Don Lancaster's

Hardware Hacker

February, 1993

Relaxation oscillators
Newtek's video toaster
Broadcast trade journals
Syncronizing video sources
Electric Discharge Machining

This month, we seem to have a pair of really exciting new opportunities from opposite ends of the broad hardware hacking spectrum. Before we begin, though, our usual reminder that you can pick up technical help, consultant referrals, and off-the-wall networking by calling me per the box below.

Let's start off with…

Newtek's Video Toaster

Tim Jenison recently sent me one of his *Newtek* video toasters to play with. What follows is just some of my preliminary impressions and random comments, rather than a thorough or unbiased review…

Their video toaster is basically an Amiga computer having some special software, a plug-in card, and several extra jacks on the back. At a street cost of $2000 (card only) or $4000 to $5300 (a full slow or fast system), the video toaster can replace something like $100,000 worth of real broadcast quality video postproduction editing equipment.

Not imitates. Replaces outright. Or even totally blows away.

In theory, you can now cheaply and quickly produce total broadcast quality videotapes in your own home. The present genlocking and switching abilities of the video toaster do seem three years or so ahead of anything Mac based, and eons beyond anything using an IBM or PC platform.

The video toaster performance is absolutely and totally stunning. But let's knock it anyway. Just so you are sure what you are getting into.

First, if you just want to slap some titles or computer art onto any old home video, that virtually unknown $129 *Apple II Video Overlay card* is much cheaper, surprisingly powerful, and vastly easier to use. *A2 Central* is one continuing source.

Second, you do not simply drop this beast down on your kitchen table. An *entire room* dedicated *exclusively* to the video toaster is your minimum possible workspace. Although quite compact by itself, the toaster often will attract bulky and expensive high tech goodies like a huge magnet.

Third, plain old VHS is flat out not suitable for *any* serious production or editing. Period. One big reason is the *generation loss* effects where copies simply are not as good as an original. Another is the inability to selectively edit a single frame. Writing a single frame gets essential for any animated sequence. Many of the toaster's more exotic features are definitely not VHS compatible. No way.

Yes, you can handle fairly fancy production with the latest of Super VHS or Hi-8. But if you are in the least bit serious about creating any commercially marketable product, a minimum of *Sony Betacam* should probably get used for your taping.

Fourth, by the time you pick up a "real" camera or two, a "real" VCR or two, the three quality color monitors required, the two time base correctors demanded for the VCR's, your station synching genlock, an extra ac circuit breaker, your storyboards, and some support furniture, your price for the toaster itself does not seem to matter all that much.

Fifth, the toaster does not address any audio mixing or processing. It simply passes the audio on from input tape to output tape. There's sort of an unbalance here, since the toaster does so much so well on the video tracks. Yet it almost completely ignores the audio side.

Finally, the toaster has a very steep learning curve. Bunches of time and

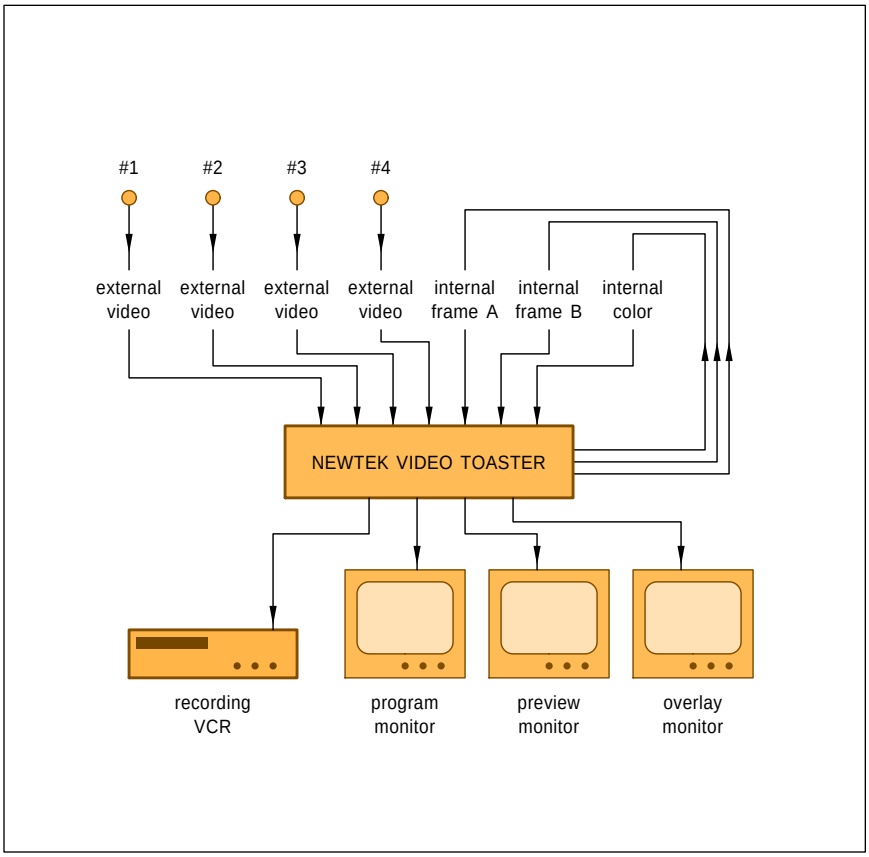

Fig. 1 – NEWTEK'S VIDEO TOASTER 2.0 can be used to cheaply replace as much as $100,000 worth of video editing and post-production equipment, while still offering full network broadcast quality. Best results are obtained with fancier video formats that allow single frame writes.

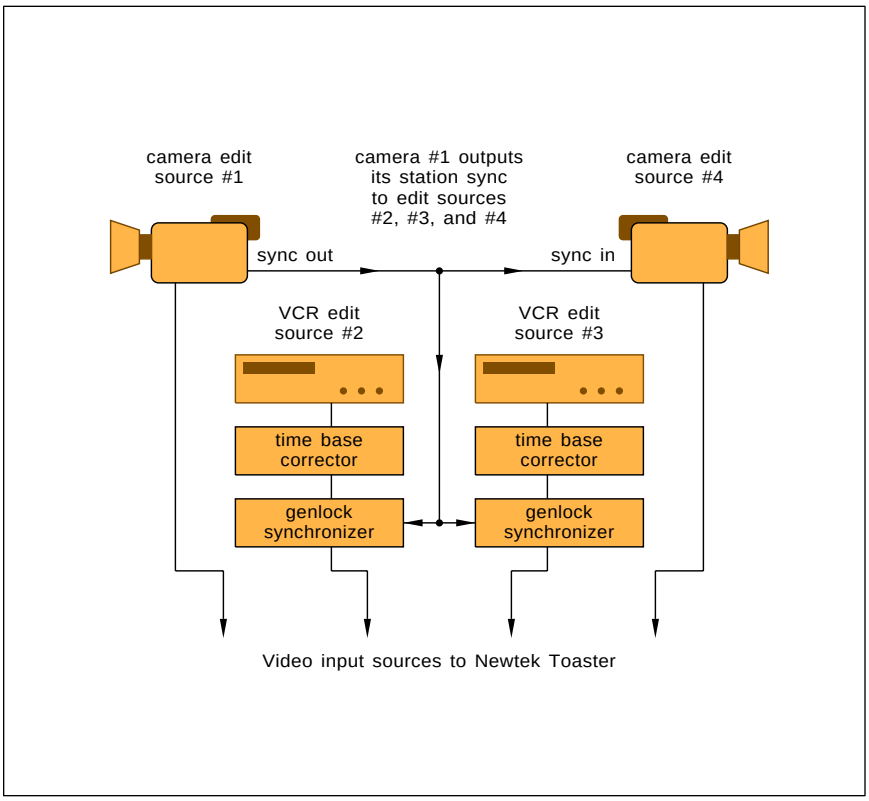

Fig. 2 – AS WITH ANY VIDEO EDITING SETUP, all input VCR's must be time base corrected, and all input video sources must be carefully synchronized together. This arrangement uses Camera #1 for your station sync.

effort are required to do the job right. Just because your toaster *potentially* can do full broadcast quality doesn't mean that you still can't create totally and utterly atrocious results.

So, what is in the box?

Figure one shows a typical toaster configuration. The toaster card and software consists of nine very fancy subsystems. These are the *switcher*, the *keyer*, the *framestore*, the *chroma FX processor*, *digital video effects*, a *character generator*, a *ToasterPaint drawing program*, the *Lightwave 3D* modeling program and the *genlock*.

The production switcher forms the heart of the system. There are three buses, called the *program* bus, which is your *current* output, your *preview* bus, which often will be your *future* output, and the *overlay* bus, which often determines how your preview and future outputs get combined.

Each bus can get manually or else software connected to seven different sources. These include four live video inputs, two still picture frames, or a background color.

Say you want to switch from live video to a color title screen. To do an instantaneous switching, you would put the live video on the program bus, the title art on the preview bus, and press the *take* button. To do a manual gradual fade, there's a large mouse controlled "T" handle which lets you gradually change between the two. There's also lots of preprogrammed wipes and fades available. Either in manual or 3-speed automatic. Plus you can write your own font software or use third party effects.

It gets complicated from there, but you can easily do picture-in-picture, and pretty much every other special effect that you'll see on a network or cable program. A full animation is certainly possible. But *only* when you use those video formats and control hardware that let you do single frame writes under exact control.

The luminance keyer lets you put live action over a fixed background. As a selected "white" or "black" level gets tripped, your switcher instantly changes between the action and the background. The frame grabber does what you would expect: freezing an instant of live video for future use.

Except that it actually grabs *four* fields at once. This is needed because there are two fields per frame and two frames used for the NTSC color phase sequence. A number of options are available to remove any blurring or motion in any particular field.

The chroma FX processor lets you do all sorts of neat color stuff, while the digital video effects give you lots of wowie-gees like sliding, spinning, zooming, or a spherical mapping. All of which is software programmable. The key to all these effects is to reach into a RAM memory and address it in a nonobvious manner.

The character generator is used to place messages upon your screen. It offers some very fancy special effects including glitter, highlights, chromes, drop shadows, etc…

ToasterPaint is a powerful drawing program, while the Lightwave 3-D is a sophisticated image rendering and animation system. Once again, your actual animation is only useful on the video standards and support hardware that allows single frame writes. Your animation sequences can be up to 120 frames, or four seconds long.

Ah yes, that genlock. When you take any old pair of video sources and try to switch between them, you will get a horrible and useless glitch. The only way around this is to make sure that *each* of your video sources gets carefully locked to the *exact* same timing. By an exact lock, this means that all horizontal lines must start precisely at the same instant and last exactly the same time. Your color phase on all the lines must precisely match. The vertical synchronization pulses must be precisely aligned. And finally, those four NTSC color phase fields must be in precisely the correct time sequence.

Now, *if* you have one *single* live video camera source or one *single* off-the-air live video broadcast, your toaster will automatically lock all of its effects. Genlock here should be no problem. But *any other combination* of sources needs careful thought as to how your genlocking is done.

Most VCR's introduce a second big problem, even if you are only using

one of them. Mechanical differences, alignment changes, and tape stretch might slightly but continuously jitter the timing coming off a prerecorded source. A twenty nanoseconds error is noticeable.

To clean up the output from any recorder, one or two steps might be needed. A *time base corrector* simply eliminates jitter. If you are using *one* recorder as your *only* video source, then a plain old TBC will suffice. On the other hand, if you are using two or more video sources, your recorder output will have to route through a much fancier combination TBC and *frame synchronizer*.

Typical low end TBC's include the *Digital Processing* VT-2000 and the *Iden* TR-7. Fancier TBC/synchronizer devices do include the *Hotronic* AP41 and the *Iden* IVT-7. The typical street pricing ranges from $750 up to $1600. With widely expanding markets, it's likely that these prices should soon drop dramatically.

Grass Valley Group and *Ikegama* offer full broadcast quality switchers, synchronizers and correctors. And so does *Sony*. These are not cheap.

At any rate, if you want to use multiple video sources, you pick your absolute best source and use it for the *station sync*. Additional sources that accept external synchronization can be cable connected to this one station sync source. Sources that cannot be externally synchronized have to go to their own TBC/synchronizers, which in turn are cable connected to your station sync.

Figure two shows you a typical synchronization hookup. Remember that *all* recorders *must* be time base corrected, and that *only one* source is allowed to provide station sync. All other sources must be locked.

One more time: All VCR's need at least time base correction, and all of your video sources *must* get precisely locked together for the toaster or any other video production system.

What's wrong with it?

While the current 2.0 version of the video toaster is a stupendous product, I feel this certainly could be further improved. Firstoff, a true Mac based version is a must. Commodore may have a temporary and illusory lead on genlocking, but the Mac color image generation and editing has long ago passed up the Amiga (and everybody else) like they were sitting on blocks. Obvious examples do include Pixar's *Renderman*, Apple's own *QuickTime* and Adobe's *Photoshop*.

Newtek's new *Mac Desktop Video Gateway* is a good first step towards full Mac compatibility.

Speaking of Adobe, some toaster compatibility with their PostScript language and its *Acrobat* offspring sure would be useful. PostScript is ideal for most video artwork, either regular or animated. While the public domain *GhostScript* (now available cheaply from a *www.tinaja.com* link) can be immediately used, a genuine Adobe Display PostScript is the best choice. PostScript type I and type III fonts are ludicrously better than the current crop of toaster characters.

Full compatibility with Kodak's new *PhotoCD* technology is also a must. As is better audio processing; full support for wavelet, fractal, and the MPEG compression options; and improved time code use.

And their toaster would be even more useful if some other technical improvements can come down. Like figuring out a method to effectively single frame edit plain old VHS. Or getting true read/write CD ROM out of the starting gate. Or speeding up the CD ROM access by a hundred or more. Probably the best way to do this is with multiple heads and some sort of holographic sensing. Orange or (sigh) blue laser diodes would also help considerably with their shorter wavelengths and higher densities. As would a giant two-port buffer.

The price of time base correctors and synchronizers also has to drop bunches. But this will surely happen as this market expands. We also need a newer *GoVideo* like product having multiple genlocked and single frame writable recorders all in one low cost system package.

Also needed are lots of improved "on the fly" techniques similar to an instant replay. Where a full minute of RAM based video could be instantly synchronized with and then real time overlain to *any* video format.

Who needs it?

Judging by all of the people who immediately piled up on my doorstep on the mere *rumor* I was getting one, pretty near anybody. In fact, your chances are good that "Wanna play with my toaster?" is now the number one singles bar pickup line.

Its amazing who your friends are.

Let's see who was on the pile. Phil runs the alternate cable service here and is about to offer ultra-cheap local ads. Diane is the public information officer (a.k.a. the directorate of the ministry of propaganda) for a federal bureaucracy. Henry now consults for

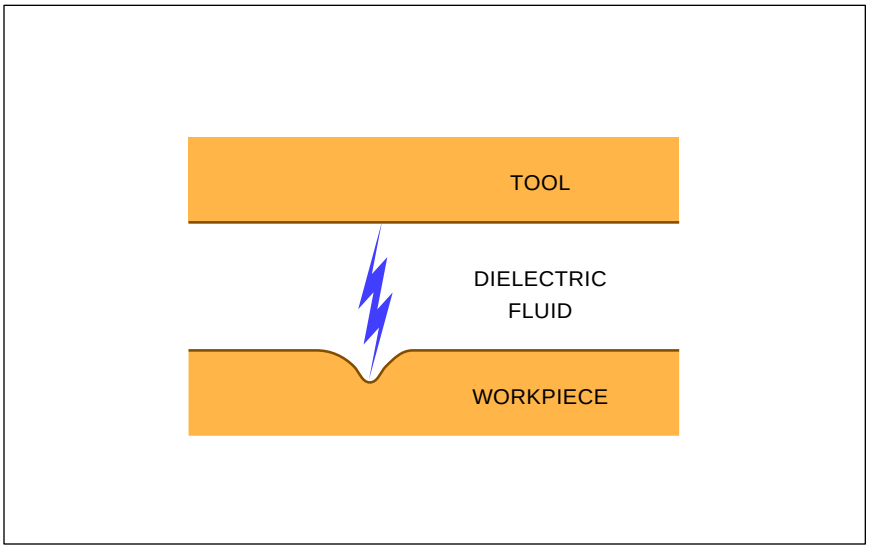

Fig. 3 – ELECTRIC DISCHARGE MACHINING uses a spark to literally blast craters out of a workpiece. The dielectric fluid washes the dregs away after each spark. Surprisingly, sub mil accuracies and microinch finishes are easily and cheaply possible. The trick is to use lots of sparks and tiny craters.

a university multimedia department. Craig is a timber management type. Kathy is big into theater arts. Bee is into how-to papermaking. Irene sells weaving and loom stuff.

Boyd shoots rodeo events. Dan is heavy on his computer servicing. Jeff now publishes a high-tech magazine. And Chris is shooting fire department sprinkler hookup videos. Myra is now busy networking all her regional Bed and Breakfasts. Mike is editing down his UFO stuff. Jay has been making a big flap in avian raptor research. Also birds. Keith is the honcho of a large regional rent-a-vid chain. And I am producing PostScript intro videos.

To get started off with the Newtek video toaster, first get a copy of the mind-blowing free video demo, either by calling them or circling the bingo card. Newtek also has an outstanding tech support helpline. One of many retail toaster sources is *B & H Video*, who also stock TBC cards.

The leading mag is *Video Toaster User*, while *Coffee and Toast* is one interactive video service. One source for toaster fonts is *Kara Computer Graphics*, while public domain disks of toaster effects are available at $6 each from *Timmins/Kingsway*.

Electric Discharge Machining

EDM, otherwise known as *spark machining* has held a rather obscure corner in the odd world of industrial electronics. But EDM has recently moved out of the toolroom and onto the production floor. There's nothing inherently expensive or complicated about EDM. It has some great new hacker potential. Especially since it lends itself so well to CAD/CAM and computer control.

Figure three shows you the basic idea. You place a *workpiece* of metal to get machined under a normally recirculating and insulating dielectric fluid. While kerosene was originally used, deionized water with a polymer resin is more popular today. You then bring a tool close to *but not touching* your workpiece and then discharge a capacitor between the two.

Which creates a spark.

The spark vaporizes a volume of the dielectric and blasts a crater out of the workpiece, creating a liquid metal puddle. After the spark ends, the puddle solidifies and the moving dielectric washes the dregs away. The "dirty" electrolyte is then filtered and recycled for reuse.

The process is repeated zillions of times. The next arriving spark strikes somewhere else, since the crater just increased the average spacing. As the workpiece erodes, the tool can get lowered somewhat. Eventually, the workpiece should assume the exact shape of the tool. Servo controls can sense the spark intensity and control the descent rate, making sure that an optimum spacing between a tool and workpiece is held.

Although spark machining sounds rather crude, EDM can easily do ultra smooth microinch machining having accuracies to a fraction of a mil.

Figure four shows several popular variations. With *die sinking EDM*, a master pattern is "pushed" into the workpiece. The tool can be arbitrarily complex and virtually any shape so long as there are zero undercuts. *Wire EDM* works sort of like a bandsaw. You start with a supply reel of brass or other wire above your work and have a takeup reel below the work. The speed is adjusted so that the wire will erode and get "used up" at an acceptable rate. Wires are typically from two to ten mils in diameter.

With *small hole EDM*, tiny holes can be "drilled" very deeply and very accurately. One obvious use for small hole EDM is for drilling pilot holes to start an internal path wire for EDM machining process.

Finally, a *metal disintegrator* is a coarser EDM process which uses a vibrating electrode and an arc welder to literally blast some holes into your workpiece. Important uses are to remove snapped studs, stuck taps, or broken drills.

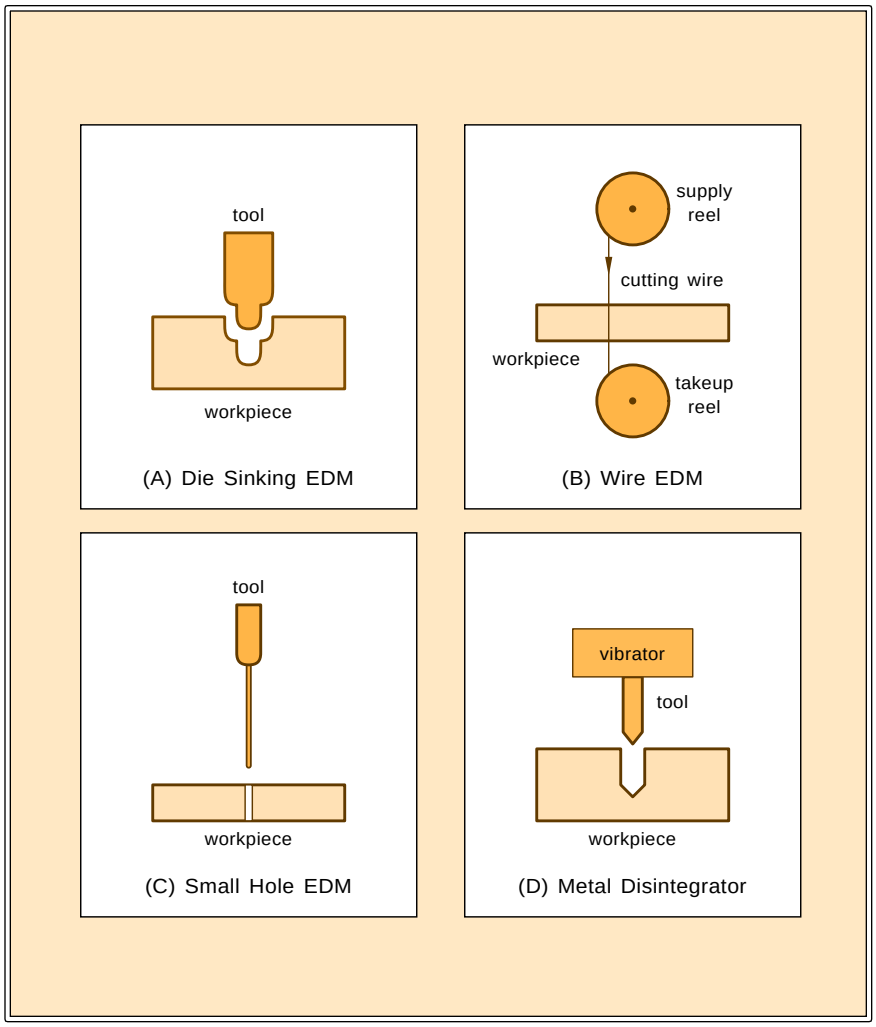

Fig. 4 – FOUR POPULAR VARIATIONS on Electrical Discharge Machining.

There's several unique advantages to EDM. The tool can be much softer than the workpiece, so you can now routinely use brass, copper, or carbon to cut up hardened steel, titanium, or carbide alloys. Ideally, there is zero tool contact, so there is no friction, chatter, or side loading.

By chosing the correct discharge polarity, the workpiece erodes much faster than your tool. Since you can now temper or harden the workpiece *before* you machine, the final results can end up more accurate.

Those EDM tool paths can be very complex. You can easily pull such tricks as "drilling" a deep and blind square hole that has sharp bottom corners. With wire EDM, a punch and a die can be *simultaneously* cut from a single piece of steel, guaranteeing a perfect fit with exact clearances.

The disadvantages to EDM? Both the tool and your workpiece must be conductors. Tool life is fairly short. And the machining rates are rather slow, say a cubic inch an hour for die sinking or thirty square inches per hour for wire EDM. Thus, a job may take overnight, even using stacked work and multiple heads. But this easily automated process can be done largely unattended.

The voltages and currents needed are not that big a deal. Since your arc is less than a mil long, 80 volts or so is all you usually want. Typical EDM power needs are several kilowatts. Or roughly the same as a larger milling machine or lathe.

Spark repitition rates are usually 20,000 to 500,000 sparks per second.

Most EDM circuits use a variation of the simple *relaxation oscillator*. Sort of a big brudder to the neon lamp flasher circuit we have shown you in figure five.

In any relaxation oscillator, your capacitor will slowly charge up to its critical voltage which breaks down or turns on some nonlinear switch such as the gas plasma or the breakdown of a tool's spark gap.

The capacitor normally continues discharging at high current until it drops below a current threshold. At that point, your gas deionizes or the spark quits, and the capacitor is free to once again begin recharging. The cycle then repeats.

Typical EDM capacitors are in the 50 microfarad region. The value of the capacitor determines the size for each spark crater, thus trading off the smoothness against the cutting time. High quality capacitors having a low ESR series resistance are an absolute must. Electrolytics are a no-no.

An EDM machine can also be a

EDM (SPARK MACHINING) RESOURCES

Alsop Engineering
PO Box 3449
Kingston, NY 12401
(914) 338-0466

American Machinist
1100 Superior Avenue
Cleveland, OH 44114
(216) 696-7000

Barnes/Raymond
PO Box 586
Maumee, OH 43537
(800) 228-1156

Belmont Equipment Co
32035 Edward Avenue
Madison Heights, MI 48071
(313) 588-7011

Ebbco, Inc
35500 Mound Road
Sterling Heights, MI 48310
(313) 268-7000

EDM Today
1212 State Route 23
Butler, NJ 07405
(201) 838-3130

Gisco
100 Laser Court
Hauppauge, NY 11788
(516) 273-5353

Hansvedt Industries
803 Kettering Park
Urbana, IL 61801
(217) 384-5900

Hurco Manufacturing
One Technology Way
Indianapolis, IN 46268
(800) 441-1036

Ingersoll
1301 Eddy Avenue
Rockford, IL 61103
(815) 654-5800

Lindsay Publications
PO Box 538
Bradley, IL 60915
(815) 935-5353

Metlfax
29100 Aurora Rd, Ste 200
Solon, OH 44139
(216) 248-1125

Mitsubishi EDM
1500 Michael Drive
Wood Dale, IL 60191
(708) 860-4210

Sodick Inc
710 Cooper Court
Schaumburg, IL 60173
(708) 310-2600

TRC Electronics
2216 West 16th Street
Broadview, IL 60153
(708) 681-1810

US EDM Systems
7960 S Roberts Road
Bridgeview, IL 60455
(800) 837-6808

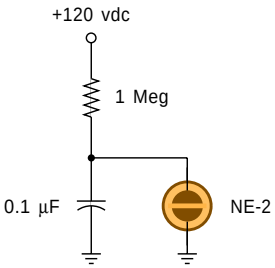

Fig. 5 – THE CLASSIC NEON LAMP relaxation oscillator. The lamp flashes several times a second. Some EDM circuits use a much faster and far more powerful version of this circuit, substituting the tool spark gap for the neon gas breakdown.

NAMES AND NUMBERS

Analog Devices
1 Tech Way, PO Box 9106
Norwood, MA 02062
(617) 329-4700

A2 Central
PO Box 11250
Overland Park, KS 66207
(913) 469-6502

B&H Video
119 West 17th Street
New York, NY 10011
(800) 932-1977

Black Book Auction Report
PO Box 758
Gainesville, GA 30503
(706) 532-4111

Digital Processing Systems
11 Spiral Drive, Suite 10
Florence, KY 41042
(606) 371-5533

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

Grass Valley Group
PO Box 1114
Grass Valley, CA 95945
(916) 478-3000

HDS Systems
PO Box 42767
Tucson, AZ 85733
(602) 881-2632

Hotronic
1875 S Winchester Blvd
Campbell, CA 95008
(408) 378-3883

I.DEN
9620 Chesapeake Dr, Ste 204
San Diego, CA 92123
(619) 492-9239

Ikegami
37 Brook Avenue
Maywood, NJ 07607
(201) 368-9171

Kara Computer Graphics
2554 Lincoln Blvd, Ste 1010
Marina Del Rey CA 90291
(310) 578-9177

NewTek
215 SE 8th Avenue
Topeka, KS 66603
(800) 765-3406

Radio World
5827 Columbia Pike, Ste 310
Falls Church, VA 22041
(703) 998-7600

Rodeo Video
PO Box G
Snowflake, AZ 85937
(800) 331-1269

Sierra
2075 N Capitol Avenue
San Jose, CA 95132
(408) 263-9300

Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

Timmins/Kingsway
2427 Hart Avenue
Santa Clara, CA 95050
(408) 244-9692

Toast & Coffee
12219 Nicollet Avenue S
Burnsville, MN 55337
(612) 890-2189

TRW
Box 2472
La Jolla, CA 92038
(619) 475-1000

TV Technology
5827 Columbia Pike, Ste 310
Falls Church, VA 22041
(703) 998-7600

Video Toaster User
21611 Stevens Creek Blvd
Cupertino, CA 95014
(408) 252-0508

spark gap transmitter that generates a horrendous amount of very bad radio interference. The usual shielding and other tricks are a must to get RFI down to acceptable levels.

In modern EDM, triacs or other electronic switches can speed up and improve the operation of the simple relaxation oscillator. But the idea is still the same. Charge a capacitor to spark breakdown. Then discharge the capacitor into the spark gap. Repeat the cycle over and over again. Spark times and duty cycles are adjustable over a wide range.

As our resource sidebar for this month, I've gathered together some places to go for more info on EDM. The leading trade journal is called *EDM Today*, while ads and articles occasionally show up in *American Machinist* and *Metalfax*. Besides all

the other great machinery and home shop books, the *Lindsay Publications* folks offer a *Practice and Theory of Electrochemical Machining*, and the *Ramah Machine Metal Disintegrator*. Several other resources listed form a random sampling of higher profile manufacturers and distributors for EDM machinery and supplies.

Let's have your thoughts on new low cost hacker EDM opportunities. There should be lots of exciting new possibilities here. Especially with the latest of electronic switching power supply techniques.

There's great opportunity here.

New Tech Lit

There's loads of interesting new chips piling up. Particularly the *Aria* sound circuits from *Sierra*, or that new TMC22190 digital video layering engine and the TMC22070 genlocking video digitizer from *TRW*.

A multimedia stereo audio mixer ap note from *Analog Devices*.

The *Black Book Official Auction Report* is sort of like a car blue book for shop machinery. This also lists bunches of auction houses likely to conduct electronic auctions.

A great cable and television station tabloid tech mag is *TV Technology*. Among other stuff, it's got lots of ads for toaster support products. And a similar pub for commercial radio stations is called *Radio World*.

For all the fundamentals of digital integrated circuits, be sure to check into my *TTL Cookbook* and *CMOS Cookbook*. Autographed copies per my nearby *Synergetics* ad.

Our new *Synergetics Consultant's Network* is also now up and running. Do give me a call at (602) 428-4073 if you want to participate on this or need any info on any other technical or tinaja questiong topic.

Let's hear from you. ✦

NEED HELP?

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