BY SAM GOLDWASSER
SERVICE EDITOR

Monitor High-Voltage Problems

IN ADDITION TO THE OBVIOUS "MONITOR SCREEN IS AS BLACK AS A COAL MINE" SYMPTOM, PROBLEMS IN THE HIGH-VOLTAGE POWER SUPPLY CAN RESULT IN A VARIETY OF BRIGHTNESS, RASTER GEOMETRY, AND OTHER PICTURE PROBLEMS AS WELL AS arcing corona, or other sights, sounds, and smells not normally associated with a properly functioning monitor. This month we will deal with some of these symptoms. Other video-related problems will be dealt with next time.

HV Power-Supply Fundamentals

Most monitors derive the high voltage for the CRT second anode (THE high voltage—called EHV by some), focus, and (sometimes) screen (G2) from the horizontal-deflection system (see Fig. 1). That technique was developed quite early in the history of commercial TV and has stuck for a very simple reason—it is very cost effective. A side effect is that if the horizontal deflection fails and threatens to burn a vertical line into the CRT phosphors, the high voltage dies as well. Of course, if the vertical deflection dies....

Some auto-scan monitors use a separate high-voltage supply. One reason for that approach is to decouple the horizontal deflection from the HV in auto-scan monitors, thus simplifying the design.

Usually that supply is a self-contained inverter module. It if can be opened, then repair may be possible. With a separate HV supply, there is no need for a HV flyback transformer on the mainboard. Some designs may use a separate HV supply including a flyback, which is part of the mainboard but is self contained and independent of the horizontal-deflection system.

Most TV and monitor (flyback) high-voltage supplies operate as follows:

1. The horizontal-output transistor (HOT) turns on during scan. The current increases linearly in the primary of the flyback transformer since it appears as an inductor. The magnetic field also increases linearly. Note: the flyback is constructed with an air gap in the core, which makes it behave more like an inductor than transformer as far as the primary drive is concerned.

2. The HOT shuts off at the end of the scan. The current decreases rapidly. The magnetic field collapses, inductively coupling to the secondary and generating a HV pulse. The inductance and capacitance of the flyback, snubber capacitors, and parasitic capacitance of circuitry and yoke form a resonant circuit. Ideally, the voltage waveform across the HOT during the flyback (retrace) period will be a single half cycle, and it is clamped by a damper diode across the HOT to prevent undershoot.

3. The secondary of the flyback is either a single large HV winding with HV rectifiers built in (most often) or an intermediate voltage winding and a voltage multiplier (see the section: "What is a tripler?" that follows). The output will be DC HV pulses.

4. The capacitance of the CRT envelope provides the needed filtering to adequately smooth the HV pulses into a DC voltage. Sometimes there is a separate HV capacitor as well.

5. A high-resistance voltage divider provides the several kV focus voltage and sometimes the several-hundred volt

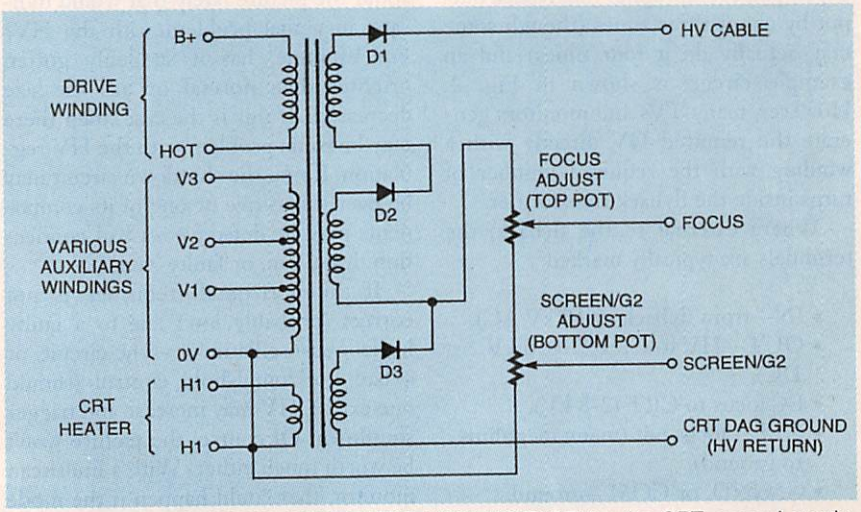

FIG. 1—MOST MONITORS DERIVE THE HIGH VOLTAGE for the CRT second anode, focus, and (sometimes) screen from the horizontal-deflection system.

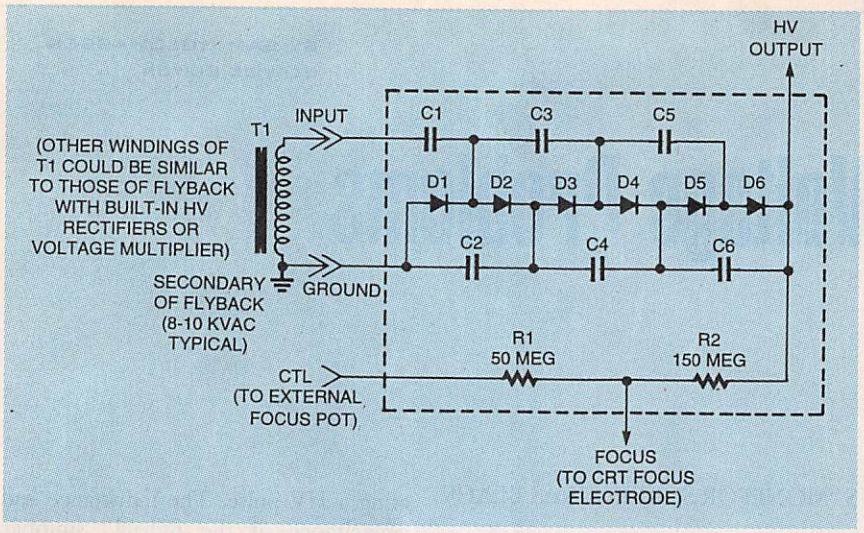

FIG. 2—THE FLYBACK TRANSFORMER only generates about 6-10 kV AC, which is then boosted by a capacitor-diode ladder (called a tripler) to the 18-30 kV needed for modern color CRTs.

screen (G2) voltage as well. Often, the adjustments for these voltages are built into the flyback. The focus and screen are generally the top and bottom knobs, respectively. Sometimes they are mounted separately. This or a similar divider may also provide feedback to control high-voltage regulation.

The operation of the deflection system was discussed in great detail in a pair of previous "Service Clinic" articles.

What Is A Tripler?

In some TVs and monitors, the flyback transformer only generates about 6-10 kV AC, which is then boosted by a capacitor-diode ladder to the 18-30 kV needed for modern color CRTs. The unit that does this is commonly called a tripler since it multiplies the flyback output by about three times (though some may actually do it four times) and an example circuit is shown in Fig. 2. However, many TVs and monitors generate the required HV directly with a winding with the required number of turns inside the flyback transformer.

Where external to the flyback, the terminals are typically marked:

- IN—from flyback (6-10 kV AC).
- OUT—HV to CRT (20-30 kV DC).
- F—focus to CRT (2-8 kV).
- CTL—focus pot (many megohms to ground).
- G, GND, or COM—ground.

Symptoms of tripler failure are: lack of high voltage or insufficient high voltage, arcing at focus-protection spark gap, incorrect focus voltage, other arcing, overload of HOT and/or flyback, or focus adjustment affecting brightness (screen) setting or vice-versa.

High-Voltage Shutdown

A monitor that runs for a while or starts to come on but then shuts down may have a problem with the X-ray protection circuitry correctly or incorrectly determining that the high voltage (HV) is too great (risking excessive X-ray emission) and shutting everything down.

A side effect of activation of this circuitry is that resetting may require pulling the plug or turning off the real (hard) power switch.

Was there anything else unusual about the picture lately that would indicate an actual problem with the HV? For example, has it suddenly gotten brighter than normal or has the size decreased? If this is the case, then there may be some problem with the HV regulation. If not, the shutdown circuit may be overly sensitive or one of its components may be defective—a bad connection, leaky cap, or faulty Zener.

If the horizontal frequency is not correct (probably low) due to a faulty horizontal-oscillator or -sync circuit, or a bad horizontal-hold control (should one exist!), HV may increase and trigger shutdown. Of course, the picture won't be worth much either! With a multiscan monitor, that could happen if the mode switching is faulty resulting in incorrect component settings for a given scan rate. A symptom might be HV shutdown when switching scan ranges.

The HV shutdown circuit usually monitors a winding off of the flyback for a voltage that exceeds some reference and then sets a flip flop shutting the horizontal drive off. On some Sony models, a HV-resistive divider performs that function and these do fail—quite often. The red block called the "HSTAT module" or just that "big red capacitor thing" is a common cause of immediate or delayed shutdown on certain Sony monitors and TVs.

Low or No High Voltage

Most of these problems are due to faults in the horizontal deflection system—shorted HOT, shorted windings or HV rectifiers in the flyback, defective tripler, or other bad parts on the primary side of the flyback. In addition, with auto-scan monitors, the incorrect voltage or other component could be selected due to a logic fault or a problem with the selection relay or other circuitry.

However, if you discover an inch-deep layer of filth inside the monitor, the HV could simply be shorting out—clean it first.

In most cases, these sorts of faults will put an excessive load on the horizontal-output circuits so there may be excessive heating of the HOT or other components. You may hear an audible arcing or sizzling sound from internal shorts in the flyback or tripler. Either of those might get hot, crack, bulge, or exhibit visible damage if left on with the fault present.

Many modern monitors do not regulate HV directly but rather set it via control of the low-voltage power supply to the HOT (B+) via snubber capacitors across the HOT and the turns ratio of the flyback. The HV is directly related to the B+ so if that is low, the HV will be low as well. Faulty snubber capacitors will generally do the opposite—increase the HV and the X-ray protection circuits may kick in. However, low HV is also a possibility. The only way the turns ratio of the flyback can change is from a short, which will manifest its presence in other ways as well—excessive heating and load on the horizontal-output circuits.

While a shorted second anode connection to the CRT is theoretically possible, this is quite unlikely (except, as noted, due to dirt).

Excessive High Voltage

Any significant increase in HV

should cause the X-ray protection circuits to kick in and either shut down the set or modify the deflection in such a way as to render it harmless. Symptoms include arcing/sparking of HV, smaller than normal picture, and under certain scenarios, possible excessive brightness.

The causes of the HV being too high are:

1. Excess B+ voltage to the HOT. The likely cause is a low-voltage regulator failure.

2. Open snubber capacitors across the HOT. These are under a lot of stress and are located near hot components so failure is possible.

3. Incorrect excessively long scan drive to the HOT caused by failure of the horizontal-oscillator/-sync circuits. However, other things like the HOT will probably blow up first. The picture will definitely be messed up. This is more likely with auto-scan monitors than TVs since what is too long for one scan range may be correct for another and the selection circuitry is confused or broken.

4. The failure of the HV regulator. Actual HV regulators are uncommon today but the HV may be controlled by a feedback voltage from a divider (focus or screen, or its own), or a secondary winding on the flyback is used to set the B+ or drive timing. That could result in a picture that is underscanned (smaller than normal) and likely excessively bright as well.

Snaps, Crackles, and Other HV Breakdowns

Various problems can result in occasional or sustained sparking or arcing sounds from inside the monitor. Note that a static-electricity buildup is common on the front of the screen. It is harmless and there is nothing you can do about it anyhow.

The following sections deal with problems that could result in occasional or sustained sounds that are not commonly associated with a properly working TV or monitor. There may or may not be flashes or blanking of the screen at the same time as the audible noise.

Arcing, Sparking, or Corona From CRT HV Anode

The CRT HV anode usually appears as a red wire/suction cup. Symptoms could include a sizzling corona or more likely, an occasional or rapid series of sharp snaps—possibly quite loud and quite visible—from the anode cap on the CRT to the grounded coating on the outside of the CRT or a chassis ground point (or any other conductor nearby). Corona is a high resistance leakage through the air without total breakdown. The snapping is caused by the sudden and nearly complete discharge of the CRT anode capacitance through a low resistance ionized path similar to lightning. There are two likely causes for this:

1. Dirt, dust, and grime around and under the suction cup on the CRT are providing a discharge path. This may be more severe in humid weather. Safely discharge the HV and then remove and thoroughly clean the HV suction cup and the area under it and on the CRT for several inches around the HV connection. Make sure there are no loose wires or other possible places for the HV to discharge to in the vicinity.

2. The high voltage has gone through the roof. Usually, the X-ray protection circuitry should kick in, but it can fail. If cleaning does not help, this is a likely possibility. See the "High Voltage Shutdown" and "Excessive High Voltage" sections earlier in this column for more.

Arcing at CRT Spark Gaps or Gas-Discharge Tubes

Spark gaps (see Fig. 3) and gas-discharge tubes are protective devices intended to break down and divert excessive voltage away from the CRT (usually). Arcing there is rarely due to a defective spark gap or gas discharge tube but rather is a safety mechanism like a fuse designed to protect the internal electrodes of the CRT if the focus or screen voltage should become excessive. The spark gap breaks down first and prevents internal arcing in the CRT.

Arcing at a spark gap or a glowing or a flashing discharge tube may be accompanied by total loss of picture or bad focus or brightness, focus fluctuations, or any of a number of similar symptoms. A common cause is a breakdown inside the focus divider (usually part of the flyback or tripler) but could also be due to excessive uncontrolled high voltage due to a failure of the B+ regulator or HOT snubber capacitor, or (ironically) even a short inside the CRT.

Spark gaps may be actual two- or three-pin devices with seemingly no insides and could be part of the CRT socket or printed on the circuit board

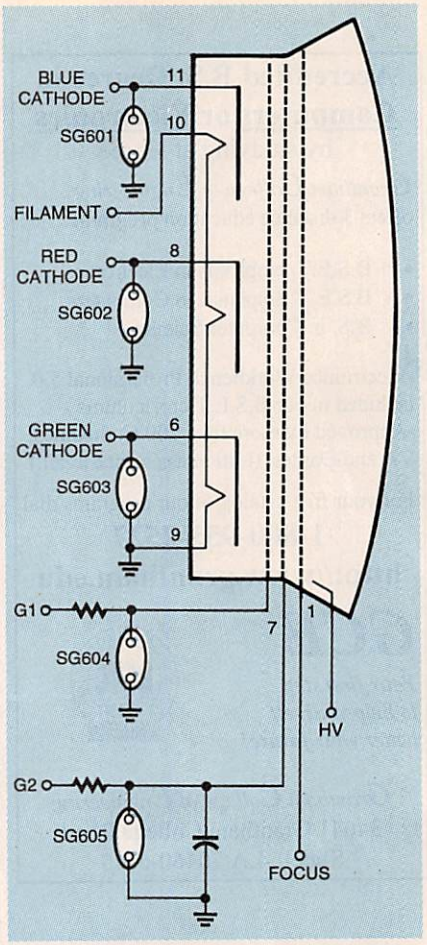

FIG. 3—SPARK GAPS are protective devices intended to break down and divert excessive voltage away from the CRT. If you see arcing within one, don't replace it—find out why.

itself. Gas discharge tubes look like small neon lamps (*e.g.*, NE2) but could be filled with some other gas mixture to provide a controlled higher breakdown voltage. Since these are protective devices, like a fuse, don't just replace or disable them—locate and correct the underlying problem. The CRT makes an expensive fuse!

Arcing From Flyback or Vicinity

Arcing may be visible or audible and result in readily detectable levels of ozone. Note that very slight traces of ozone may not indicate anything significant, but if the TV smells like an office copier, there is probably some discharge taking place.

WARNING: It is possible for arcing to develop as a result of excessive high voltage. Symptoms might be a smaller than normal, excessively bright picture, but this may not be able to be confirmed until the flyback is repaired or replaced.

See the section: "Excessive High Voltage." Here's some of what you are likely to see or hear:

• On the HV output, it will probably be a loud snapping sound (due to the capacitance of the CRT) with associated blue/white sparks up to an inch or more in length. If the arc length is short enough, this may turn into a nearly continuous sizzling sound with yellow/orange arc and melting/burning plastic.

• Prior to the HV rectifier, it will likely be a continuous sizzle with orange/yellow/white arc and melting/burning plastic or circuit board material.

• Internal arcing in the flyback may be audible and eventually result in a bulging and/or cracked case (if some other component doesn't fail first as this would take some time to develop).

• A corona discharge without actual sparks or a visible well defined arc is also possible. This may be visible in a totally dark room, possibly more likely when the humidity is high. A thorough cleaning to remove all dust and grime may be all that is needed in this case.

• If the arc is coming from a specific point on the flyback—a crack or pinhole—this may be patched well enough to confirm that the rest of the monitor is operational and a new flyback is worth the money. Otherwise, there is no way of knowing if the arcing may have damaged other circuitry until a replacement flyback—possibly money wasted—arrives.

To attempt a repair when arcing is present, scrape off any dirt or carbon that is along the path of the arcing and its vicinity. Then clean the area thoroughly with alcohol and dry completely. Otherwise, the dirt and carbon will just act as a good conductor and the arcing will continue under your repair! Several layers of plastic electrical tape might be adequate for testing. Multiple coats of high-voltage sealer or *non-corroding* RTV silicone (if it smells like vinegar—acetic acid—as it cures, it could get in and affect the windings so don't use it) would be better if the objective is an actual repair. A thick layer of Epoxy may be even better and affected less by possible HV corona. Either of those might prove to be a permanent fix, although starting a search for a source for a new flyback would not hurt just in case. The arc most likely did damage the insulation internally, which may or may not be a problem in the future. Some more notes:

• In some cases, the pinhole or crack is an indication of a more serious problem—overheating due to shorted windings in the flyback or excessive secondary load.

• If the arc is from one of the spark gaps around the CRT or the CRT socket, this could also be a flyback problem indicating internal shorts in the focus/screen network.

• If the arcing is inside the CRT, this could indicate a bad CRT or a problem with the flyback focus/screen network and no or inadequate spark gap protection.

Where repair seems possible, first, clean the areas around the arc thoroughly and then try several layers of plastic electrical tape. If the monitor or TV works normally for say, an hour, then there is probably nothing else wrong and you can try for a proper sealing job or hope that tape holds out (put a few more layers on—each is good for about 8-10 kV theoretically).

However, replacement is really the best long-term solution both for reliability as well as fire risk.

The CRT Return

The Aquadag coating on the outside of the CRT is the negative plate of the HV filter capacitor. If this is not solidly connected to the HV return, you will have your 25 kV+ trying to go where it should not be. There should be a wire solidly attached to the CRT neck board or chassis. Without this, voltage will build up until it is able to take some other path—possibly resulting in damage to sensitive solid-state components in the process. Therefore, it is important to rectify the situation.

Warning: If you find the CRT return disconnected, don't just attach it anywhere. You may instantly kill ICs or other solid state components. It must be connected to the proper return point on the CRT neck board or chassis.

Flashovers Inside The CRT

Due to sharp edges on the electron-gun electrodes, impurities, and other manufacturing defects, there can be occasional arcing internal to the CRT. Properly designed HV, deflection, and power-supply circuits can deal with these without failing, but not all monitors are designed well.

If your HV is not excessive, there is nothing you can do about flashovers. If these persist and/or become more frequent, a new CRT or new monitor will be needed.

Ozone Smell and/or Smoke From Monitor

Smoking is just as bad for monitors as for people, and usually more quickly terminal (no pun intended). White acrid smoke may indicate a failed electrolytic capacitor in the power supply, probably in conjunction with a shorted rectifier. Needless to say, pull the plug at once.

A visual inspection should be able to easily confirm the bad capacitor as it will probably be bulging and have condensed residue nearby. Check the rectifier diodes or bridge rectifier with an ohmmeter. Resistance across any pair of leads should be more than a few ohms in at least one direction. Remove the suspect device from the circuit to confirm. Both the faulty diode(s) and capacitor should be replaced (though the capacitor may work well enough to test with new diode(s).

If a visual inspection fails to identify

the smoking part, you can probably plug the monitor in for a few seconds until the source of the smoke is obvious but be prepared to pull the plug in a real hurry. If the smell/smoke is coming from the flyback, then it has probably gone belly up. You may be able to see a crack or bulge in the case. While the flyback will definitely need to be replaced, it is likely that nothing else is wrong. However, it might be prudent to use a Variac when performing initial testing with the replacement just in case there is a secondary short circuit or excess HV problem.

X-ray and Other EM Emissions

X-ray radiation is produced when a high-velocity electron beam strikes a target containing heavy metals. In a modern monitor, that can only take place at the shadow mask/aperture grille and phosphor screen of the CRT. Really old TVs (prior to around 1975) may still have HV rectifier and regulator tubes—other sources of X-rays. However, modern TVs and monitors implement these functions with solid-state components.

For X-rays, the amount of radiation (if any) will be proportional to brightness. The energy (determined by the CRT high voltage, called kVP in the medical-imaging field) is not affected. This is one reason many monitors and TVs are designed with brightness-limiting circuits.

In any case, there will be virtually no X-ray emissions from the front of the CRT as the glass is greater than an inch thick and probably contains some lead for added shielding, but there may be some emission from the thinner sides. At 25-30 kV (quite low as X-ray energies go) X-rays will be stopped by almost any metal so what you have to worry about is where there are no shields.

However, realistically, there is very little danger. I would not worry about exposure unless you plan to be sitting for hours on the sides, behind, or under the TV or monitor—with a picture (there will be none if the screen is black).

It is interesting that even those 1.5-inch Watchman and 0.5-inch camcorder viewfinder CRTs have X-ray warning labels even though the high voltage used with these isn't anywhere near high enough to be of any concern!

Electromagnetic radiation (EM) is produced mostly from the deflection yoke and to a lesser extent from some of the other magnetic components like transformers and inductors. Depending on monitor design (some are specifically designed to reduce this), EM emissions can vary quite a bit. Frequencies range from the 60 Hz of the power line or vertical scan rate to several hundred kHz in the AM-broadcast band. The intensity and spectral distribution will vary depending on horizontal and vertical scan rate.

As mentioned a second ago, a totally black screen will reduce X-ray emission to zero. It will not affect EM emissions significantly as most of this comes from the magnetic parts, particularly the deflection yoke.

There is no measurable microwave, IR, or UV radiation.

I refuse to get into the discussion of what, if any, health problems result from low level EM emissions. There is simply not enough data.

Wet Flyback

You put your can of Coke where???? Needless to say, if a liquid gets into the back of a TV or monitor, unplug it immediately. Inspect around the target area for obviously blown or damaged components. Test fuses and fusable resistors. Remove all traces of liquid—especially sugary or corrosive liquid. Use water first and then alcohol to promote drying. Repair burnt solder connections and circuit board traces. Once the monitor is entirely dried out, power it up—preferably through a series light bulb and/or Variac until you are sure nothing else will let loose. Look, listen, and smell for any unusual behavior. If it now works, then consider yourself lucky. If not, there may be damage to transistors, ICs, or other components.

Another source of liquid-related damage is using spray cleaner or a too wet rag on the front of the CRT (or other parts of the monitor, for that matter). Any liquid that drips inside (all too likely) may short out circuitry on the mainboard with very expensive consequences.

Erratic Focus or Screen Voltage

Symptoms here could include fluctuating focus or brightness. In extreme cases, the result may be a too bright or dark picture or other behavior caused by breakdown in the focus/screen(G2) divider network.

Usually, this problem will require flyback replacement to repair reliably. Sometimes, the section with the controls can be snapped apart and cleaned, but this is not common.

First, just try rotating the screen (G2) control back and forth a few times. This may clean up the contacts and eliminate the erratic behavior. Possibly, positioning it a bit to one side of the original location will help. Then, use the individual or other master background/bias adjustments to compensate for the improper brightness.

If pressing in on the erratic control helps to stabilize the setting, you might try adjusting it to the optimal position and then put a dab of hot-melt glue (or Superglue if you can manage not to stick your fingers together) on the shaft to hold it with a little more contact force.

If none of this helps, here's a "well it's going in the dumpster anyhow" procedure to try:

After discharging the CRT (so you don't get zapped) drill a tiny hole in the plastic cover near the bad control. Be careful you don't damage anything inside—you just want access to the contacts of the controls. Use a hand drill with, say, a 1/16-inch bit. Don't drill more than about 1/8-inch deep, which should enter the airspace. Then spray some contact cleaner through the hole and work the controls. Wait sufficient time (say, 24 hours) for everything to dry COMPLETELY and see if behavior changes (or if it works at all).

Again, this is a "you have got to be kidding" type of repair so no guarantees, and only use this as an absolute last resort before disposal. If by some miracle it does work, fill the hole with a drop of RTV or just put a couple of layers of electrical tape over it.

Wrap Up

That's it for now. Next time we will continue our discussion of monitor troubleshooting and repair. Until then, check out my Web site, www.repairfaq.org. I welcome comments (via e-mail only please at sam@stdavids.picker.com) of all types and will reply promptly to requests for information. See you next time! EN