Don Lancaster's

Hardware Hacker

April, 1995

A.C. Motor Drives
New BASIC Stamps
PIC Micro Resources
More magic sinewaves
"Not even wrong" results

Way on back in the seventh grade, I got this brilliant idea on how to "improve" VHF radio vacuum tubes by *eliminating* all of their internal interelectrode capacitance!

The scheme was to arrange the cathode and plate planar beside each other. Then place the grid up at right angles. The reasoning was that there would be zero capacitance among the three. Magnets got vaguely assigned to somehow bend the e-beam from cathode through grid to plate.

I even sent this idea to RCA.

Sorry, but electrical capacitance *always* exists *everywhere*. Separate a conducting point from another with an insulator, and you got a capacitor. Period. All that my scheme did was reduce it slightly. Obviously, I had never heard of *transit time*, *electron ballistics*, or *parasitics*. Or any of the other crucial gotchas important for any high frequency design.

Naturally, it never dawned on me for an instant that similar ideas might have occured to RCA's hired help.

Uh, history seems to be repeating itself. First as a tragedy and then as a farce. So we need to talk about…

"Too Good to be True" Results

Let's see. One caller has this zero inductance scheme that is remarkably similar to my zero capacitance one.

There's all of the usual motors and magnets perpetual motion folks.

Another has information traveling faster than the speed of light. One believes that a ridiculous amount of spark advance is all you need for a super efficient gas engine.

Yet another claims an ultra small satellite antenna.

I would really like to reply to all of these people "You are wrong." The outcome is not now and never was in doubt. All that remains is deciding whether you want to find out *how* or *why* you made your error.

Well, figure one shows you my guidelines for dealing with "too good to be true" results.

If you have *any* conductor routed between two points in space, you *do* have inductance. Period. All that a non-inductive winding does is make the inductor physically *larger*.

Nobody, but nobody who has ever stayed awake during the Physics 101 lecture would even dream of trying perpetual motion. Without exception, *each* and *every* attempt to date has failed spectacularly. There is *not one shred of evidence* that such a thing is even remotely possible.

On extreme spark advance, there are few dead horses that haven't been whipped as thoroughly as this one. Try the *SAE Library* for more info.

I got the impression the antenna person never even heard of Doctor Maxwell's silver hammer. Nor read chapter twelve of H. Jasik's *Antenna Engineering Handbook*. Nor have they appreciated the zillions of small antenna failures and outright scams littering all of TVRO history.

An antenna has an *effective area*. There is a specified amount of input energy flux going into that area. You can do no better than grab it all. But even *trying* to grab it all will lead to a bad scene with ugly *sidelobes*.

You want a smaller antenna, raise your frequency and up your transmit power. That's how the DBS folks do it for their new services.

I very much do like to encourage people to think about things and then come up with new ways of looking at problems. And, yes, new or improved antennas are certainly possible.

But results that are "too good" are *always* suspect.

New BASIC Stamps

Lance Wally of *Parallax* just sent me a few samples of his brand new BS1-1C *BASIC Stamp Module*. This is an *entire* computer measuring 0.4 by 1.4 inches. At $29 each. Figure two shows you this stamp's actual size. The schematic for the new stamp is shown in figure three.

Just in case you've come in late, there's a new microcontroller on the block called a PIC chip. These are now clearly *the* hacker component of the *decade*. Under one dollar in large quantities. Dozens of PIC projects already have appeared in print. With hundreds more on the way.

Thanks to an unusual architecture and a minimal RISC instruction set, PIC's *completely* blow away *all* of

0. They are.
1. The primary cause of an outrageous result is an outrageous mistake.
2. The secondary cause of an outrageous result is not having enough tools and skills to understand the problem.
3. Outrageous results *demand* that you make heroic efforts to thoroughly *disprove* them.
4. It is trivially easy to be "not even wrong".
5. Have others ever thought about this problem? When? How?
6. Have you completed a thorough DIALOG search? Do you personally subscribe to most of the industry trade journals? Are you agressively using online resources?
7. What do you know that "they" do not?
8. What are you bringing to the table that is genuinely new?
9. Is hubris a factor?
10. Extreme paranoid secrecy or obsessions with patent "protection" are *certain* to cost you dearly in the long run.
11. If the result *still* looks legit, reduce the effect to its most fundamental terms. Then create a simple and reproducible experiment that some disinterested outsider can verify or disprove.

Fig. 1 – MY GUIDELINES FOR results that are "too good to be true".

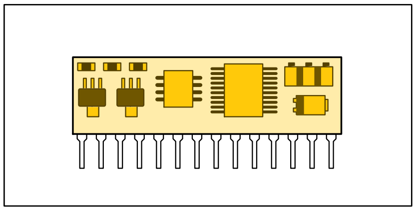

Fig. 2 – NEW $29 BASIC STAMP is a superbly versatile microcontroller. It is shown here full size.

the earlier microcontrollers. Usually with 3X or even higher performance. The same unusual architecture makes it possible to distribute any problem among two or more PIC chips.

The PIC chips are far easier to use than, say, a 555 timer. And lead to *far* lower cost products.

If your circuit has *eight* or more parts in it and if one of them is any active device, then you most likely should use a PIC instead.

As we saw last month, you can easily perform such PIC tricks as a complete digital sinewave generator using only *six* bytes of code.

But the really great thing about PIC chips is that they are simple and fun to use. *None* of the traditional micro hassles remain.

You can easily hand code these without ever going even remotely near an assembler or an emulator. In fact, I strongly recommend that you write *at least* your first 1200 lines of PIC code *by hand*.

For those of you that don't want to jump in with both feet, the BASIC Stamps make becoming micro literate quite easy. After a few of the stamp projects, you can step up to "real" PIC projects with blazing speed.

No matter where you look in the PIC universe, amazing and elegant hacks show up. Note the apparent misprint in figure three, where a logic output becomes the supply pin for another chip. This is in fact a cute power saving trick.

If you aren't immediately using a chip, disconnect it.

I'll get into these a lot more in future columns. But for now, you get started by picking up the free catalog from *Parallax*, the "must have" free *Microcontroller Handbook* and *PIC Applications Manual* from *Microchip Technology*, and the really unique *PIC Tools* and *Stamp Extenders* from *Scott Edwards Electronics*.

As our resource sidebar for this month, I've listed several more key sources for PIC info and applications support. Don't miss this one!

AC Motor Drives

Induction motor speed controls and electric auto drives are both of major hacker interest these days. In both cases, your key secret is to come up with a variable voltage and a variable frequency power sinewave.

Cheaply and conveniently.

Sadly, a plain old linear amplifier will not hack it. Because there's no known linear amplifier scheme that offers any decent efficiency.

Instead, we might want to go to one of the routes of figure four. A dc power supply gets connected to one winding of an ac motor through a pair of switches. These switches are often called a *bridge drive*.

The trick is to flip the switches just right so that your motor thinks it is seeing a variable voltage and variable frequency pure sinewave.

What gets hairy fast is that we'll want to minimize motor *harmonics*. Because harmonics cause power loss, whine, cogging, and even instability. You'll also want to flip your switches as *few* times as possible *per* cycle. Because each flip costs you dearly in *transition* losses.

A classic method of dealing with power sinewaves is known as PWM, short for *pulse width modulation*. A high frequency carrier becomes duty cycle modulated with the sinewave.

The fundamental is *not* present at first. It only appears after you *sum*, or *integrate* up your PWM waveform. Fortunately, the inductance of the motor winding forms a low pass filter which doubles as an integrator. Thus converting the duty cycle variations into a fundamental sinewave.

There'll be no low harmonics if the carrier frequency is high enough.

But PWM does have some nasty habits. Nonlinearities, quantization, or dc offset in the modulation shows up as output distortion. And the high frequency carrier amplitude is *always* larger than the fundamental.

Gruesomely so for low amplitude fundamentals. And there is all that higher frequency energy to contend with. Also ugly are the high number of transitions per cycle.

By using the *magic code* method,

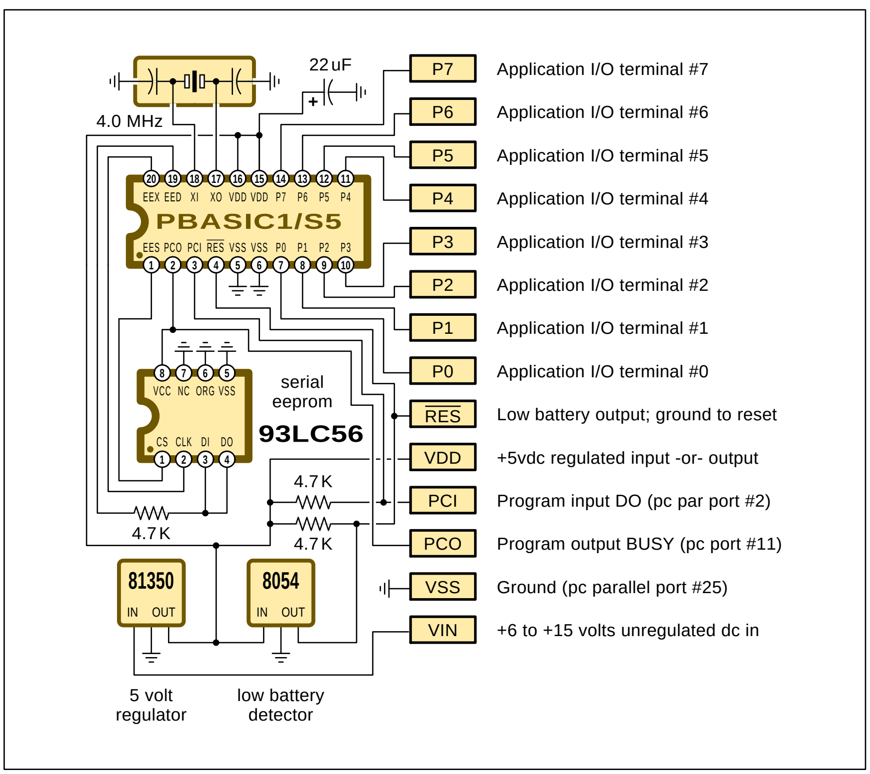

Fig. 3 – BS1-IC BASIC STAMP schematic. This is the first microcomputer that is faster and easier to use than a 555 timer.

you come up with a switch flipping pattern that looks like a fundamental sinewave. The waveform shown is one of the simplest you can build that has a strong fundamental, zero even harmonics, and a zero third. It has very few transitions per cycle. On the other hand, there's only one value available. And it's got a fairly strong fifth and seventh.

Do note that classic PWM changes *both* sides of the bridge at the same time. Even for a comparable number of transitions per cycle, PWM has *twice* or more the losses.

In our simple example shown, the magic code requires only *four* single transitions per cycle, compared to *twenty-four* double ones for PWM. While we can't claim this is "twelve times more efficient", we certainly might say that those high frequency transition losses are only 1/12th as much. And PWM often uses *much* higher frequencies for even worse performance.

Fewer losses, of course, let us use cheaper drivers, lower temperatures, and smaller heatsinks.

Thus, the magic waveform method would seem to be better. *If* we can locate some having lots of different amplitudes and low harmonics.

We saw last month that a magic half waveform of 001011111111010 has no dc term, no even harmonics, no third and fifth, and a fairly weak seventh.

To pick up the other half, you use a code of 00-10-1-1-1-1-1-1-1-10-10. Do this by reversing your bridge to run your current *backward* through the motor winding.

All of which is a good start. Go through the 30-bit math, and you'll also find that 000110111101100 has around 83 percent amplitude and that 000101011010100 has got around 62 percent amplitude. Equal to 69 and 38 percent power. While still keeping a zero third and fifth. Plus, of course, good old trivial 000000000000000 for the zero amplitude.

Which gives us four amplitudes to work with at 30 bits. For many aps, you'll want a lot more than this. The obvious thing to do is increase the number of bits in your word. It turns out that words that are *products* of low harmonics can force all of those harmonics to zero.

The most obvious next stopping point is a 105-bit half word. Because 3 x 5 x 7 equals 105. Now, there are a *lot* of possible 105 bit words. Rows and rows of them even. But it turns out that only a mere 2219 or so of them end up with zero third, fifth, and seventh. These also have zero ninth, fifteenth, twenty-first, and such. Plus no dc term and no evens. Which means that harmonics 0,2,3,4, 5,6,7,8,9,10,12,14,15,16,18,20,21, and 22 are all zero.

And that ain't half bad.

Some of the magic sinewaves will have too much distortion. Others will have too many transitions. And yet others won't hit the amplitudes we want. Or cause amplitude jitter.

But if you go through the list, you can pick out 103 or so magic sines per our list in figure five. These give you roughly one percent amplitude control. And have far fewer losses than PWM.

To use this list, you "unfold" the strings to get magic words of length 210. You then stash these in a table lookup memory somewhere. Pick a magic word for an amplitude. Pick a selected delay for a frequency. And that's all there is to it.

If really needed, the few "missing" words in figure five can be gotten around by going to 420 bits.

NEED HELP?

Phone or write all your US Tech Musings questions to:

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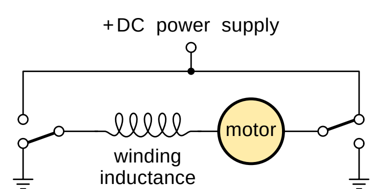
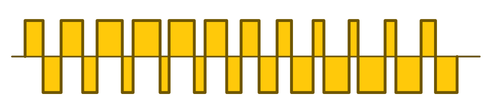
Howdidyadoit?

With PostScript and an Apple IIe, of course. How else are you going to exhaustively explore all possible 210 bit binary words?

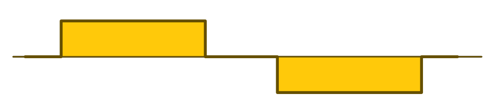
As always, I've found PostScript's friendly interactivity to be *the* way to solve a seemingly sticky problem.



(A) The object of the game is to flip the switches as few times per cycle as possible, while still convincing the motor it is seeing a clean sinewave having the desired alternating current frequency and amplitude.



(B) With the "PWM" method, a high frequency carrier gets integrated by the motor's inductance to produce the desired waveshape. While amplitude is easy to adjust, there are many efficiency degrading transitions.



(C) With the "magic waveform" method, a shape having a desired fundamental and acceptable harmonics gets used. This example has no third or even harmonics. The transitions are few, but it is tricky to find useful values.

Fig. 4 – TWO APPROACHES to high power adjustable sinewaves.

As with all sticky problems, once you get inside, things simplify a lot.

Ferinstance, to end up with zero even harmonics, we have to have half wave symmetry. Which drops us to 105-bit words. For easy analysis, we want quarter wave symmetry. Giving us sine terms only. Which drops us to 52-1/2 bit words. We deal with the half bit by always splitting a zero.

This leaves us with a 52 bit word. A mere 4,503,599,627,370,496 states to run a full Fourier Series on. All in all, this still might make for a fairly long Postscript evening.

But wait. We can easily write 17 equations that force a zero third. And 10 equations for a zero fifth. And 7

This table of "magic" values can be used to generate efficient digital power sinewaves having very low distortions and minimum state transitions. Important uses include induction motor speed controls and electric automobiles…

00 - 0000000000000000000000000000000000000000000000000000
01 - Not available yet
02 - Not available yet
03 - Not available yet
04 - Not available yet
05 - Not available yet
06 - Not available yet
07 - Not available yet
08 - Not available yet
09 - Not available yet

10 - 00100000000000000000001000000000000001000000000100000
11 - Not available yet
12 - 00000000000000000100000000000000100000100000000000001
13 - Not available yet
14 - Not available yet
15 - Not available yet
16 - Not available yet
17 - Not available yet
18 - Not available yet
19 - 00001000000000000000010001000000000100010000010001000

20 - Not available yet
21 - 00000000000000100000100000000000011100000000000001100
22 - 00010000000000000010000010000001000000110000001000001
23 - 00000100000000000000100000100100000000000110010000000100
24 - 0000000000100000000000100100000100000100000101100000
25 - 01000000000000001000001000000010000011000010000001100
26 - Not available yet
27 - 01000000000000001000100000000011000001000110000000110
28 - 00001000000000001000000001100010000000011000110000010
29 - 00000000100000000000001100000100000101000001100001100 0

30 - 00000000000100000001000001000011000000011000011000010
31 - 00100000000000001000001010000000000111100000000101100
32 - 00000001000000000001000001100000100010001001001100000 1
33 - 00000000010000000000011000000011000010000110010000110 0
34 - 00100000000000000110000000100001100000101100001000001 1
35 - 00000010000000000010001000001100010000010011100000100 1
36 - 00000000001000000001100000000111000000011100010000110
37 - 01100000000000100000001010000110000001100011000011100 0
38 - 00000001000000001000000010011010000010000011110010010 0
39 - 00000000000000110000000000110010000011100000100110110 00

40 - 00100000000010000001000001100001100000101100001110000 1
41 - 00001000000000000110000000110001010000011100011000001 1
42 - 00000000000100000101000001000011100000111000011000001 1
43 - 01100000000010000000000111000010001000111000100011110 00
44 - 00000001000000000001110000000001110001000111100000001 11
45 - 01000001000000000001100011000000011001110010000110001 1
46 - 01100000000010000000111000000110000111001100000011110 0
47 - 00000010000000000110000010011000011000110010110010001 1
48 - 00000000000100001100000000110001110000011100011100001 1
49 - 00100000000000110000000001110010000011110000100111110 00

50 - 00001000000000001100001000110001000111001100011000111 0
51 - 00000000010001000000001011100000001111100000001111110 00
52 - 00010000000000001110000000011011100000011110110000011 1
53 - 00000010000000001100001000011101000101000111110000111 0
54 - 00000000001000001100100000100111100000111100110000011 1
55 - 01100000000010010000011000011110000011001111000111100
56 - 00000000110000000000001111100000001111100000111111100 0
57 - 00000000100000100001101000001110001110001111000011110
58 - 00100000000100001100000101100011100001111000111100011
59 - 00110000000000011000000111001100000111110001100111110 0

60 - 00000000001100000001100100100111100000111100111100110
61 - 00010000010000010000011110010000011111100001101111100
62 - 01110000000000110000001110011100000111100111001111100
63 - 00000000010001000100010111000000111111100000111111001
64 - 00000110000000000100011100011100001101100111110001111 0
65 - 00000000110000000001001111000100011101110001110111100 1
66 - 00000000010000011010010000011111010001011111100001111
67 - 00100000000000011110000000010111110001010111110100011 11
68 - 00000000110000000100011111000000111111100001111111100 1
69 - 01000000001100000000111100000111110001011111001101111 0

70 - 01100000000000011101000001100111100011101111001100111 1
71 - 01110000000000100110000011110011100001111110011111001 1
72 - 00000000000110001100001001110011110001111001111110011
73 - 01100000000100000110011100000111110001111111001001111 1
74 - 00000010000000110100000011111100001111100011111111101 0
75 - 00000000000100111000001100111000111111000111011111110
76 - 00010000000000010111000100001111110010101111111000111 11
77 - 01110000000100010001011100011111000011111111001111110
78 - 00100010000000011100000011111101000111100111111110111 0
79 - 01100000000110000000011111000011111000111111100111111 10

80 - 00000001100000010011000111100111001110011111111110011 1
81 - 00000000000110011000011001110011011111101100111111111 0
82 - 00001000011000000000111110001111011000111111111101111 10
83 - 01110000000010001100001110011111100001111111110111111 0
84 - 00000000011000001100111000011111110001111111111001111 1
85 - 01100000000110000100011110010111110001111111011111111 0
86 - 00000010000000110110000011111100011111100111111111101 1
87 - 00000000000011010001110100001111111010111111100111111 1
88 - 00110001000000001110000111111001100111111101111111011 1
89 - 00000000101100000000111110010111110101011111111111111 0

90 - 00100010000000011110000011111101010111110111111111011 11
91 - 00000110000000010110010101111100011111101111111101111 1
92 - 01000100000010001110001100111110111001111111111110111 11
93 - 00000000000011001110001100111001111111111110011111111 1
94 - 00000100100100000001111110010110111101111111111011111 11
95 - 00110000000000111010100011101111100111111111110111111 11
96 - 00001100000000110001110011110110011111111111101111111 1
97 - 00000100100100000101111101100101111111111110111111111 1
98 - 00001000000001011101000101111101011111111110111111111 11
99 - 00000000010001110101000111011110111111101111111111111 1

100 - Not available yet
101 - 00000000111000000001111111000111111101111111111111111 1
102 - 00001100100000010001110111110110011111111111111111111 1

210-bit values shown in approximate one percent steps. Each listing consists of a zero followed by 52 active bits. To form the first half cycle, MIRROR the listing and REMOVE THE FINAL ZERO, giving a 105 bit half word.

To form the second half cycle, duplicate the first half, replacing each 1 with a -1, completing the 210 bit word. Do NOT mirror the second half!

To use, stash the words in a table lookup memory and pick the one you want.

More details (including full spectral analysis) in MAGIC210.PS, FOURIER.PS, ZEROHARM.PS and SNCAT420.PS on GEnie PSRT.

Fig. 5 – 103 MAGIC POWER SINEWAVES. Shown as one percent amplitude steps. Harmonics 2,3,4,5,6,7,8,9,10,12,14,15,16,18,20,21, and 22 are ZERO. Harmonics 11 and 13 are tame. Few transitions give good efficiency.

PIC MICROCONTROLLER RESOURCES

Advancd Transdata Corp 14330 Midway Road #128 Dallas TX 75244 (214) 980-2960	**ED Technical Publications** PO Box 541222 Merritt Island FL 32954 (407) 454-9905	**Microchip Technology** 2355 W Chandler Blvd Chandler AZ 85224 (602) 963-7373	**Parallax** 3805 Atherton Rd, #102 Rocklin CA 95765 (916) 624-8333
CCS PO Box 11191 Milwauke WI 53211 (414) 781-2794	**Scott Edwards Electronics** 964 Cactus Wren Lane Sierra Vista AZ 85635 (602) 459-4802	**microEngineering Labs** Box 7532 Colorado Springs CO 80933 (719) 520-5323	**Picard Industries** Box 61 Clarendon NY 14429 (716) 589-0419
Circuit Cellar Ink 4 Park Street #20 Vernon CT 06066 (203) 875-2751	**Electronics Now** 500-B Bi-County Blvd Farmingdale NY 11735 (516) 293-3000	**Nuts & Volts** 430 Princeland Ct Corona CA 91719 (714) 371-8497	**Zeta Electronic Design** 18 Bismark Street Manchester NH 03102 (603) 644-3239

for a zero seventh. 34 equations in 52 unknowns should, in theory, reduce to one equation in 18 unknowns.

262,144 states or so.

Which still might need a break or two for coconut anchovy pizza.

Instead, we think smarter and not harder. These are *general* equations. But *all* of our inputs and *all* solutions have to end up *binary* ones and zeros. You can thus eliminate some of these words immediately and test for the rest. Which quickly generates all the 2219 possible candidates.

You then run your Fourier Series only on the good ones. Leaving you with a few hours work at most.

Full details are on *www.tinaja.com* in FOURIER.PS, ZEROHARM.PS, and SN210CAT.PS. Plus a few others.

Many thanks to math genius Jim Fitzsimons for his valuable inputs on all this. Yeah, we've got consulting services available for this exciting new hacker topic. A kit or two may also be in the works.

Surely others have plowed some of this ground before. If you know of any tech papers on power waveform harmonics, plase send them to me.

For a free *Incredible Secret Money Machine II* book copy.

Now, the real challenge is to find the improved 440 bit magic word list. Which should give us fewer losses, lower distortion, and more choices. Yet still keep reasonable 26.4 kHz switching frequencies.

This one might take a tad longer, though…

New Tech Lit

From *Sony*, a bunch of new data books. Including their *Multimedia Computer Audio/Video*, *CCD Area Sensors*, *CCD Linear Sensors*, and *Radio Communications IC's*.

From *Motorola*, a new *Rectifier Applications Handbook*. It includes some mind numbingly obsolete filter design info.

They completely missed the fact that you can *instantly* design any 60 Hertz full wave filter cap simply by memorizing this factoid: In an 8300 microfarad capacitor, your *volts* of ripple equals the *amps* of current.

Marvin Simon's *Spread Spectrum Communications Handbook* offered by *McGraw Hill* does seem to be the definitive tome on the subject.

All 1228 pages of it.

This textbook clearly shows the military jamming heritage of spread spectrum comm. For it takes them until page 1186 or so to get around to mentioning that there *might* be some commercial uses for this stuff. For a totally different approach to the same subject, check out Randy Robert's *Spread Spectrum Scene*.

From Dave Strom, a new *Power Up* book on making battery adaptors for military surplus radios. Pub by *CRB Research*.

That *Scientific American* mag for January 1995 has a great project on sonoluminescence. In their *Amateur Scientist* section. Costs are in the hundred dollar range. Useful results should be obtainable in any fairly advanced home lab.

The fusion energy potential for sonoluminescence is talked about in

NAMES AND NUMBERS

Anomalous BBS PO Box 228 Kingston Spr TN 37082 (615) 952-5638	**Electric Spacecraft Journall** 73 Sunlight Drive Leicster NC 28748 (704) 683-0313	**McGraw-Hill Bookstore** 1226 Sixth Ave New York NY 10020 (212) 512-4100	**Scientific American** 415 Madison Avenue New York NY 10017 (212) 754-0550
AVIOS 4010 Moorpark Ave #105M San Jose CA 95117 (408) 248-1353	**GEnie** 401 N Washington St Rockville MD 20850 (800) 638-9636	**Motorola** 5005 E McDowell Rd Phoenix AZ 85008 (800) 521-6274	**Sony Semiconductor** 10833 Valley View Street Cypress CA 90630 (714) 220-9100
CRB Research PO Box 56 Commack NY 11725 (800) 656-0056	**Historically Brewed** Historical Computer Soc 2962 Park Street #1 Jacksonville FL 32205	**SAE** 400 Commonwealth Dr Warrendale PA 15096 (412) 776-4841	**Spread Spectrum Scene** PO Box 2199 El Granada CA 94018 (800) 524-9285
Dialog Information Svc 3460 Hillview Ave Palo Alto CA 94304 (415) 858-2700	**Kleinhuis North America** 7526 Relience Street Worthington OH 43085 (800) 544-2105	**Science/AAAS** 1333 H Street NW Washington DC 20005 (202) 326-6400	**Synergetics** Box 809 Thatcher AZ 85552 (602) 428-4073

Science of December 16, 1994, p1804. Sonoluminescence can routinely hit a million degrees C and a 100 million atmospheres. All in a flask.

Of course, I did tell you all about sonoluminescence long ago. More in HACK73.PS on *www.tinaja.com*.

Lots of info on *bright* blue light emitting diodes in the January 6, 1995 *Science* on pages 51-55.

Few people are aware that LED's are potentially five to ten *times* more efficient than an incandescent lamp. As auto taillights, LED's are also *much* safer. That quarter second or so turn on risetime of an incandescent lamp translates to *twenty feet* of delayed warning at thruway speeds!

For info on speech synthesis and recognition, check into the *AVIOS*, or *American Voice I/O Society*. Their next applications conference will be Sept. 12-14 in San Jose, CA. Journals, proceedings, and vendor's directories are also offered.

The *Electric Spacecraft Journal* is one interesting pseudoscience pub. There is also an *Anomalous BBS* on related off-the-wall topics.

Historically Brewed is that unique magazine offered from the *Historical Computer Society*. $3 trial issues.

Free *P-Nut* connector samples are available through *Kleinhuis North America*. These are a long overdue improvement to wire nuts.

For most hardware hackers most of the time, patents are an utter and total waste that is *guaranteed* to cause you a net loss of time and money.

The reasons behind this along with fully tested and proven real-world alternatives now appear in my *Case Against Patents* package. Which also *includes* my *Incredible Secret Money Machine*. Details are found in my nearby *Synergetics* ad.

A reminder that unique downloads, freebie insider secrets, catalogs, and technical help are available on my *www.tinaja.com* Details in that *Need Help?* box.

As usual, most of these resources I've mentioned appear in the *Names & Numbers* or that *PIC Resources* sidebars. Be sure to check here first before you call our no-charge US technical helpline.

Let's hear your comments on some of these new opportunities. ✥