# Don Lancaster's Hardware Hacker

# June, 1994

just got this call from a graduate student who is certain they have now proven that the second law of thermodynamics is wrong and what should they do about it? It was something about statistical thermal gradients nailing *Maxwell's Demon* in a driveby shooting. Naturally, the effect is purely theoretical. It is "too small to measure in the lab."

The obvious answer is to go out for some coconut anchovy pizza and then forget the entire incident. But do *not* mention this to your thesis advisor.

Actually, our helpline will average around three second law violations or so per month. So, let us go over the rules one more time: True, the second law of thermodynamics ("you can not break even") has never been proven.

And probably is *not* provable.

But on the other hand, and *without* exception, every attempt to find any counterexample that would prove it wrong has utterly and totally failed. At least on the normal everyday scale of things. Literally billions of tests are unintentionally rerun day in and day out that overwhelmingly suggest the law really is true.

Congress is not expected to repeal the second law any time soon.

If this student is convinced he is right, he has two options. He can go the *real science* or the *pseudoscience* route. With the real science route, he has to create some simple and easily duplicated experiment which allows disinterested third parties to get his effect to show up fairly well.

And do so in such a manner that his explanation for what is coming down seems to be the most probable and the most reasonable.

The results *must* end up well above experimental noise floors. After the results are independently duplicated and verified, then his paper can get presented to a credible journal for a peer review and publication.

With the pseudoscience route, he can go to any of the members of the pseudoscience industry press and can instantly get published. Or else could pick slow news days in obscure rural newspapers for his coverage. Or go to even more obscure semi-scholarly foreign publications of questionable pedigree. But none of these alternate routes will look good on his resume.

I've just posted lots more info on exploring pseudoscience resources as RESBN26.PS on *www.tinaja.com*.

#### Solitons

Outside of a classic ghost town in Colorado's San Juans, there is this free-hanging old mining cable which literally goes up the wall. This beast is nearly a mile long and over an inch in diameter. Which leads us to some utterly fascinating real world and real time physics. If you grab this cable near the low end and shake it once, you can watch a solitary sonic wave running up, reflecting, and returning several seconds later.

What is really amazing is that the solitary return wave is so violent that it will try to rip your arm right off the cable. Something special does appear to be happening.

Second law violations Soliton wave references Superb CD ROM directory Santa Claus Machine update Several hacker opportunities

> A century ago, a mathematician decided that certain solitary waves can indeed be special. He was riding his horse along a canal bank and was daydreaming about waves.

> A barge suddenly stopped and then launched a single solitary wave. He immediately noticed that this wave was unique in that it kept going much further than ordinary waves. In fact, he followed the wave for miles.

> After some analysis, he called this special type of wave a *soliton*.

Today, solitons are an incredibly hot research topic. One big use is for fiber optic communications, where a soliton can go much further between repeating amplifiers. In fact, soliton fiber comm a third of the way around the earth with a 20 Gigabyte data rate has been demonstrated.

Why will any wave die out? You'll find three main reasons. First, your wave will *dissipate* when it does such things as flex a resisting cable or go up against air resistance. Dissipation ultimately transforms all of the wave

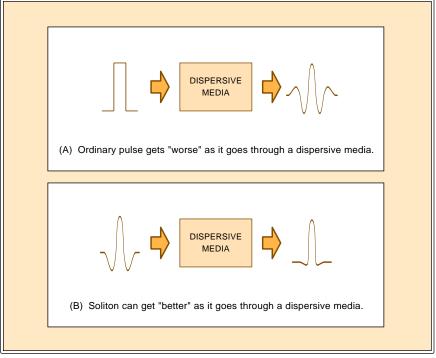


Fig. 1 – SOLITONS are a special class of solitary waveforms that can travel much further than ordinary waveshapes. They are a hot research topic.

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# **Hardware Hacker**

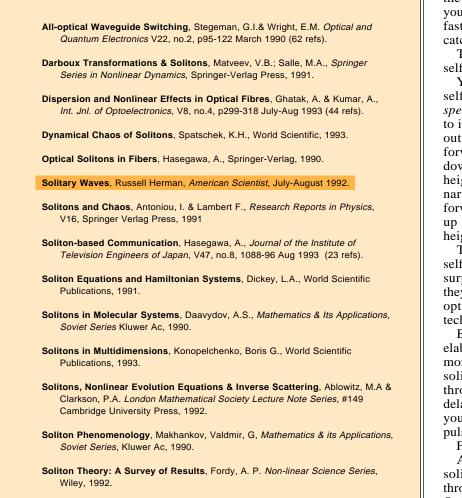


Fig. 2 – SOME RECENT SOLITON REFERENCES. There are 8300 more!

energy into low grade heat.

Second, portions of the wave will *reflect* whenever it encounters any changes in the media impedance or uniformity. In the case of that San Juan cable, the end ring is something less than a perfect short, so you don't get everything back.

Finally, and most important for a soliton, the wave will *disperse* if the media lets higher frequency waves go on by faster or slower than lower frequency ones. Usually, your wave energy "stretches out" over time.

Any waveform can be represented as a group of high frequency and low frequency components. If these ever get out of step, your wave shape will change drastically.

As will the detectability.

A different name for one type of dispersion is group delay distortion.

For instance, if the frequency for a one in a modem has more delay than the frequency for a zero, you may get times when you've got a one, a zero, *both*, or *neither* at your output.

Obviously, "both" or "neither" are bad news when it comes to extracting useful information.

Figure one shows the essentials of solitons. An ordinary pulse which is sent through a dissipative media gets worse and hard to detect. A soliton sent through the same media actually gets *better* and easier to detect. For the best results, your media has to be known, stable, and fixed length. The soliton shape also has to be designed to match the media.

What a soliton wave tries to do is *predistort* itself so that, by the time it gets sent *through* the media to your intended receiver, the dispersion of

the media and the "undispersion" of your initial waveform cancel out. The fast and later frequency components catch up with slow and early ones.

The soliton wave sort of becomes self-reinforcing.

Your innermost technical secret to self-reinforcement is this: Make the *speed* of a soliton wave proportional to its *height*. Should the wave stretch out, its amplitude will drop and the forward parts of the wavefront slow down to pile back up, re-raising the height. Should the wave become too narrow, its amplitude raises and the forward parts of the wavefront speed up to stretch back out, lowering the height back to where it was.

The effect can be made perfectly self-compensating. Soliton waves are surprisingly common in nature, but they can end up real tricky to do with optics. Special lasers and nonlinear techniques are needed.

Bats and military radars use a more elaborate *chirp* scheme that works in more or less the same way as do the solitons. Send any swept FM signal through any media that has a linear delay versus frequency response, and you get a narrow and high amplitude pulse back out.

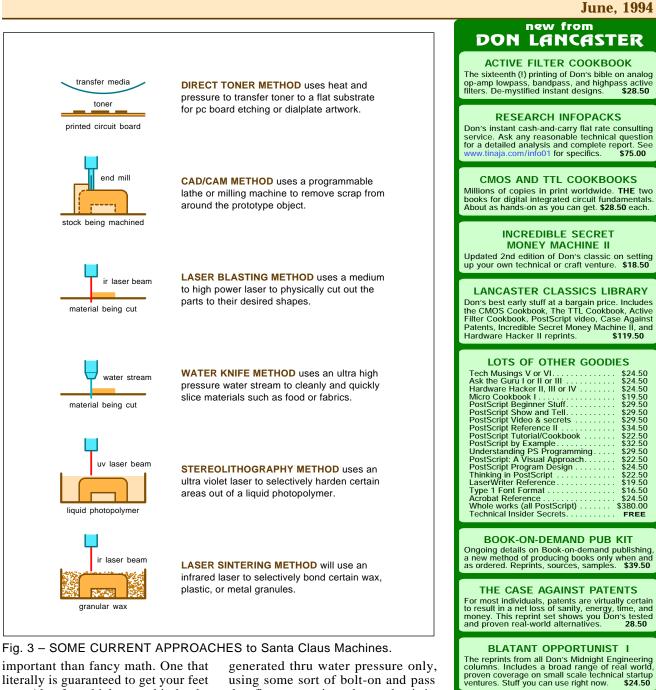
Fourier transforms and all.

Another very unusual property of solitons is that they can freely pass through each other without colliding! Ordinarly waves often destructively interfere if you attempt this.

When you explore the literature, you will find 8,316 soliton papers on *Dialog* alone! There are also dozens of textbooks. Sadly, many are totally unreadable and involve horrendous math. I have posted a more or less random and rather short sampling of these to figure two. These sources and their end bibliographies should be enough to get you started.

Be sure to let me know if you find any favorite soliton tutorials on your own that are easy to understand. An *Incredible Secret Money Machine II* for your trouble.

What good are solitons for all you hardware hackers? Well, obviously, we've got a great subject for science fair projects, student papers, or even thesis topics. But there's a possible new use for solitons that just about anybody can explore. And for which hands-on backyard testing is more



literally is guaranteed to get your feet wet. Also for which some big bucks just might be made. Simply answer this question: "Can

solitons improve fire streams?"

Between spelunking, tinaja quests, and pecan harvests, I am also a city fireman. The deck gun on a pumper has an effective fireground range of slightly over 200 feet. There sure are times and places when that flat out ain't enough. At least theoretically, the solitons should be able to extend this range significantly.

Ideally, all your solitons should be

using some sort of bolt-on and pass thru flutterwumping adaptor that is in series with the water supply.

But go ahead and use electronics or even high pressure air to prove the idea works. Because of an exciting and an incredibly effective new CAFS foam firefighting technique, certain new pumpers now include a reliable compressed air supply.

Let me know what you can come up with here. Obviously, you can use an ordinary garden hose for all your initial tests. This one appears to be an outstanding hacker opportunity.

**RESOURCE BIN I** A complete collection of all Don's Nuts & Volts columns to date, including a new index and his master names and numbers list. \$24.50 FREE SAMPLES Check Don's Guru's Lair at http://www.tinaja.com for interactive catalogs and online samples of Don's unjue products. Searchable reprints and reference resouces, too. Tech help, hot links to cool sites, consultants, email: don@tinaja.com FREE US VOICE HELPLINE VISA/MC SYNERGETICS Box 809-EN Thatcher, AZ 85552 (520) 428-4073



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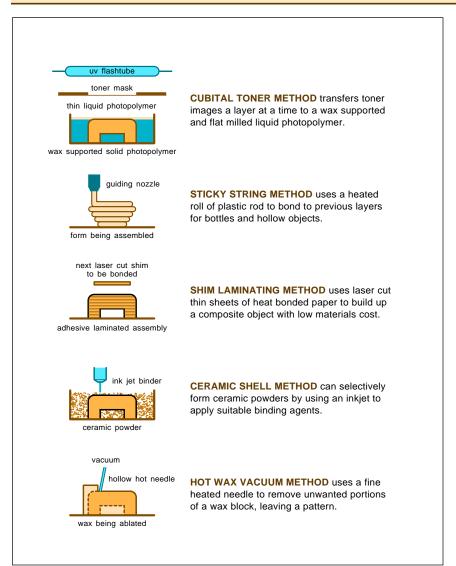


Fig. 4 – ADDITIONAL CURRENT APPROACHES to Santa Claus Machines.

#### Santa Claus Machines

The science fiction authors called them *Santa Claus Machines*. Magic boxes which could run off a copy of anything – a BMW, a pastrami on rye, a new girlfriend, or a duplicate \$20 bill. Starting with either a sample or a set of software plans.

These days, crude approximations to the Santa Claus machines really do exist. And they literally are getting better every day.

Today, these are often known as *desktop manufacturing* or else *rapid prototyping systems*. The pastrami on rye still leaves this distinctly acrylic aftertaste. But it definitely is low in fat and has zero cholesterol.

There's now a dozen approaches to

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Santa Claus machines, so I thought I would once again gather several of the bigger players together into this month's resource sidebar.

Most of the systems we'll look at are outrageously expensive. A house and two cars. But there is no reason the whole kit and kaboodle of them could not be replaced with about \$175 worth of hacker parts, bunches of time, and a lot of imagination.

So there are some incredible new opportunities here. Either for custom systems of your own or as a service bureau for others.

Some of the major approaches to Santa Claus machines are shown you in figures three and four. Let's do a brief rundown of a few of the more obvious possibilities here ... *Direct toner method* – This one is the cheapest, the most accessible, and the most hacker friendly. But it is pretty much restricted to two-dimensional work such as instant printed circuits, front panels, or dialplates.

With this method, you PostScript laser print your toner image onto a transfer sheet. The transfer sheet is placed in contact with your printed circuit board or whatever. Heat and pressure is then applied. Your toner transfers to the board and becomes the etch resist. Or the image.

The two leading suppliers here are *DynaArt Designs* and *Techniks*, with the pc supplies sold by *Kepro*.

*CAD/CAM* – has been around for a while. Which works like an ordinary lathe or milling machine, chewing up scrap to leave the desired object. The difference is software control where you feed it a set of plans and it does the rest by itself. Low end machines have only started to appear here.

While much lower in cost than old "industrial strength" machinery, they still remain obscenely overpriced for most hacker uses.

Typical low end CAD/CAM outfits do include *Roland*, *Techno Isel*, and *Light Machines*. Others advertise in such places as the *School Shop* and *Industrial Education* trade journals.

Custom CAD/CAM bits and pieces are available at *Stock Drive Products*. Two other material sources are *MSC Specialties* and *McMaster-Carr*.

*John Rees* offers a hacker version here that can let you use ordinary car alternators as power stepper motors.

A CAD/CAM prototyping system can be used with a machinable wax. Instead of metals or plastics. The wax can then become a pattern or a mold for your final items. This is easier on tools, and mistakes can be recycled. Wax is also a good way to practice.

One source of machinable wax is *Freeman Supply*, while *Kindt-Collins* provides a wide range of all sorts of industrial and artistic waxes.

*Laser Blasting* – The medium power laser is one variation on CAD/CAM that is revolutionizing crafts, model making and smaller parts in general. Parts are cut quickly, accurately, and splinter free. A twenty watt carbon dioxide laser could be used for such things as the precision cutting of doll

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house furniture or slicing up parts for model railroad structures.

More info on power laser systems appears in *Industrial Laser Review*, while two hacker friendly sources for lasers are *Meredith* and *MWK*.

*Water Knives* – are a more or less similar Santa Claus system. An ultra high pressure water stream does all the work. My favorite demo has one of these chopping up a gooey piece of chocolate cake *and* a four inch thick steel slab at the same time.

*Flow International* is one source. *Haskell* makes the special pumps.

*Stereolithography* – The pioneer here is a company called *3D Systems*. With stereolithography, you start off with a vat of a liquid photopolymer. A stage sits very near the vat surface.

A scanning laser then hardens out one layer of photopolymer. The stage is lowered slightly and a new layer is progressively put down.

The process keeps repeating until your part is completed. Virtually any shape can get made, including those impossibly difficult to machine.

The photopolymers aren't all that different from the ones used by the flexographic printing or rubber stamp folks. Two suppliers are *Merigraph* and *Grantham Polly-Stamp*.

Selective Laser Sintering – is a rapid prototyping method that starts with a fine powder of wax, plastic, or even certain metals. The laser selectively melts and bonds portions together in a thin layer by sintering. Sintering is melting things just enough that they stick together. Then your part gets lowered, more powder is leveled, and a second layer is imaged, building up the desired prototype.

The final objects are often sturdy enough for use as actual parts. Unlike stereolithography, the materials used are low cost and non-hazardous. The laser is also cheaper since infrared rather than ultraviolet can be used. *DTM Corp* in Austin seems to be the main champion of this method.

*Cubital Toner Imaging* – This one is related to the direct toner method. An *unfused* toner laser image is contact printed onto a photopolymer. Then your unhardened photopolymer gets sucked up and recycled, as does the toner image. Voids are then replaced

### SANTA CLAUS MACHINE RESOURCES

**Cubital America** 1307F Allen Drive Troy, MI 48083 (313) 585-7880

DTM Corp 1611 Headway Circle, Bldg 2 Austin, TX 78754 (512) 339-2922

DynaArt Designs 3535 Stillmeadow Lane Lancaster, CA 93536 (805) 943-4746

**Grantham Polly-Stamp** 418 Central Avenue NE E Grand Forks, MI 56721 (218) 773-0331

Helisys 2750 Oregon Ct Bldg M-10 Torrance, CA 90503 (310) 782-1949

Kepro 630 Axminister Drive Fenton, MO 63026 (800) 325-3878

Light Machines 669 E Industrial Drive Manchester, NH 03103 (603) 625-8600

McMaster-Carr Box 54960 Los Angeles, CA 90054 (213) 692-5911

Meredith Industries 5035 N 55th Ave Ste 5 Glendale, AZ 85301 (602) 934-9387

Merigraph Box 3064 Naperville, IL 60566 (800) 323-1832

with a suitable wax filling.

The surface is carefully milled flat and another layer is created. Unlike stereolithography, you are rapidly forming an entire layer at once, rather than a single spot. You are also using far less photopolymer, since only a thin layer is used. First developed in Israel, a source is *Cubital America*.

One service bureau here is *Stature Machining Technologies*.

*Sticky Strings* – Although this looks like a refugee from a special ed arts class, this approach seems well suited for such hollow objects as shampoo

MSC Specialties 6700 Discovery Blvd Mableton, Ga 30059 (800) 645-7270

MWK Industries 1440 S State College Blvd 3B Anaheim, CA 92806 (800) 356-7714

Rapid Prototyping Report 841 Turquoise Street, Ste D San Diego, CA 92109 (619) 488-0533

John Rees Route 1 Box 1551 Sautee, GA 30571 (706) 865-5495

Roland Digital 7200 Dominion Circle Los Angeles, CA 90040 (213) 685-5141

Soligen 19408 Londelius Street Northridge, CA 91324 (818) 718-1221

Stock Drive/Techno 2101 Jericho Turnpike New Hyde Park, NY 11042 (516) 328-0200

Stratasys 14950 Martin Drive Eden Prairie, MN 55344 (612) 937-3000

**Techniks** 45 J Ringo Road Ringoes, NJ 08551 (908) 788-8249

**3D Systems** 26081 Avenue Hall Valencia, CA 91355 (805) 295-5600

bottles or similar packaging items. A correct name for the process is *fused deposition modeling*, and *Stratasys* is its main source.

In use, a large reel of thermoplastic rod is unwound along a path. The rod is deposited just hot enough that the outside is liquid, causing it to stick to the previous layer of the pattern.

The results are sort of a corduroy, but you could trade off wire diameter versus smoothness. A final polish or filler or solvent spray can be used to improve the surface finish.

Apparently, IBM is working on a variation on these sticky strings that

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# NAMES AND NUMBERS

#### Aero/Skyways 15 Crescent Road Poughkeepsie, NY 12601 (914) 473-3679

Buddy Products 117-A Commercial Drive Thomasville, GA 31792 (912) 225-9758

Burman Industries 1441 Covello Street, Ste 6A Van Nuys, CA 91405 (818) 782-9833

#### **Dialog** 3460 Hillview Avenue Palo Alto, CA 94304 (415) 858-2700

First Light Video Publishing 8536 Venice Blvd Los Angeles, CA 90034 (800) 777-1576

Fluorescent Mineral Society PO Box 2694 Sepulveda, CA 91343 (818) 786-4885

GEnie 401 N Washington St Rockville, MD 20850 (800) 638-9636

is a cross between this sticky string method and a hot glue gun. The new process is cheaper than some of the others. Even *chocolate* can be used as a design material with their scheme. Besides the usual plastics and waxes.

Can pizza-on-demand be that far behind?

It appears to me a hacker might easily fake this using a hot glue gun and substituting polyethylene for the glue sticks. We did look at this back in the *Hardware Hacker III* reprints. One obvious use is custom cast house numbers or names.

*Laminated Paper Shims* – works just like the contour lines on a topo map. It is also known as *laminated object manufacturing*. At the current chosen elevation, a piece of adhesive coated paper of the desired thickness is cut out with a laser.

The latest piece then gets carefully aligned to the previous sheet and then heat set. This process repeats often enough to build up the desired part. A

# The Calculator Collector

Intl Assn Calculator Collectors 10445 Victoria Avenue Riverside, CA 92503

Morph's Digital Outpost PO Box 578 Orinda, CA 94563 (510) 238-4545

Polytek Development PO Box 384 Lebanon, NJ 08833 (908) 534-5990

**Save the Planet Software** Box 45 Pitkin, CO 81241 (303) 641-5035

Sony Semiconductor 10833 Valley View Street Cypress, CA 90630 (800) 288-SONY

Telecom Library 12 West 21st Street New York, NY 10010 (800) LIBRARY

Vangard Services Box 1031 Mesquite TX 75149 (214) 324-8741

final surface coating of some sort can eliminate the individual steps.

Materials costs are exceptionally low, and only a lower power laser is needed. This method is particularly good for sand casting. One supplier of these systems is *Helisys*.

*Ceramic Shell Casting* – Originally developed at MIT, *Soligen* is now the leading proponent of this method. A thin layer of ceramic powder is put down. A scanning head having one or more inkjets passes over the powder, selectively applying a binder.

The part is lowered and repeated, causing layer upon layer of binder to build up in the desired shape.

The final shell can be directly used for the high temperature casting of chrome alloys, aluminum, and even nickel. Hollow items can be done by building up integral cores.

*Wax Vacuuming* – is a new hacker concept that just might revolutionize jewlery and small art object creation. Picture a hypodermic-like needle that has a hot tip that can be moved along five or six mechanical axes.

The needle works its way around a block of wax, first melting and then vacuuming all the molten wax away from the pattern. Curved needles can be used for internal details or hard to access points. The intended use is for such things as class rings, and silver ornaments. *John Rees* is one source.

By the way, anytime you are using both X and Y motions, it pays to split up the problem. Move your tool in the X direction and your workpiece in the Y direction. This can convert a thorny two-dimensional problem into simpler one-dimensional ones.

And greatly simplify things.

For more info, there is one pricey industry newsletter called the *Rapid Prototyping Report*. These folks also do directories, conferences, and trade shows. *Batelle* does fancy research on rapid prototyping.

We'll have lots more on this topic as it emerges. Especially the low end hacker stuff. I've just added a new *Santa Claus Library Shelf* to my website. We'll be adding lots of files as time and our *banner advertisers* permit me to.

Finally, many ongoing Santa Claus Machine developments are likely to appear in those *Machine Design* and *Design News* trade journals.

#### New Tech Lit

There's a mind-boggling UFO and pseudoscience BBS up and running at (214) 638-8369. They've got scads of utterly fascinating files on all of the usual weird stuff. Free access. Their sponsor is *Vangard Services*.

Morph's Outpost on the Digital Frontier is a unique new multimedia magazine in newspaper format. This one offers the latest inside scoop of multimedia developer happenings.

Two other unusual magazines are *Skyways* and *WWI Aero* for those of you interested in early aviation.

From Sony, a new Computer Audio & Video Multimedia data book.

A *CD-ROM Selector* from *Save the Planet Software* is a well researched directory of 1600+ CD-ROM titles.

Laser Buddy Document Spray by Buddy Products offers Bakerizing in a can. You can spray this glop on any laser printed output and it will get



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blacker, smoother, and more durable. The resoution appears to go up and text gets slightly bolder.

Their spray is mostly methylene chloride, acetone, and some isobutyl acetate. Works like a champ. But use this one outdoors only. Watch out for fingerprints. No, it won't help direct toner printed circuit transfers much.

Because of residues.

The Calculator Collector is a new labor-of-love newsletter published by the International Association of Calculator Collectors.

Lots of telecommunications books are offered by the *Telecom Library*. Some useful multimedia videotapes are sold by *First Light Video*.

#### NEED HELP?

Phone or write all your US Tech Musings questions to:

> Don Lancaster Synergetics Box 809-EN Thatcher, AZ, 85552 (520) 428-4073

US email: *don@tinaja.com* Web page: *www.tinaja.com* 

The *Fluorescent Mineral Society* looks at rocks in the dark.

A fine catalog of moldmaking and casting materials is available from

*Polytek Development*. A similar new catalog from *Burman Industries*, yet another special effects supplier.

I've now got a brand new catalog with a greatly expanded insider secret section in it. Write, call, or email me for a free copy.

You might also send me technical questions, new catalog requests, and orders to *don@tinaja.com* or visit my Guru's Lair website that you'll find at www.tinaja.com.

Most of the mentioned items are found in the *Names & Numbers* or *Santa Claus Machine* sidebars. Do be sure to check here first before calling our no-charge technical helpline.

Let's hear from you.  $\blacklozenge$ 

