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SERVICE EDITOR

# Testing Flyback Transformers

WHEN PROBLEMS DEVELOP IN THE HORIZONTAL DEFLECTION/HIGH VOLTAGE SUBSYSTEMS OF TVs OR MONITORS (OR EVEN MODERN OSCILLOSCOPES AND OTHER CRT DISPLAYS), THE FLYBACK TRANSFORMER (OR LINE-OUTPUT TRANSformer for those on the other side of the pond) is often a suspected cause. That is due in part to the fact that the flyback is usually the most expensive and hard-to-find replacement part in the unit and because flybacks are often less well understood than other more common components.

This month, we will look at the flyback in detail. We'll deal with what it is, how it fails, how to test it, and what to do if it is indeed defective. But first, a...

**Warning:** Read, understand, and follow the safety recommendations published in previous "Service Clinic" articles or at my Web site (www.repairfaq.org) before attempting any troubleshooting of a monitor or TV! If you don't know what you are doing, or are careless, both you and your set could suffer irreparable harm.

## What Is The Flyback?

The typical flyback or Line OutPut Transformer (LOPT) consists of two parts:

• A special transformer that, in conjunction with the horizontal-output transistor/deflection circuits, boosts the B+ of the low-voltage power supply to the 20 to 30 kV for the CRT and provides various secondary lower voltages for other circuits.

• A voltage divider that provides the focus and screen supplies. The focus and screen are generally the top and bottom knobs, respectively.

## Why is the Deflection and High Voltage Combined?

One of the main reasons that TVs and many monitors are designed with horizontal-deflection driven flybacks is simply economics—it provides a cheap way to get the high voltage and many or most of the other voltages for the set with minimal hardware. (High quality computer monitors sometimes use a separate high-voltage supply.) The use of the horizontal frequency rather than the AC-line frequency of 50 or 60 Hz allows the power-supply components to be small and light compared to a line-operated power transformer and filter capacitors.

## Flyback Construction

While details can vary somewhat, all flybacks consist of a set of windings on a gapped ferrite core. High-voltage diodes and resistive dividers (often with adjustment pots) for focus and screen (G2) may also be present.

A typical flyback includes the following components:

• Drive winding—for a typical TV or monitor, this may be 100 or so turns of medium gauge (e.g., AWG 26) wire. This is what is connected in series with the B+ to the horizontal output transistor in a TV or monitor.

• High voltage winding—several thousand turns. This winding may be split into several series sections with a high-voltage rectifier for each, or it could be a single winding. An alternative is to provide a lower-voltage winding and use a voltage multiplier (diode-capacitor ladder) to boost that to what is required by the CRT. Very fine wire (e.g., AWG 40) will be used for the high-voltage winding. The high-voltage lead to the CRT is fed from the highest voltage output of the rectifier or multiplier. (Sometimes the multiplier is external.)

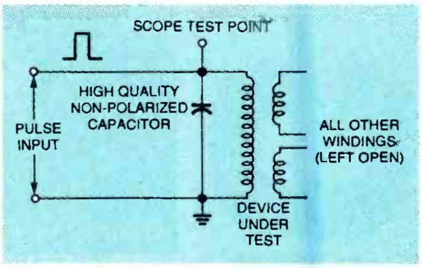


FIG. 1—IF YOU HAVE A SCOPE, a ring test using this set up is the easiest way to test a flyback.

• Resistive divider network for focus and screen (G2)—this will probably be fed from only one of the series connected windings (if used). Often, there are adjustments for focus and screen right on the flyback.

• Auxiliary windings—anywhere from a couple of turns (for the CRT filament) to several hundred turns (for a boost source). Those supply various voltages for the typical TV or monitor: CRT filament, logic power, analog power, boost source (where the flyback does not include its own screen supply), etc.

• Ferrite core—this consists of two C shaped pieces clamped together with either a spring arrangement or studs and nuts. There will be a gap of a fraction of a millimeter provided by a set of spacers between the two C sections.

Most modern flybacks have all the windings on the same leg of the core. The drive winding and auxiliary wind-

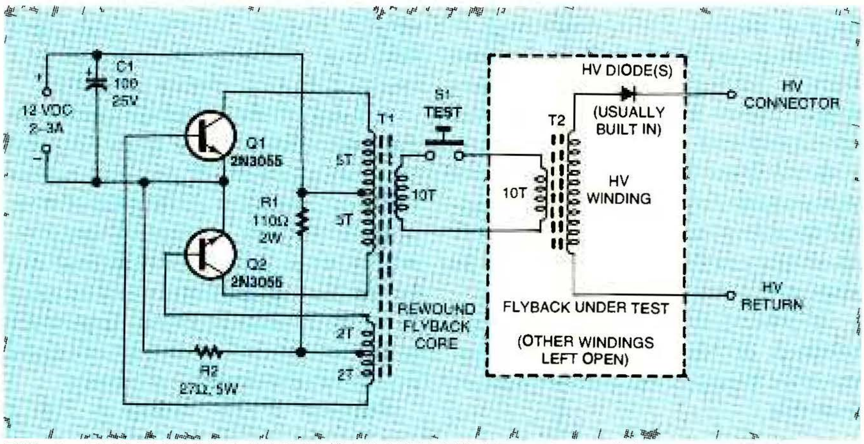


**FIG. 2**—THE CHOPPER-BASED FLYBACK TESTER excites a flyback in much the same way as would occur in normal operation.

ings will be wound and separately insulated under the high-voltage winding. The high-voltage winding will consist of many layers that have insulating material (i.e., Mylar) between them.

The other components will be mounted in a separate part of the assembly and the entire unit is then potted in an Epoxy-type filler. Part of the core is generally accessible—often one entire leg.

A flyback is not an ordinary transformer. The ferrite core contains a gap. Energy is stored in the magnetic field of the core during scan as the current is ramping up. This was discussed when we dealt with deflection systems in previous Service Clinic articles on deflection systems.

CAUTION: The gap is critical to the proper operation and is usually determined by some plastic spacers. Mark each one and replace them in exactly the same position if you disassemble the core for any reason.

## Why Do Flyback Transformers Fail?

While flyback transformers can on occasion be blown due to a failure elsewhere in the TV or monitor's power supply or deflection circuits, in most cases, they simply expire on their own. Why?

Flybacks are wound with many layers of really, really fine wire with really, really thin insulation. This entire assembly is potted with an Epoxy resin that is poured in and allowed to cure.

In some ways, these are just short circuits waiting to happen. Flybacks get hot during use, and this leads to deterioration of the insulation. Any imperfections, nicks, or scratches in the insulation, or trapped air bubbles and impurities in the Epoxy fill material contribute to failure. Temperature cycles and manufacturing defects result in fine cracks in the Epoxy potting material reducing the insulation breakdown voltage, particularly in the area of the high-voltage windings, rectifiers, and focus/screen divider network. They also physically vibrate to some extent. A whole bunch of other factors are also no doubt important.

Once a breakdown—sparking or arcing—develops, it is usually terminal. Actually, it is amazing that flybacks last as long as they do with the stresses they are under.

## How Do Flyback Transformers Fail?

Flybacks fail in several ways:

1. Overheating leading to cracks in the plastic and external arcing. If there is no major damage to the windings, repair may be possible. However, arcing from the windings punctures their very thin insulation so that shorted windings may already have developed. Even if the windings are currently in good condition, long-term reliability of any such repairs is questionable.

Nonetheless, it doesn't hurt to try cleaning and coating with multiple layers of high voltage sealer, corona dope, or even plastic electrical tape (preferably as a temporary repair, though I have gotten away with leaving this in place permanently). If possible, moving the point to which the flyback is arcing further away (i.e., a piece of metal or another wire) would also help.

2. A cracked or otherwise damaged core will effect the flyback characteristics to the point where it may not work correctly. In some cases that could even blow the horizontal output transistor and other expensive parts, like the low-voltage regulator or switch-mode power supply. If the core can be reconstructed so that no gaps (other than the required ones where the two halves join) are present and clamped and/or glued in place, it should be possible to perform testing without undue risk of circuit damage but consider a replacement flyback as a long-term solution.

3. Internal shorts in the focus/screen divider network, if present. One sign of this may be arc-over of the focus or screen spark gaps on the PC board on the neck of the CRT.

4. Internal shorts in the windings.

5. Open windings.

More than one of these may apply in any given case. As noted, temporary repair at least is sometimes possible for failures 1 and 2. For failures 3 to 5, replacement is usually the only alternative.

## Initial Tests

**Warning:** Before proceeding, make sure you have the TV or monitor unplugged and confirm that the main filter capacitor(s) and CRT have been safely discharged!

For these first tests, you'll only be using your senses and perhaps a multimeter. First, perform a careful visual inspection with power off. Look for cracks, bulging or melted plastic, and discoloration, Look for bad solder connections at the pins of the flyback as well. If the TV or monitor can be powered safely, check for arcing or corona around the flyback and in its vicinity,

Next, perform ohmmeter tests for obvious short circuits between windings; look for greatly reduced winding resistances and open windings. Don't neglect to check between the CRT HV connector (suction cup) and the pins on the base; that should measure infinity.

For the low-voltage windings, service manuals may provide the expected DC resistance (*Sams' Photofact*, for example). Sometimes, that will change enough to be detected—if you have an ohmmeter with a low-enough scale as these are usually a fraction of an ohm. It is difficult or impossible to measure the DC resistance of the HV winding since the rectifiers are usually built in. The value is not published either.

Any measurements that are much less than the published values likely indicate a partially shorted winding. However, a difference of 10% might not be significant at all. Higher than normal readings might simply indicate that a design change was made.

Of course, any continuity between separate windings is definitely a fault.

Partially short-circuited windings (perhaps, just a couple of turns) and sometimes shorts in the focus/screen divider will drastically lower the Q and increase the load the flyback puts on its driving source with no outputs connected. Those types of failures, which are not detectable by simple ohmmeter tests or visual inspection, require the troubleshooting techniques described in the "Advanced Testing" section, a little later in this article.

It is also possible that various types of flyback faults can damage other circuitry (beyond taking out the horizontal-output transistor and its associated parts). Therefore, if shorts are detected in the flyback, it is worth testing some of the components in the vicinity, and *vice-versa.*

## The Process of Elimination

Before attempting the more advanced tests suggested below, there may be ways of being more certain that your flyback is the problem component. The following assumes that running the TV or monitor with the suspect flyback results in an excessive load on the low voltage (B+) power supply, blowing a fuse (or attempting to blow a fuse—excessively bright series light bulb). The B+ likely drops from its normal 65 VDC to 140 VDC or more (depending on the actual TV or monitor and mode) to some low value like 25 VDC when measured on the low-voltage power-supply side of the flyback-drive winding. (Measuring at the HOT can result in all sorts of weird readings due to the pulse nature of the waveform and is not recommended—especially when everything is working properly—since there you will be dealing with 1500 V pulses!)

• Disconnect all the secondary loads from the suspect flyback including the CRT. Connect only the drive (B+ and HOT). Power up the TV or monitor (preferably with a series light bulb or on a Variac). If the B+ now climbs to a more normal value, a problem with the HV (CRT short) or one of the secondary loads is indicated. Connect each of these up one a time (or test individual components) to localize the fault. The flyback is likely good.

• Remove the suspect flyback and connect just the HOT and B+ to the drive winding of a known good flyback for a similar size TV or similar type of monitor (as appropriate). It may be close enough to keep the drive circuitry happy. Power up the TV or monitor (preferably with a series light bulb or on a Variac). If the B+ now climbs to a more normal value, a problem with the original flyback is indicated. However, more thorough testing may be desirable to be absolutely certain.

If you do this regularly, keeping a selection of "flyback simulators"—just the drive windings and cores—might be desirable.

## Advanced Testing

When the basic tests are inconclusive, there are several ways of testing flybacks (assuming you do not actually have special test equipment for this purpose). Here are two possibilities. The first is easier if you have a scope, but the second is more fun.

**Method 1:** The following technique works for flybacks; chopper transformers; motors; mains transformers; deflection-yoke windings; VCR, video, and other magnetic heads; and other transformers, coils, or inductors. It is called a "ring test" and is the method often used by commercial flyback (or other coil/transformer) testers. The theory is that a faulty flyback will have shorted turns in one of the coils. In such a case, the Q of the transformer is greatly reduced. If excited by an impulse, a faulty transformer will resonate with a highly damped oscillation while a good one will decay gradually.

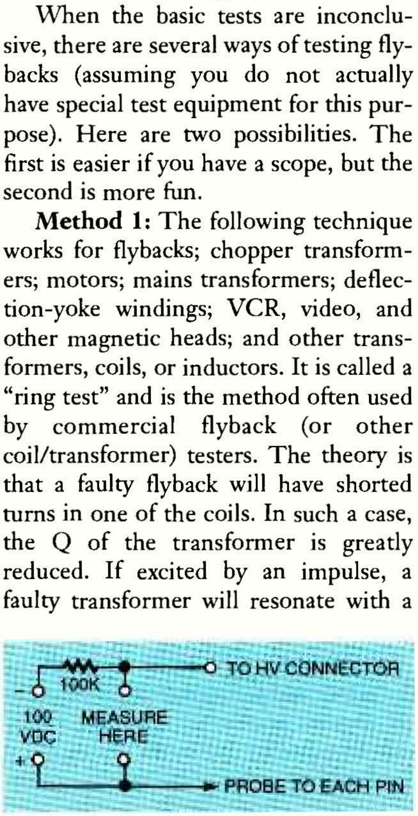


**FIG. 3**—IT IS IMPORTANT TO LOCATE the HV return. This circuit makes that easier to do.

• Connect a high quality capacitor across a larger winding (not the filament) of the suspect device; see Fig. 1. Hope for a resonant frequency of a few kHz. You may need to select the capacitor value for best results. I have found that a capacitor in the 0.001- to 1-µF (non-polarized) range will usually be satisfactory.

• Apply a pulse waveform to the parallel-resonant circuit. In 1960, most scopes had a "sync out" on the time base that provided a few tens of volts at enough current for this. If you don't have one of these, use a simple 555 astable circuit or function generator.

• Look at the waveform across the resonant circuit with a scope. A good unit will give a nicely decaying oscillation, of at least a few cycles, possibly tens of cycles. If there is a shorted turn **anywhere** in the device, the oscillations will be seriously damped, and you'd be lucky to see two complete cycles. Experience and/or comparison with a known good device will tell you what to expect.

**Method 2:** The circuit in Fig. 2 excites the flyback in much the same way as in normal operation; note that none of the component values in the circuit are particularly critical. The only caution is that this tester probably does not put enough stress on the flyback to find an intermittent that fails only under full operating conditions. However, most flyback failures are solid—once a short develops, there is a meltdown of sorts and it is there to stay.

You will need a 12 V power source of at least 2 or 3 amps capacity (regulation is not important—I just use a simple transformer, rectifier, filter capacitor type of power supply). If the circuit does not start oscillating at about 5 volts or less, interchange the two feedback connections to the transistor bases.

The tester is just a chopper feeding the salvaged core from an old flyback (I removed the inductance control spacers for this core). The drive (5T+5T) and feedback (2T+2T) coils can be wound from hookup wire (#14-#20) and well insulated with plastic electrical tape. Connect the center taps directly to the coils—do not bring out a loop of wire. Make sure all the turns of each coil are wound in the same direction. Wind the feedback coil directly on top of the drive coil. The secondary of this core is a 10-turn well-insulated coil similar to the other two wound on the opposite side of the ferrite core.

You will need to remove the suspect flyback from the TV or monitor. Another 10-turn coil is wound on the suspect flyback core anywhere it will fit. Connect one end of this coil to one end of the 10-turn coil on your old flyback core. Use a wire nut or twist together securely. Provide an easy way of connecting the other ends momentarily—a pushbutton comes in handy.

Make sure you locate the HV return lead on the flyback and use that as the return for the arc. Otherwise, you may

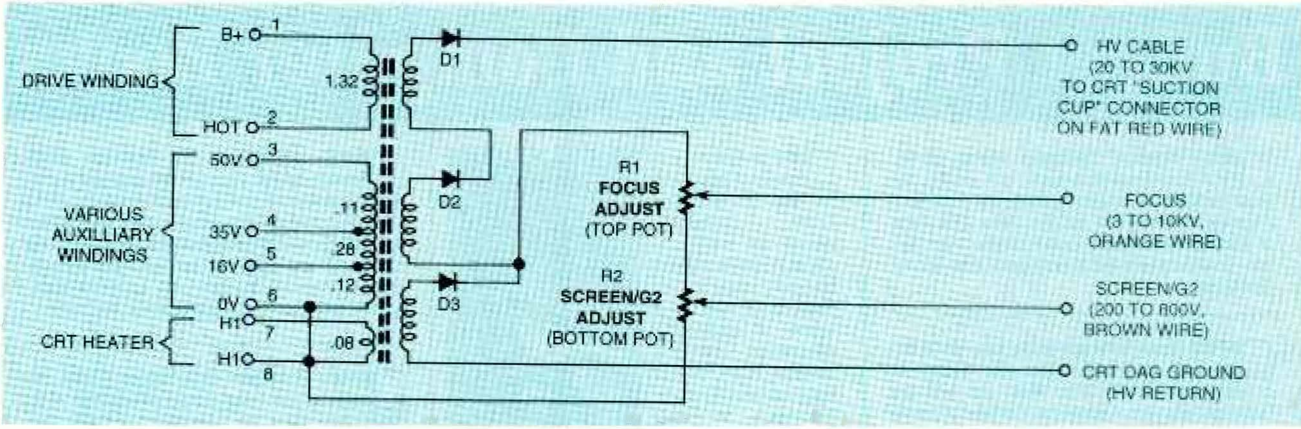


**FIG. 4—A SCHEMATIC DIAGRAM** of a typical flyback. Note the resistance values shown are illustrative and may differ widely from the ones on your unit.

puncture the insulation when the high voltage finds it own path to ground. There are several approaches that can be taken to identify the lead—possibly in combination:

- Process of elimination—the HV return will often be an isolated pin on the flyback not connected to anything else. Check with ohmmeter.
- Check all connections on the circuit board and identify those that go to ground. One of those flyback pins will be the HV return. It will do no harm to connect them all to ground during testing.
- Use a 100-VDC or greater power supply and a high-value resistor, say 100K in the set up shown in Fig. 3. Connect the power supply negative output through this resistor to the HV lead on the flyback (suction cup connector). Check each pin on the base of the flyback with the probe. Touching the return pin will result in the voltage reading dropping to perhaps 50 or 60 volts. This is the forward voltage drop across the high-voltage rectifier stack inside the flyback. All other pins will result in it remaining at the supply voltage.

Once the HV return is found, the circuit in Fig. 2 is wired, and everything is double checked, it is time to "turn on the juice."

- If the flyback is good, then with the coils connected there will be several kV at its output—enough to create a small arc (⅛-inch typical, up to ½-inch for color flybacks).
- The load imposed on the oscillator will be modest (the frequency increases in response to load). If there are any shorted windings, then there will be no significant HV output and the load on the oscillator will increase dramatically.
- If you get arcing or corona from **under** the flyback—at the pins—either you did not locate the correct HV return or there is a short inside resulting in HV arcing internally to the low voltage windings.

I have used this "tester" on a dozen or so flybacks. It has never been wrong (though I have opted not to believe it and gotten in trouble).

## Flyback-Testing Equipment

Sencore and others sell test equipment that includes the "ring test" or similar capabilities built in. For the professional, these are well worth the expense. However, a hobbyist could probably purchase lifetime TV replacements for the cost of one of these fancy gadgets.

Bob Parker has now designed an inexpensive, easy-to-use LOPT/Flyback Tester available through Dick Smith Electronics. Information is available at: www.nlc.net.au/~bobp/fbt.htm (Bob Parker's FBT Page). This (along with his ESR meter) have been highly recommended on the sci.electronics.repair newsgroup.

Other flyback testers are described at: www.usit.com/kephart/flyback.htm (Kephart's FBT Page) and www.vaag.es/produc/art/hr-stvdst-01/index_en.htm (VAAG FBT Page). Various electronics magazines have published construction articles for various types of simplified versions of these devices as well.

## Testing for Bad High-Voltage Diodes

A single diode failure would be tough to find if it is in series with other diodes (as is typical on larger flybacks) as it would only be a problem when run near full output. However, this sort of failure is unlikely.

General diode failure (shorts) would probably not be detected with the sorts of tests described above or with typical flyback-testing equipment. Actually, a simple ohmmeter test between the HV output and return might suffice! If this doesn't reveal anything, I suggest the following:

One possible way to test for this would be to attach a high-voltage capacitor between the HV output and return of the flyback. If the diodes are good, the tester's excitation should then charge this cap up (watch out—the voltage might get to be quite high!). While charging, this load will make the flyback fail any ring test. Once charged, it should pass. However, if the diodes are shorted, I would expect the flyback to test bad as the cap will continue to present an AC load on the output and never charge properly.

## Typical Flyback Schematic

The diagram in Fig. 4 shows a typical flyback that might be found in a direct-view color television or computer monitor. Resistances are included for illustrative purposes only and may be quite different on your flyback.

The high-voltage section on the right might actually be constructed as a voltage multiplier rather than a single winding with multiple HV diodes. The rectifiers or multiplier, and/or focus/screen divider might be external to the flyback transformer in some models.

Flyback transformers used in black-and-white TVs and monochrome computer monitors do not have a focus and screen divider network. Older ones do not include a high-voltage rectifier

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either—it is external.

As stated early in this article, the ferrite core of a flyback transformer is constructed with a precision gap usually formed by some plastic spacers or pieces of tape—don't lose them if you need to disassemble the core. The ferrite core is also relatively fragile, so take care.

The focus and screen divider network uses potentiometers and resistors (not shown) with values in the tens to hundreds of megohms, so they may not register at all on your multimeter. The high voltage rectifiers (D1 to D3 on this diagram) are composed of many silicon diodes in series and will read open on a typical VOM or DMM.

Note that there is no standardization to the color code. However, the fat wire to the CRT is most often red, though it could also be black. Of course, you cannot miss it with the suction cup-like insulator at the CRT-anode end. The focus and/or screen connections may also be to pins rather than flying leads.

### Replacement Flyback Transformers

Unfortunately, you cannot walk into RadioShack and expect to locate a flyback for your TV or monitor. However, there are other options:

• Original manufacturer—most reliable source but most expensive. Older models may not be available. This may be the only option for many TVs and monitors—particularly expensive or less-popular models.

• Electronics distributors—a number of distributors sell replacement flybacks. However, there may be no way of knowing if what you are getting is an original replacement or a generic equivalent, and you could end up with something that isn't quite compatible (see below). Thus, unless the catalog listing says "original part," these may be no better than ones from the generic sources we'll detail shortly.

In your search for flybacks, here are some places to try:

Component Technologies, Tel: 888-FLYBACK or 800-878-0540; e-mail: fbtxformer@aol.com

CRC Components, Tel: 800-822-1272

EDI (Electro Dynamics, Inc.) NY, Tel: 800-426-6423

Data Display Ltd, Canadian sub of CCS, Tel: 800-561-9903

Global Semiconductors (Toronto, Canada), Tel: 800-668-8776, Web: www.globalsemi.com

• Generic replacements—ECG, NTE, ASTI, HR Diemen, for example, offer lines of replacement flybacks. These companies have sites on the Internet that include a cross reference to their replacement based on TV or monitor model and/or the part or house number on the flyback:

NTE Electronics: www.nteinc.com
ECG Philips: www.ecgproducts.com
HR Diemen: www.hrdiemen.es
ASTI Magnetics:
www.astimagnetics.com
Flybacktransformer:
www.flybacktransformer.com
Cactus Technology Corp.:
www.flyback-transformer.com.

Note, however, that generic replacements might be of lower quality or be not quite compatible with your original. In an effort to minimize the number of distinct flyback models, some corners may be cut and one-size-fits-many may be the rule resulting in all sorts of problems that could even further complicate your troubleshooting. In short, turn to these only if availability or economics leave you with no other choice.

### 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

## COMPUTER CONNECTIONS

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work with your standard phone lines.

To take advantage of xDSL, you'll need to equip your computer with an appropriate modem—usually ADSL or SDSL. The difference between these two is that ADSL is designed to have more bandwidth for downloads, making it perfect for Web use, while SDSL has synchronized speeds in both directions, making it a great solution for videoconferencing and file uploads. Maximum speeds for xDSL are expected to be about 2 Mbps; this seems slower than cable at first glance, but what you should know is that you'll get this speed on a regular basis and don't have to worry about bandwidth being used up by others someday (it's hard to say if cable companies will keep their promise of speed and bandwidth control).

**VENDOR INFORMATION**

**Compaq**
20555 State 249
Houston, TX 77070
Tel: 800-345-1518
Web: www.compaq.com

**Hughes Network Systems (DirecPC)**
11717 Exploration Lane
Germantown, MD 20876
Tel: 800-DirecPC
Web: www.direcpc.com

**DSL Communications**
4675 Stevens Creek Blvd.
Suite 241
Santa Clara, CA 95051
Tel: 408-249-6400
Web: www.dsl-com.com

As only a few areas are currently operating with the technology, xDSL's pricing is difficult to determine right now. From what we've seen, at its cheapest it's about $60 a month—almost double the cost of cable. Keep a look out for xDSL announcements in your area in the coming months. Computer vendors like Compaq are already shipping machines with modems that can handle both xDSL and standard analog lines (check out their Presario 5600 line), and companies like DSL Communications are already shipping add-on modems for use with any computer.

That's all for now. Until next time, here's hoping you have a viable high-speed way to get on the Net. If you'd like to get in touch, you can send e-mail to connections@gernsback.com, or snail-mail to *Computer Connections*, **Electronics Now**, 500 Bi-County Blvd., Farmingdale, NY 11735. EN