlaced, line-doubled NTSC picture than the previous poster was complaining about, anyway.)

   Therefore, a auto-scan monitor needs more sophisticated deflection and power supply circuitry. It must run at much higher scan rates and this complicates the circuitry as well.

4. Geometry. The precision of a good computer monitor is much greater then any TV. The sides will be parallel and square. Adjustments are provided to eliminate pincushion, keystone, and trapizoid distortions.

5. Stability. The image on a high quality computer monitor is rock solid and does not shift position or change size as components warm up, or the power line voltage fluctuates, etc.

Problems with Designing a Combination TV and Computer Monitor

(The following is from: Bob Myers (myers@fc.hp.com).)
It's possible, and has been done (for instance, Toshiba has one product and offerings from other companies are available or are on the way). But such designs ARE compromises, and won't give the best performance possible in either application.
There is a fundamental difference between CRTs designed for TV use, and those used in computer monitors. It's a brightness/resolution tradeoff - TV tubes are run about 3X or so the brightness of a typical computer monitor, but sacrifice the ability to use small spot sizes and fine dot pitches to do this. You don't see very many color tubes running at 100 - 150 fL brightness and still using an 0.28 mm pitch!

Picture Tube Disassembly for Demonstration Purposes

Here are several questions from a budding exhibit constructor:

> "1. I am interested in using a dead CRT for a display at our science center on how things work and know about the safety issues. Also, I would really like to cut one (or parts of one) open, so it would be great to know what other things to worry about or what tools to use."

(Portions from: Jeroen H. Stessen (Jeroen.Stessen@philips.com).)
Back in the TV-lab we have an unassembled picture tube for that purpose. Most convenient!

- First, make sure that the electrical capacitance of the CRT is properly discharged. Pull the mains plug. Connect a wire to the outer aquadag. Then push it under the anode cap and make a good short-circuit. Remove the anode cap and EHT wire.

- Next you want to break the vacuum. This is my preferred method:

    - Use a sharp object or a drill to punch a small hole in the anode contact. It's made of really soft metal, probably copper. It takes several minutes for the air to fill the entire tube. In the mean time you can have some fun putting your finger over the hole. No, that's not harmful.

    - The other way to break the vacuum is via the thin tube that was used to pump the air out of the tube. That is located in the middle of the socket at the end of the neck. Remove the plastic part around the pins and break the little tube by hitting it with e.g. the tip of a screwdriver (+hammer). If you score it with a fine triangular file, it will crack off cleanly.

  I like this method less, for fear of breaking too much glass.

- You might also want to cut off the neck for easier manipulation and study of the electron gun parts. Use a glass cutting saw if one is available. Else, score totally around the neck with a fine triangular file or glass cutter and then it should snap fairly cleanly.

  Don't just chop off the neck - especially if you have not released the vacuum. Aside from the danger of flying bits of glass, you get a very characteristic dirty spot on the front of the screen, it looks as if the phosphor layer has been blown away from the faceplate by the strong inrush of air. Or maybe it was the shadow mask being blown against the faceplate. Very tell-tale and spoils your nice display.

- The deflection coils (and purity/convergence magnet assembly, if used) are also easily removed. Loosen the clamps and twist and slide them off of the neck. It's best to find an old tube where the coils have not been potted (against the noise they tend to make). Then you can see them very well.

- The difficult part will be to cut the connection between faceplate and funnel. Normally the two parts are glued together. I think it will require a glass cutting saw to get the tube open again.

  You want to separate it just behind the faceplate or else there will not be enough space to grab and remove the shadow mask. That's just clicked into place, very easy to unclick.

And one more question:

> "2. I would assume the phosphors are a problem... Any things I need to know about chemical hazards?"

Old tubes had environmentally unfriendly phosphors, containing heavy metals such as cadmium and some rare earths. Nothing immediately toxic but the long-term effects are not healthy either. Modern tubes should at least have cadmium-free phosphor. But the phosphor is covered with a metal layer, so normally it would not even be exposed. Just don't touch it.

> "3. Or that we would need to bond a cover over the exposed interior components both for safety and to keep them intact?"

Obviously, you will want to prevent the curious from being injured by sharp metal parts but nothing will fall apart (assuming your original disassembly was not overly violent). The

internal magnetic screen is attached to the shadow mask, which is clicked into metal parts at the face plate. The whole assembly removes easily.
Have fun, this is going to be a wonderful demonstration of a very practical application of some heavy *physics*.

Turning a Large CRT Faceplate into the Side of a Fish Tank

So, you want to turn your 1950's vintage console TV into the ultimate fish tank experience.
WARNING: Make sure the CRT capacitance had been discharged and the vacuum let out first! See the section: Disposing of Dead TVs or Monitors (CRTs and Charged HV Capacitors).
Cutting the CRT apart would be a tricky business. If it is a typical color TV, the front is over an inch thick so you have to slice it around the edge behind the main faceplate. I wouldn't recommend even trying a glass cutter except as a last resort. If you can gain access to a diamond saw to cut around the edge, that is possible - a masonry dealer or industrial glass company might be talked into doing this. With the proper tools, it is a 10 minute job. The problem then becomes whether the inside surface is frosted or not. The phosphors may be at least somewhat toxic (to fish at least) so every trace of them need to be removed. Once this is done, the resulting finish (if the glass itself is frosted) may interfere with your fish viewing pleasure. :-)

Why do TVs Overscan?

(The following includes material from: Jeroen Stessen (Jeroen.Stessen@philips.com).)
TVs are always set up to generate a picture which is 10-15 percent large than the visible face of the CRT. Why?
In the early days of TV, this was probably done to make the design easier. Component tolerances and power line voltage fluctuations would be masked even if they caused changes in picture size.
There certainly is almost no reason today to have any more than a couple of percent overscan.
Most modern TVs have very well regulated power supplies and component values do not really drift much.
Computer monitors, for example, are usually set up for no overscan at all so that the entire image is visible.
We are constantly reminded of that, now that we are building TV's with VGA inputs (PD5029C1 in the USA, US$ 2000). This mixed application has overscan in TV mode and underscan in VGA mode. Geometry adjustment is quite critical if you see border-on-border.
Unfortunately, TV's may be good but VCR's certainly are not. If you have too little overscan and then put the VCR in any feature mode (like picture search) then one (black) picture edge may become visible. Bad form. Viewers do not like this.
While design considerations may have been the original reason for overscan, now it has become accepted as a de facto standard, and broadcasters are counting on the overscan being a certain percentage. One wonders whether it will ever change or whether this really matters.
I suppose when we have true flat panel digitally addressed displays, we might have 0% overscan.
At the Japan Electronics Show all the signs are pointed toward flat panel displays so maybe I will not have to hold your breath for much longer.
Physically, as with an LCD display on a laptop computer, there will be 0% overscan (no need to build the extra pixels) but that doesn't mean that all 480 lines will be visible.

What is Aquadag?

You may see the term 'Aquadag' referring the the black paint covering the outside of most of the funnel section of the CRT.

(From: Nicholas Bodley (nbodley@tiac.net).)
Aquadag used to be a trademark of Acheson Colloids [Corp.?], I think around Niagara Falls or Buffalo, NY. It was one of many "-dag" colloidal graphites; they also made Oildag, Gredag (grease), and Alcoholdag, as I recall. Unfortunately, it's probably sold in 55-gallon drums minimum. I hope you can find smaller quantities. Are there any CRT rebuild shops around the USA? See the Thomas Catalog (ThomCat) in a library to find Acheson.
I am pretty sure there's nothing magic about the graphite. If you can find some reasonably-priced nickel-flake or copper-flake paint (be sure it's conductive!), you might have an affordable (?) coating. How about plain metal foil, maybe even ordinary aluminum foil? You surely don't need current-carrying capacity; you would need a decent adhesive, though. How to make sure you have continuity between pieces, I'm not so sure; shoot for really tight crimps that deform the metal and are gas-tight. (This might, however, be quite unnecessary.)

Why are Indirectly Heated Cathodes Used in CRTs

Here are three reasons:

1. The cathode can be made of and/or coated with a material optimal for emitting electrons without regard to its performance as a heater.

2. The separate cathode and filament can be electrically isolated so that the filament voltage and cathode drive signal, if any, do not interfere.

3. The cathode can have an optimal shape for the application. This would be particularly significant for CRTs. The spot on the screen is a reduced focused image of the effective shape of the emitting portion of the cathode.

Frequency Response of CRTs

(From: Jeroen Stessen (Jeroen.Stessen@philips.com).)
The impedance of a gun is fairly high, with 50 to 100 V p-p swing and 1 to 5 mA p-p beam current it is in the order of 10 to 100 K Ohm. Consequently, series inductance plays no important role but parallel capacitance does! In fact, the video amplifiers supply more parasitic capacitive current than beam current!
For a TV tube the total parasitic capacitance (CRT + socket + PCB + amplifier output devices) is at least 10 pF. Assuming a beam current of 5 mA p-p at 100 V p-p swing then above 800 kHz there will be more peak-peak capacitive current than beam current !
The pull-up resistor in the typical class-A video amplifier also consumes current, about 12 mA p-p for an 8.2 K Ohm resistor. Together with the beam current this shifts the dominant pole up to 2.7 MHz. Obviously there is a dominant pole well within the range of interest, even for TV.
Better tubes may or may not have lower C but it is not very important. The dominant pole is first shifted to a higher frequency by using lower-value pull-up resistors in the video amplifier. Of course this will increase dissipation losses.
Then the dominant pole is compensated by a zero in the emitter circuit of the output transistor. There may be other compensation networks too, often with inductors. This is what allows a better monitor chassis to achieve a higher bandwidth.
Frequency compensation alone is not enough. Without a sufficiently low value for the pull-up resistor the NPN transistor will simply switch off during a rising edge and the edge will be limited by the R*C of the dominant pole alone. The compensation network is effectively decoupled from the output by the switched-off transistor. Remember that, boys and girls!
Of course, class-B designs with active pull-up will improve much. But good wide-band high-voltage PNP transistors are still a bit hard to get.

Of course, spot size (sharpness of focus) is critical to allow a better CRT to achieve a sharper picture! A better monitor needs both a better CRT (sharper beam) and better video amplifiers (higher bandwidth).

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CRT Service Information

How to Read CRT Part Numbers

More than you ever wanted to know (but still not that useful)!
(From: Jeff Roberts (jroberts@axionet.com).)
The following information comes from the Sencore CR7000 Manual
The tube number is broken down in to 5 parts:

Example: M / 36 / KME / 20 / XX

Part 1: Tube Type:

A or W = TV picture tube.
M = Monitor tubes (differ in the size and pitch of the phosphor dots).
P = Projection tube.
D = Electrostatic deflection.

Part 2: Minimum viewable diagonal. Measurement is in cm. (1 inch = 2.54 cm).
Part 3: Family Number - Tubes Within a particular family have specific mechanical and electrical characteristics.

These letters are assigned alphabetically beginning with "AAA", followed by "AAB", "AAC", etc.
Tubes with the same sequence of letters are identical as far as their setup for the Sencore CR7000.
The letter sequences are grouped according to the country they are manufactured in.

Part 4: Member of Family - This one or two digit number specifies a particular member within a family.

A different number is assigned to tubes within the same family that have different neck diameters, for example. Single digit member #s = monochrome, double digit members = Color tubes.

Part 5: Phosphor Type.

Typical Color CRT Pinout

It is usually possible - with a little effort - to determine the pinout of a CRT from the markings and circuit configuration on the CRT neck board and by visually following the base lead wires inside the neck of the tube.
Here is one pinout common in color TVs. Note that this tube socket includes integral spark gaps and pin 12 doesn't actually go into the CRT.

Pin 1: Focus
Pin 2: NC
Pin 3: NC
Pin 4: NC
Pin 5: G1
Pin 6: Green Cathode
Pin 7: G2
Pin 8: Red Cathode
Pin 9: Filament

Pin 10: Filament
Pin 11: Blue Cathode
Pin 12: Sparkgap Ground

Here is another without sparkgaps in the socket:

Pin 1: Focus
Pin 2: NC
Pin 3: Blue Cathode
Pin 4: Filament
Pin 5: Filament
Pin 6: G1
Pin 7: Red Cahtode
Pin 8: G2
Pin 9: Green Cathode

(There may actually be no pins present for those marked "NC" as well as a gap between the highest numbered pin and pin 1.)

CRT Substitution

> "I have an RCA TV model # f20700dg that has a bad crt #A51ABU14X what I would like to know is can I replace it with a #A51AGC14X."

(From: Tech 7 (gscivi@aol.com).)
Perhaps you need to know why the #'s are different?
The A is for the grade of the tube (AA is all new, B is rebuilt etc), the 51 is size in cm, the ABU is gun type, the 14 is # of elements used (pins), and the X is for phosphor type. Since the gun type is different in your two tubes, I would not spend the time to sub the tube without first check the voltages on the old one, get a schematic of set for new one, compare the parameters and then decide.

CRT Replacement Worth It?

The sad fact is that even if you can obtain a new CRT you won't have the proper set up for getting proper alignment and convergence. They generally use various permanent magnet glued to the perimeter of the yoke to set the geometry of the raster. It takes a special factory jig to do this step or really great persistence and patience. However, if you have the time and will resist punching a hole in the new CRT before you finish, by all means.
Also, consider the cost of a new CRT may be more than half the cost of the monitor when it was new.
Replacing a monochrome CRT is a snap in comparison.
A better (or at least less stressful) approach is to locate a monitor that died due to a circuit problem and salvage the CRT including the yoke and all the other magical magnets and coils.
(From: Andy Cuffe (baltimora@psu.edu).)
I have found that most 15" monitors use compatible CRTs. I just put the CRT from an old Gateway2000 with analog controls into a nice 2 year old monitor. As long as the yokes and CRT sockets are similar it should work fine. Don't try to swap the yokes or you will never get it converged.

Rebuilt CRTs

(From: B. K. Richardson (rchvid7@flash.net).)
Try Hawkeye. They have been giving us good service for at least 15 years. Their rebuilds are covered by warranty.

- Hawk-Eye Picture Tube Mfg., Inc.
  724 Scott Avenue, Des Moines, IA. 50309-5052

Phone: 515-288-8567
Fax: 515-288-8568

Suppliers of standard & high resolution color and monochrome picture tubes.

What Does It Take to be a Picture Tube Rebuilder, Really?

(From: Charles Godard (cgodard@iamerica.net).)

Back in the late 50's A Tech friend of mine built a picture tube rebuilding plant from scratch. He made a living with it for a few years selling rebuilt b&w tubes. Everybody around said he sold the best rebuilt tubes that you could get. He said the secret was in the good vacuum pump and that he used and the amount of time that he pumped down the tube.

He always said that a tube could be made to last practically forever if you could get a high enough vacuum on it. The only real money he put into his plant was in the pump.

A few years ago he retired and brought the whole thing down to my shop for storage. It was a marvel to behold. The cooker was an old upright deep freeze with a pyrex pie plate for a window. The lathe where he welded the tube necks onto the tube was built of scraps of angle iron with a washing machine motor. The device that he used to cut the necks off of the tube was a model railroad controller with a homemade foot pedal and a couple of whittled down broomsticks with metal tips shaped so that you could easily fold the nichrome wire around the tube neck. He said it was the only transformer he could find, at the time, that would hold up to heat the wire hot enough to cut the neck off of the tube. It was very low voltage but would supply hi current.

He said he had the most trouble when designing the inductance heater but finally got it built with the help of a local genius who had built one of our local TV station's nearly from scratch back in the 50's.

In addition to the tube plant, he also designed and got a patent on a cotton picker. I've got a copy of his patent on display in my shop. Some of us only half believed him for years, when he said he had the patent, but when he died, we searched the shop and found his patent papers hidden away in a file cabinet of old Sams Photofacts.

We found the contract where he sold the rights to build and market the picker for a $500 per picker royalty. The guy he sold it to took the patent and went to a nearby state, borrowed $200,000 from the bank with the Patent as collateral then skipped the country. My friend never got anything from his invention, and some of his design ideas were later stolen and incorporated into some one of the big name picker manufacture's products.

Those old guys were something else. They could start with a few old scraps and build something worthwhile and useful.

Speaking of patent's, I've also seen the original patent for the hinges RCA used to hold up the tops on the old console stereo's. I made a service call a few years ago, and the guy's widow showed me the patent and his original prototype hinges. The only thing is, they took the idea from the patent and redesigned it so they wouldn't have to pay our local guy for the hinges. RCA's redesign didn't work as well as his original, but was recognizable as his original with only a couple of changes. RCA 'did him' about the same way they 'did' Philo Farnsworth.

When I get a slack spell, I'll try the inductance heater to see if it still works. If it does, I try it on the tubes and let you know. I believe you called it a Tesla coil?

Shipping Damage: Why Monitors are Like Basketballs

(From: Stephen Swann (swann@panix.com).)

Monitors are more prone to shipping damage than most other computer components, and it doesn't help that they typically pass through several people's hands (several stages of shipping) before they get to you: factory -> distribution center -> vendor -> you.

And from what I've seen first hand of shipping practices (I put in a couple of months working in a distribution warehouse during college), you can safely assume that each stage of shipping is roughly the equivalent of your monitor being dropped down a flight of stairs.
You wouldn't *believe* the abuse that UPS and FedEx can subject packages to. In fact, putting a *FRAGILE* sign on the side of the box is about the equivalent of writing "KICK ME" on it. I remember receiving packages marked "FRAGILE" where the (originally cubical) cardboard boxes had been smashed into shapeless cardboard "bags", and it took us 20 minutes to figure out what the contents of the box had originally been. ("What are all these shards?" "I think it was some kind of vase" "No, it was some kind of lamp." "Where's the bulb socket, then?" "How about this squashed piece of aluminum?" "Yeah, you're right, but where's the cord then?" etc). :-) Shipping guys would think nothing of dropping "fragile" boxes from waist-high onto a concrete floor - safe in the knowledge that the package had passed through so many hands that the damage could never possibly be traced back to them. "Blameless is Guiltless" should be the motto of these folks.
Basically, what I'm saying is that if 1 monitor in 3 arrives arrives in workable condition, you should be surprised that even that one monitor survived.

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