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## Write for Polyphony

..... It's not something that you'll get rich at, but, nevertheless, we are paying at the rate of \$25.00 per printed page for feature articles including such things as circuit modifications, new circuits, narratives, how to articles, etc. All material submitted must be original and never before published. We are also paying \$5.00 for each patch accepted for publication. Payment is made upon publication. We cannot assume the responsibility for the return of manuscripts unless specifically requested and supplied with a stamped self-addressed envelope for its return. All accepted materials and associated copyrights become the sole property of Polyphony and may not be reproduced without written permission from the publisher.

# LETTERS:

## SYNTHESIZERS FOR THE MODERN COMPOSER

Dear Polyphony,

I am one of those saving pennies for a computer system to realize my dream music, so I really appreciated both the D/A Converter article and the Lab Notes on computer music without the computer.

Please have Polyphony do more articles on non-performance oriented music systems. I am trying to design and then build the cheapest possible microprocessor-based synthesizer; or as I fancy it "The Digital Orchestra". Seriously, I will probably have to have someone build it for me - although I think I could come close and am certainly going to try.

Eight years ago when my music theory teacher told us that Bell Telephone had made a computer synthesize all sounds - natural or not, with any theoretical morphology (attack-sustain-decay characteristics) possible, etc., I thought - in fact our whole class thought - that all synthesizers would be like Bell Telephone's work of love (our teacher was a profound idealist). Anyway, when I learned about Moog's synthesizer I was completely disappointed; same with the Arp, Buchla, Aires, etc., but you guys (PAIA) seem like you're willing to give the people what they want, for a price that sounds great.

In my Music Theory class we were exposed to a lot of modern experimental music and became used to a musical world that used chromatic scales of 24 and more tones; chords, or, more appropriately tone-clusters or sonorities, built of, say, 84 different simultaneous pitches; the general rhetoric and syntax of another galaxie (or so it seemed at first). We were shown how modern music evolved from traditional music. It soon became clear that in order for the modern music to be performed accurately, it would require an orchestra of the world's greatest virtuosos - more likely, superhuman players. See how well your favorite violinist can whip through Alban Berg's Chamber Concerto, and then thank him or her, for they will be nearly dead from just 30 minutes of astonishingly demanding violin playing. I mention Berg's Concerto because he was one of the forerunners of modern music, and he wrote this masterpiece around 1925, and to "traditional ears" it is still rather rough going (forgive my condescending tone). However, after Schoenberg, Berg and Webern broke the ice, all hell really did break loose, and

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## IS THIS THE NEW FOLK MUSIC?

About a month ago we got the first copies of the new Craig Anderton Music Tape. We had a lot of fun listening to it, picking out special effects, figuring out how he got certain sounds, and all the usual fun things you do when you listen to a new album or tape. But, as we listened to it more, we began to speak of the music/concept/accomplishment in strange terms. We were searching for some way to summarize the unique experience we were having. Then John happened to say something about "new folk music. Huh? Hey, that's what it is. It suddenly dawned on us that we are on the front edge of a new wave of music -- tomorrow's folk music.

Thinking back through time, typical examples of folk music would be the backwoods-style bluegrass music, bag-pipe bands of Scotland, the acoustic guitar accompanied protest songs of the '60's, and so on. The primary similarity between these types of music is that they were originally performed purely for the pleasure of the performer or a small gathering of his peers. Folk music represents as personal a musical statement as can be made, because folk music tries to buck as much of the established commercialism of society as possible. Another important factor of folk music is that the performing musician generally prefers as little interference as possible from the outside world. He wants to do as much of the musical accompaniment as possible. This is why piano and guitar are so popular. They sound good by themselves; one performer can play these instruments and still sing his song. He becomes a one-man-band. Are you beginning to see the similarities between all this and what you are trying to accomplish with your synthesizer and tape recorder? You should.

Craig is one of the first to carry the new folk music to a point where he is actually distributing the results of his work. But, in traditional folk style, he chose to bypass the hassle of trying to get a contract with a commercial record company, and he asked us to tell all of you about the tape and try to sell a few that way. At first, the approach may seem a bit clumsy -- I mean, an electronics company selling prerecorded tapes. But, Craig knew that the readers of Polyphony would be the type of people who were most interested in listening to his type of "home-made" music.

From reading the trade magazines, it looks like there is an increasing  
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### ON THE COVER:

A cartoon by Bob Yannes shows a perplexed likeness of See Threepio looking on as an Artoo Deetoo-type robot plugs into a PAIA P4700/J Computer-Synthesizer for a friendly exchange of memory contents.

# POLYPHONY REVIEWS!

## "The Craig Anderton Music Tape"

Many of you are familiar with some of Craig Anderton's work. Perhaps you read his monthly column in Guitar Player Magazine. His book, "Electronic Projects for Musicians", was a welcome sight to many frustrated music experimenters. Or it could be that you have run across some of his free-lance design/application tutorials which he frequently whips up for the likes of Popular Electronics, Radio-Electronics, Polyphony, Electro Notes, Synapse or Contemporary Keyboard. Well, I suppose that by now you are wondering what a guy like this does in all his multitudes of spare time. For the last year or so, the answer has been writing another book and recording an album (tape). The two projects are somewhat intertwined, and should be of invaluable assistance to any serious electronic musician. The book, to be published early this fall, is entitled "Home Recording for the Musician". The tape is called "The Craig Anderton Music Tape", and it proves without a doubt that he was the proper guy to write the aforementioned book!

The music on the tape is all original, displaying yet another of Craig's many talents. The flavor of the music varies widely, from the intricately orchestrated patterns of "Dog Dreams" to the Martian reggae of "Roy Herful" to the heavy metal rock undertone of "Leave 'em Laughing". Craig's mastery of tape techniques is

showcased by the intricate mixing of a dozen or more tracks on most songs, and by the amazing number of hidden subtleties that require a dozen close listenings to discover. Outstanding instrumental performance is rounded out through the use of home made electronic drums and commercial goodies such as the E-Bow to put the proverbial frosting on the cake.

The age of the self-sufficient one-man-band is upon us. Craig has set very high standards for us.

The Craig Anderton Music Tape is available exclusively from PAIA Electronics for \$5.95 plus 50¢ postage.

"If you would like a taste of the unique sounds on the Craig Anderton Music Tape, give a call to the Paia Demo Line, (405) 843-7396. Charge card orders or catalog requests can be left after listening to Craig."

## XENHARMONIKON

XH (as their readers call it—you don't think I'm going to spend my day typing this review, do you?) is published semiannually by John H. Chalmers, Jr., 10919 Shannon Hills Drive, Houston, TX 77099. The publication is organized primarily as a place to discuss musical ideas which are not commonly accepted or recognized by the general public or musical instrument manufacturers. The primary thrust of XH seems to be the use of tunings

and temperaments other than the 12-tone equally tempered scale.

Along these lines, additional material in XH deals with how to construct instruments in new tonalities, how to write down these new breeds of sounds, and quite a bit of discussion of theory and calculation behind new types of tunings.

Sample titles from the two issues I reviewed include:

"An approach to the construction of Micro-Tonal Brass Instruments—the French Horn"

"The Pitches of Meantone Assigned to the 19-Note Generalized Keyboard"

"Cyclic Scales"

"Specifications of the Secor Generalized Keyboard Scalatron."

For those of you interested in the world of microtones, I would highly recommend this magazine. The people who are responsible for XH the musical horizons. They take an active interest in teaching the theory (both musical and mathematical) behind new tunings, and how to use that theory to build real world instruments to play the new music.

For more information, write to John Chalmers at the address given above.

Back issues are available for XH #4 and XH #5. Issues #1 thru #3 are temporarily out of print, however they may soon be reprinted as one volume. Issue #6 is to be released by the end of this year, and will cost about \$3.

## LETTERS!

continued from page 2.....

this is the point: fifty years after Berg's masterpiece, the last thing a modern composer is interested in is a synthesizer based on a traditional piano keyboard. We could care less if it is equally tempered, uses just intonation, or the opinion of the guy down the street; we want all the pitches.

That's why we're going for computers, learning digital logic, programming languages, calculus and wishing we'd studied electronics as well as music. At least that's why I am.

I'll try to make it short: ever since Popular Electronics came out with those features on micro-computers, I knew I could build the synthesizer system which could "play" the music I had in my head, (and on paper) - at least, I could learn

enough to tell someone who knew electronics just what I wanted.

Sincerely,  
Brian Hartzler

### AUTOMATED MUSIC TYPOGRAPHY

Dear Polyphony,

Two years ago KVB spent \$6,000 - \$7,000 on a study of the economics of automated music typography. Our conclusion was that we could not compete with those already in the business (only one of whom is automated on a commercial scale).

It occurs to us that the economics would be favorable if two conditions are met:

- 1) quality should be equal to that of manuscript rather than to fine engraving
- 2) the music should be generated by the composer/arranger in machine

readable form so that transcription into the computer is not necessary

Toward that end I have begun design of a music type font for KVB's Printronix dot-matrix printer. If a suitable standard language and format for cassettes were developed, KVB could print music as a service to people who have computer controlled synthesizers. The article I discussed with you on existing computer-music languages should give us some ideas for such a standard medium of communication.

Sincerely yours,  
Charles A. Bodeen  
Asst. Controller  
KVB, Inc.

Editors Note:

The article Charles mentions in his letter will hopefully appear in an upcoming

.....continued on page 19

# SPOTLIGHT

## PROFESSIONAL SYNTHESIZER CONSULTATION

Those of you in the New York/New Jersey area may already be familiar with the work of Doug Slocum and Synthetic Sound Labs (108 2nd Ave. 4C, Bradley Beach, N.J. 07720). Doug has been doing design modification and repair of electronic musical instruments for seven years. His unique Fourth Oscillator addition and Oscillator Sync Switches for the Mini-Moog are present on systems belonging to Chick Corea and other professional noteables who have heard of the reputation Doug has built up. Synthetic Sound Labs is an authorized service center for Paia equipment, as well as Moog, Arp, and a growing list of others.

Doug is currently delving into microprocessors and home computer systems so he will be able to provide consultation and interface information for those of you interested in computer controlled (or generated) synthesis. Before too long, Synthetic Sound Labs will be moving to larger facilities. At that time, Paia equipment will be available for demonstration and purchase, including the new digitally controlled systems. Being a musician himself, Doug can be a tremendous asset for those of you who are musicians with little understanding of the technical side of synthesizers. There have been several instances where musicians came to Doug asking for purchase



Larry Fast looks on as Doug Slocum pumps out some riffs on a PAIA P-4700J.

recommendations, and since there was nothing on the market to do the job — Doug built one. His full trap set percussion synthesizer is but one recent example. Those who already have equipment, but find themselves being limited by the manufacturer's design, can make use of Doug's ingenious modification and expansion concepts to broaden

your horizons without having to purchase a new system. When it comes to repairs, even if Synthetic Sound Labs isn't an authorized service center for your equipment, it would probably be well worth the money involved to have the work done by someone with as much involvement in synthesis technology as Doug Slocum.

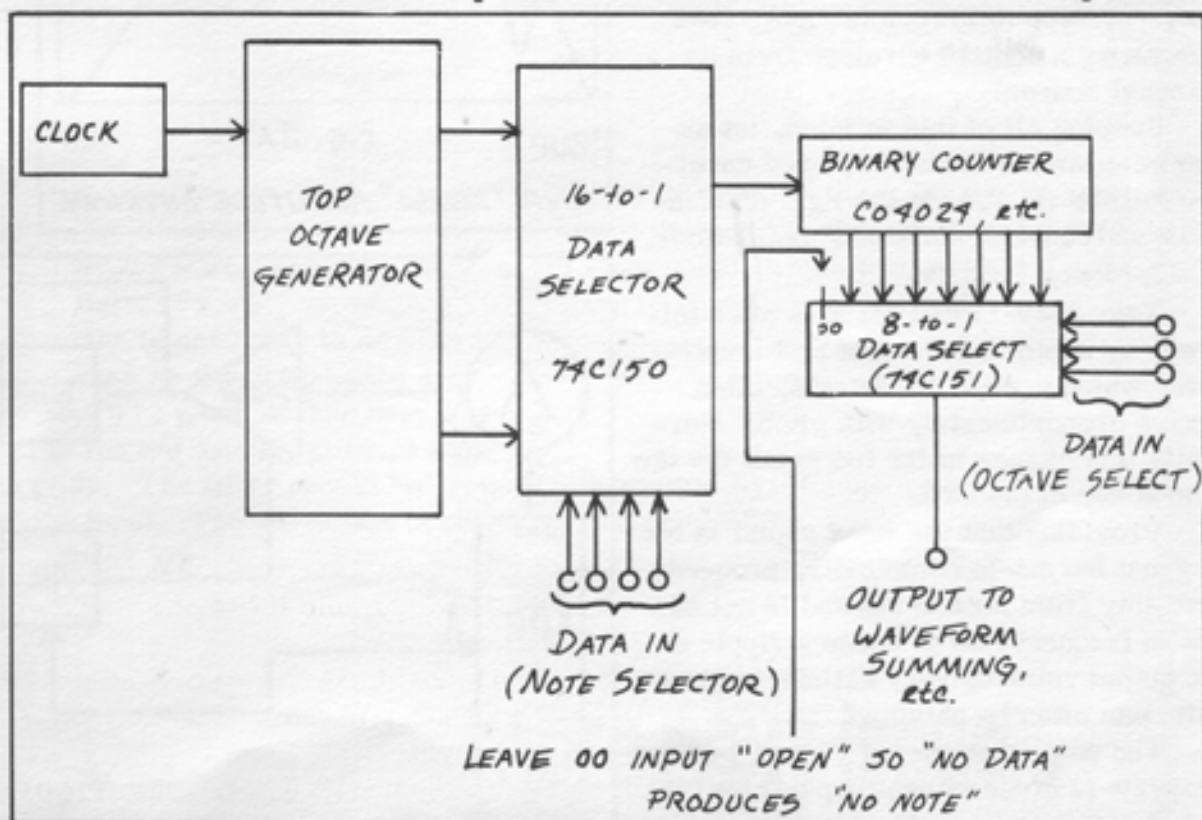
## DATA TO MUSIC CONVERSION

### A Low Cost Peripheral Circuit For Your Computer

By: Charles Fischer

I've enclosed my solution to the Data-to-Music problem. It uses the top-octave kit, a couple of Data Selectors and an 8-bit Binary Divider. With it, a 7-bit binary number can produce any equally-tempered note in a 7-octave range. By multiplexing the input data at a rate well above audio levels, Polyphony can be simulated. By using the circuit with a PLL circuit, intermediate tones, portamento, and other FM effects can be produced. Unfortunately, I have not found any decent info anywhere on using the CD4046 with the Top-Octave Generator.

But the best part of the circuit is it's simplicity and economy. The remaining data bit (in an 8-bit system) can be used for triggering envelope generators, so a quite advanced polyphonic system can be produced.



# THE SENSUOUS ENVELOPE FOLLOWER

by John A. Mitchell

Now that I've got your attention with that title, let me ask you, what do you use your envelope follower for (providing you use it at all)? I'll bet quarters to quadrature oscillators you've answered, "To convert external sound sources into control voltages for use by voltage controlled elements" and you would be right. Fact is, most folks use their envelope followers for precisely that; you plug a guitar, microphone, or what have you, into the thing and out comes a proportionate voltage with the same amplitude envelope as the input (plus a trigger and gate on better models). Usually this voltage is used to control the element through which your external signal is simultaneously being processed. This is fine -- after all, an envelope follower is primarily designed to be used in such fashion, but remember that the single-minded use of any music module is uncreative and contrary to the spirit of music!

One of the beauties of the synthesizer is that it is, as Dr. Moog would say, "Not an instrument, but a collection of instruments" which may be exploited in a variety of ways. The envelope follower -- one of those instruments -- should be no exception. For instance, would you use your LFO solely for producing vibrato in a voltage controlled oscillator? Of course not! You most probably have used it to modulate your VCA, PWM, filters, you name it -- yet I have known people who wouldn't hesitate to use their LFO's in the most bizarre applications, but would not even conceive of using their envelope followers for more than generating a control envelope from an external source!

Keeping all of this in mind, let us now re-examine the underplayed envelope follower (E.F.), in the light of creativity and consider some new applications.

## I. Pitch Follower.

Your 2720-11 can act as a pitch follower by exploiting the fact that amplitude, which your E.F. detects, often varies proportionately with pitch. Normally this change is far too small for the human ear to discern.

Providing that the input signal is not of great harmonic complexity, proceeds smoothly from note to note and is not so low in frequency as to cause a ripple on the output voltage, very satisfactory results can often be obtained.

The patch diagram of Figure 1 shows the 2720-11 in use with the popular SWTPC

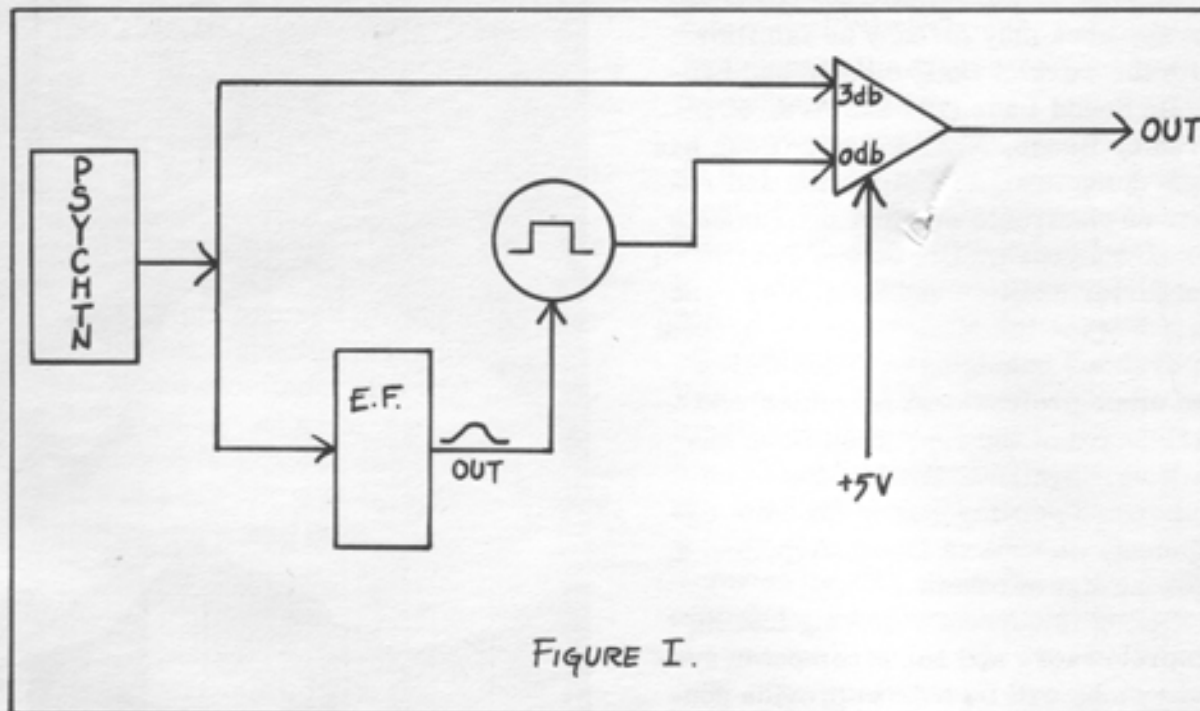
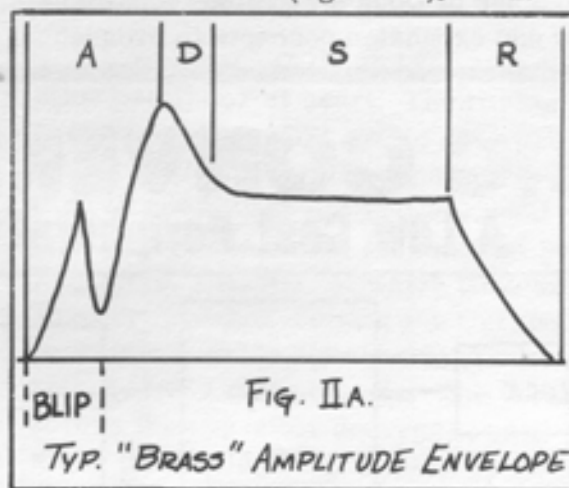


FIGURE I.

"Psychtone" composer-synthesizer. By adjusting the Psychtone's pitch and/or volume knob(s), the VCO may be set to track at a variety of intervals. With careful adjustment of the controls, the VCO will match the psychtone note-for-note producing a beautiful choral effect.

## II. Horn Blips/Timbre Modulator.

A "horn blip" is a short duration transient which precedes the normal amplitude envelope on notes produced by brass instruments (figure 2a). This



phenomenon gives them their characteristic "bite". The synthesis of brass instruments usually requires an ADSR to generate the primary envelope and an AR to create the horn blip -- the outputs of both instruments being summed in the VCA -- but by once again calling upon the multifarious envelope follower, it is possible to create a "brass" envelope, complete with horn blip, with the AR alone. Here's how it works: As the amplitude envelope begins to rise, the voltage fed to the PWM causes a corresponding change in duty factor. As the voltage continues to rise, the pulses widen at the peaks and narrow at the troughs. When the maximum value on the attack portion of the control waveform is achieved, the envelope follower "sees" only the crests of the pulse waves, as their "off times" are far too short for it to follow. The E.F. considers the sum of the long "on times" as D.C. and because it cannot pass D.C., there is no output. On the decay portion of the AR

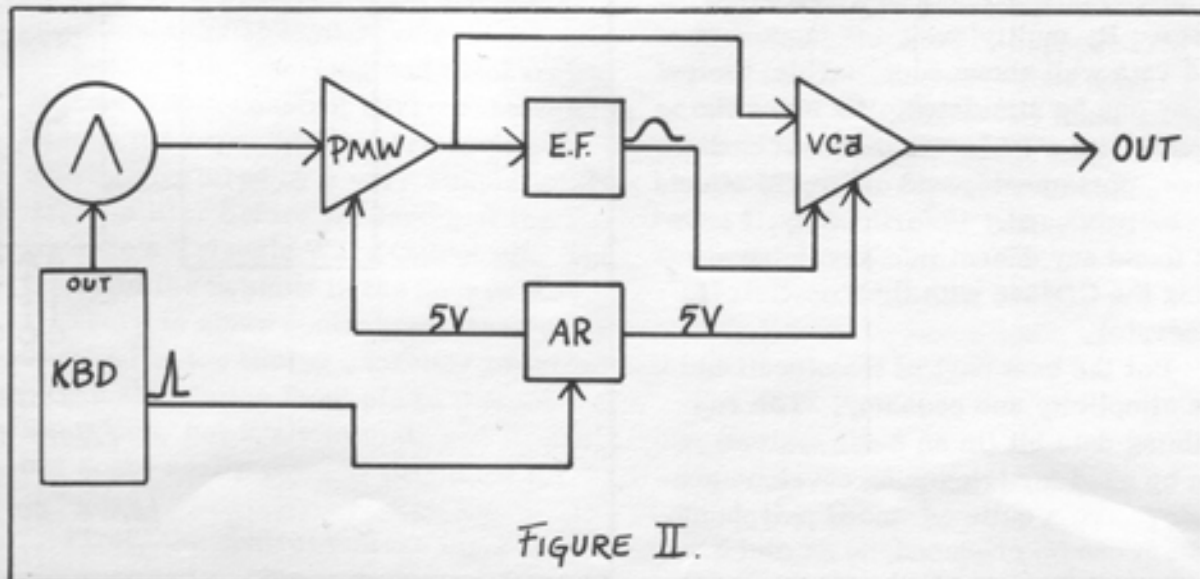
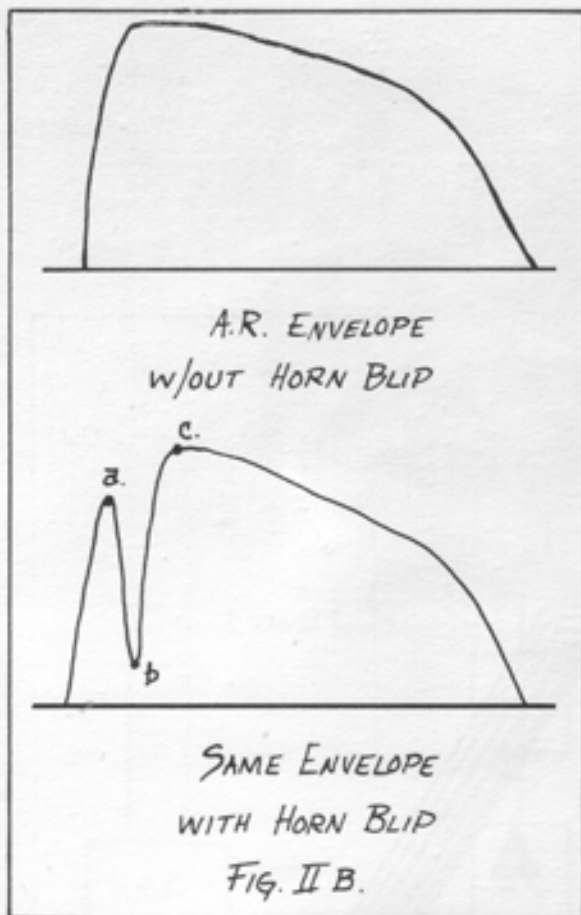
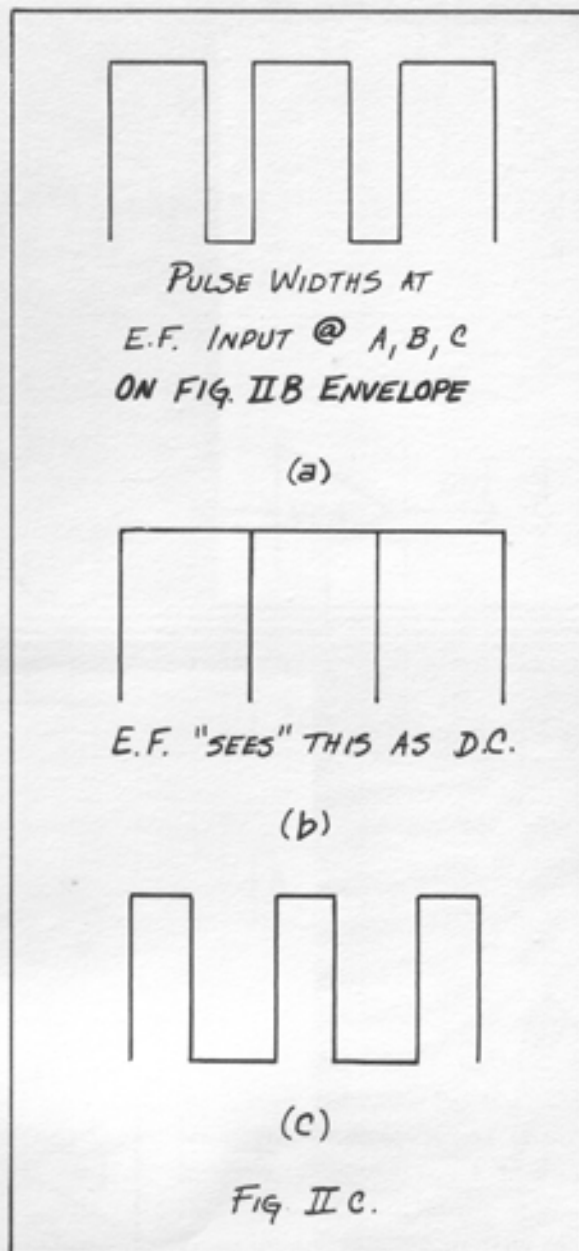


FIGURE II.



generated envelope the process reverses and sound is gradually heard again (in practice, this whole cycle happens quickly and the effect is that of a short duration AR envelope preceding the normal envelope). One nice thing about this patch is that if you own an ADSR you can use it to vary other parameters such as filtering while your AR unit simultaneously creates the horn blip/amplitude envelope. With the addition of filtering, and by playing with the AR settings (a little vibrato sometimes helps also), you can synthesize some pretty decent french horns, tubas, and trumpet-like effects. Try it!

Should this article accomplish nothing else, I hope that it will inspire the reader to experiment with the envelope follower as a timbre modulator. Start with the "Horn Blip" patch, but substitute a filter or even a ring modulator in place of the PWM. Note how adjustment of the E. F. sensitivity control affects the tone color. You will find the inclusion of the envelope follower as a harmonic modifier in your patches will open up whole new worlds of timbre for you



-- many of my most complex patches are realized in this way. Experiment!

### III. "On the Road to Thunder"

Glancing through past issues of "Polyphony" brings me to the conclusion that many readers are obsessed with getting a realistic thunder sound. For some the search may be over, as the patch of Figure 3 produces an excellent thunder imitation -- not just another variation of the "galactic explosions" effect.

To understand why this patch sounds realistic, think for a moment about the nature of thunder. A small electric arc produces not a steady tone, but a string of closely spaced pops and clicks because the electrons jumping the gap from negative to positive meet with variable atmospheric conditions along the way (hum-

idity, dust, ions, etc.) hence they do not flow in a continuous stream, but rather in a series of "fits and starts" the resulting sound being equally as random. Lightning can be thought of as a spark on a much grander scale. As it tears its way through the ether, the sudden heating and resultant expansion of air produces that succession of closely spaced explosive sounds called thunder. The rumble that we hear after the initial "crack" is due to varying reverberation times from mountains, buildings and other obstructions. These obstacles also serve as natural low-pass filters. It is interesting to note that due to such topographical intervention, thunder in one part of the country may sound radically different from thunder in another area.

The thunder patch derives its realism mainly from the "popping" effect achieved when the 2720-11 tries to follow the ever-changing envelope of filtered noise. The E. F.'s inherent low-pass response coupled with additional filtering by the 2720-3L results in a smoothing action which produces the necessary rumble. This effect is most effective if you:

- Use the tone control of your external amp. as an extra LPF.
- Record the thunder effect on fast play it back at normal speed.
- Mix in some synthesized rain and keep the volume of the thunder low.

Remember, a little thunder goes a long way, so be judicious. Also, the control settings are not absolutes, so adjust the attenuator and sensitivity controls until the effect "sounds right" to you. Work with this patch a bit -- and you won't be disappointed.

These are only a few applications for the under-used envelope follower. Further experimentation will unquestionably result in an infinity of applications -- other than as a glorified buffer for external inputs; so if it's breath-taking new timbres you're after, use that sensuous envelope follower!

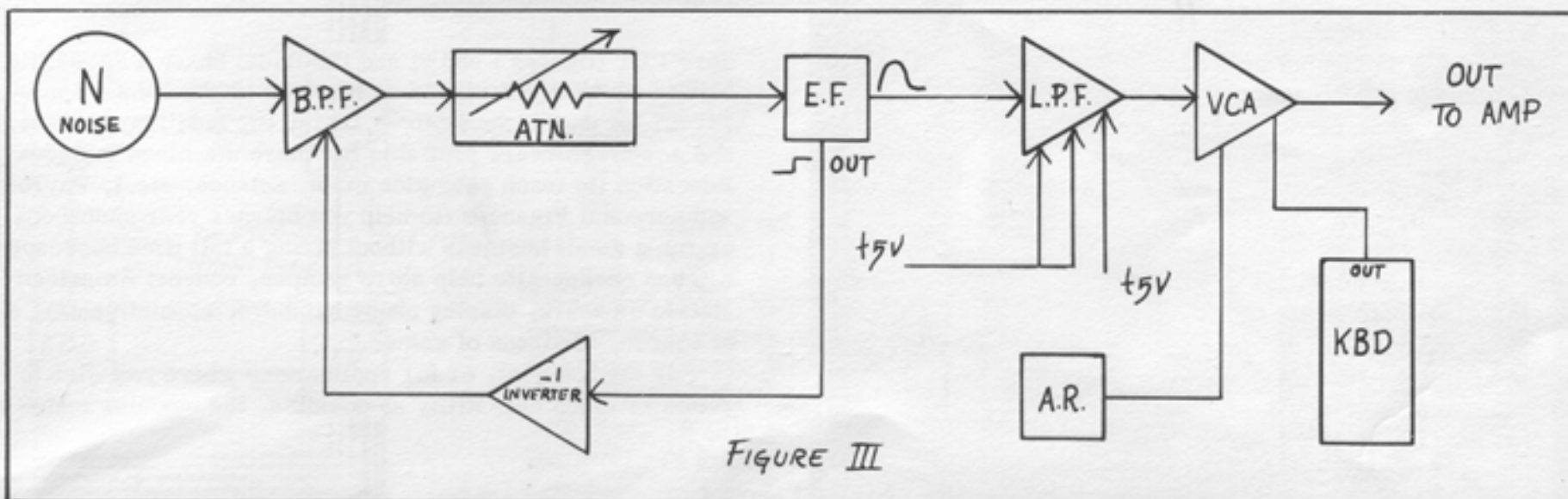


FIGURE III

# PERSONAL COMPUTING

'77:



Figure 1

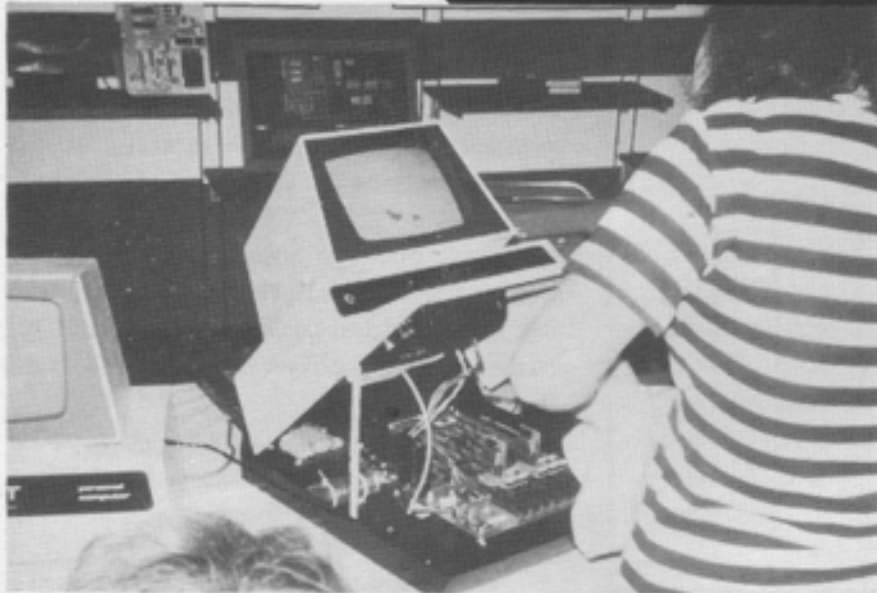


Figure 2

A  
LOOK  
AROUND

The weekend of August 27th and 28th saw the population of Atlantic City, New Jersey increase by about 10,000 as computer hobbyists and manufacturers from all over the country got together for the second annual PC show. For those of you who didn't have a chance to make it to one of the summer computer shows, we thought we would snap a few shots and show you what you missed. For those of you that did come to one of the shows in which PAIA appeared, we really enjoyed meeting you and hearing any and all comments you had about our products.

The two new products which should have the greatest impact on the non-technical consumer market are the Commo-



Figure 3

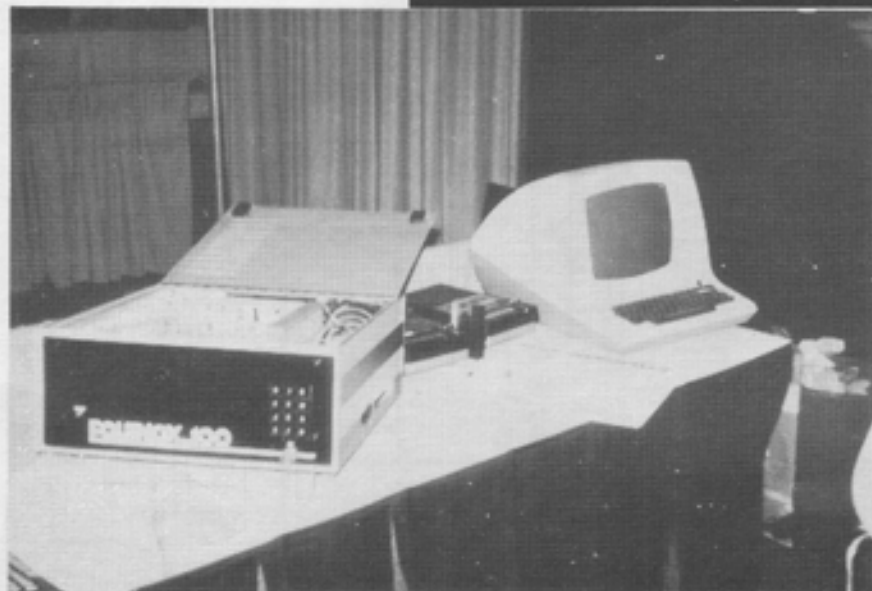


Figure 4

dore PET (figures 1 and 2) and the Radio Shack TRS-80 (fig. 3) both of which are designed as low cost (\$600) "home appliances" for use by housewives, children, small businesses, and so on. Software available for these machines includes Education (to teach your kids math, science, etc.), Payroll and personal Finances (to help you balance your checkbook or run a small business without hiring a full time bookkeeper, Kitchen packages (to help store recipes, convert American to Metric measure, display phone numbers, appointments), and of course, hundreds of games.

For the hobbyist, or for applications where you wish to retain as much versatility as possible, the modular main-



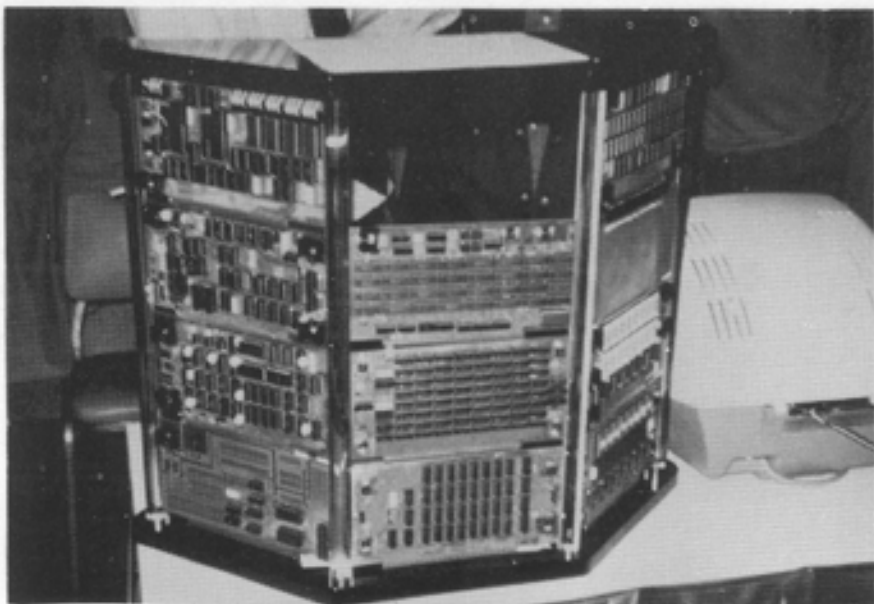


Figure 5

frame with plug-in peripherals is the best way to go. Figure 4 shows an Equinox system using portable cassette recorders for storage, and a Lear Siegler terminal for communication. These types of systems comprise the bulk of the market, and the software and peripherals available for them include a number of exciting possibilities. Figure 5 shows the array of memory and tone generator boards available from Solid State Music. The "Talking Computer" is no longer a joke, as there were two at this show. The Computalker board is shown in figure 6, while figure 7 shows an entranced passerby listening to the Digital Group/Votrax system which will be available this fall.

Heathkit had a very impressive display of their broad line of recently announced computers and peripherals. (figure 8) As usual, their systems are of top quality, with extensive documentation.

And, of course, you don't think we could do a review of the show without giving you a peek at the PAIA booth, do you? Fig. 9 looks upon PAIA technician Greer Holland expounding on the attributes of a 4700C package, while figure 10 catches technician Steve Wood ready to ward off even the most intense barrage of questions concerning the PAIA/Apple synthesizer system.



Figure 6

Larry Fast, the synthesist behind the Synergy albums, was in our booth most of Saturday. Figure 11 shows Larry carefully programming the Paia/Apple system for an intense rhythmic pattern. Upon command, the system reproduces his pattern with extreme speed and accuracy, and Larry chuckles with excitement (figure 12). The latest Larry Fast project has been a full scale "production" album which features an amazing number of musicians in a type of space-rock opera. Larry is also currently working with Nektar on their new album. For all you hard-core Synergy fans, he said to look for the new Synergy album around the beginning of '78 or shortly thereafter.



Figure 7

Another special visitor was Roger Powell, synthesist with Todd Rundgren's Utopia. Roger was talking to us about the Imsai 8080 system he recently completed. He plans to interface the computer with his existing synthesis equipment as a controller element. Many of you may recognize Roger's name as a regular columnist for Contemporary Keyboard magazine. Roger's recent columns have been dealing with computer music, and he said there are several more columns upcoming on the same subject. So, be sure to keep your eyes on his column; it will probably help answer a lot of your questions. Also, be sure to watch for Utopia on tour this fall. Attendance will guarantee an excellent demonstration of Roger's considerable mastery of his instrument.



Figure 8



Figure 9



Figure 10



Figure 11

What an exhilarating experience - to think there is as much computing technology on display at one of these shows as there was in the entire world as short as 15 or 20 years ago. And it's progressing faster every day. Not just in terms of the technology, but also in applications and practical developments which make the technology accessible to a greater number of people all the time. Very literally, there is something here for everyone. Whether you are seriously studying various systems to make a purchasing decision (figure 13) or just want to "hang around" to make new friends or get in on some tech talk, you should make a strong effort to visit the nearest computer convention. There is another batch of shows to be held later this fall, and the "circuit" will start all over next spring. So watch for your chance to get in on one of these exciting displays of state-of-the-art technology.



Figure 12



Figure 13

# The Layman's Guide to Digital Logic Gates (in one easy lesson)

by: Robert A. Rafuse

How many of you out there in the human race wonder where all these people that design and tell us about all those modern electronic circuits get all the brains? We know though, don't we! They stole 99.9% of ours and expect us to know what they are talking about. Are we content to stand back twiddling our thumbs and sing Yankee Doodle while the sun goes down? Heck no! We're going to start catching up in the knowledge department, and since we are getting interested in digital processing of synthesized music, then we might as well start with basic digital theory.

But where to start? I guess that you've all had that nightmare where a 14 legged IC, with the head of a dragon spewing hot solder, attacked your "two transistor-super-duper-do-nothing-circuit". Fear not. Just sharpen your sword...I mean pencil, put on your thinking cap, and we'll conquer that foe.

Let's first talk about the how and why of logic thinking. Even before the age of electronic computers, way back in the eighteen hundreds, an English gentleman by the name of George Boole was working with logic that is today the basis of all digital circuitry. George developed a mathematical system by which a logic statement could be proved to be either true or false. In logic thinking there are only two valid states: right or wrong, true or false, yes or no, etc. The result is that today Mr. Boole's system is with us in the form of Boolean algebra.

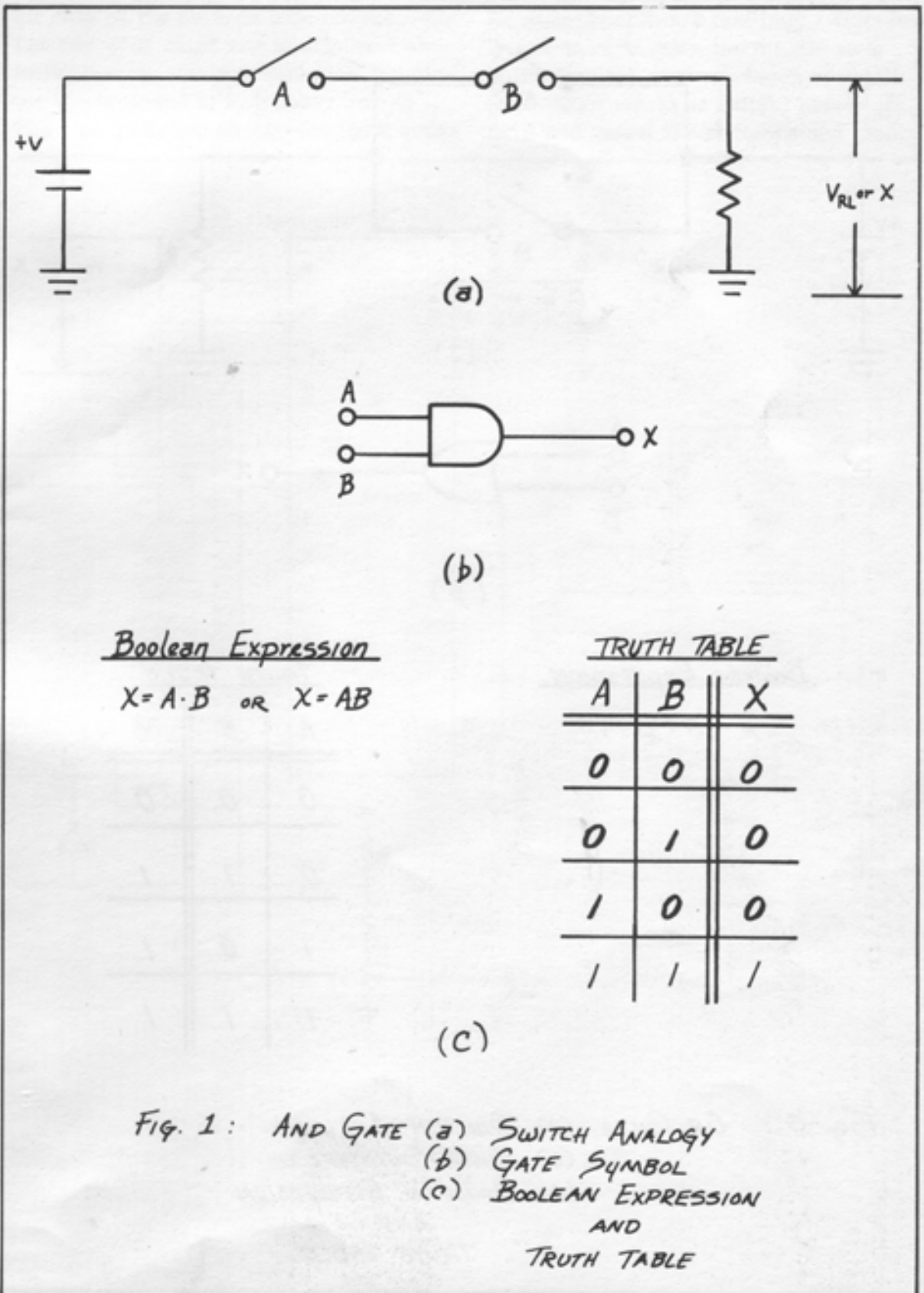
Wait now, don't stop reading! Just because I mentioned algebra don't tune me out. If your younger brother or sister is studying Boolean algebra in Jr. High School, and better yet understanding it, then there is still hope for you. The Boolean system relates directly to a mathematical system called binary. In the binary system there are only two possible states, a one or a zero. This system adapted very well to Boole's work and today is used in digital design.

The analogy of a switch seems to fit this idea very well. We can say that if a switch is closed we have a "1" and if it is open we have a "0". It doesn't really matter what type of switch it is as long as it can simulate the same principle of operation. It can be a mech-

anical one such as a toggle switch or an electronic one using such discrete components as resistors, diodes, and transistors. Let's look at the three basic building blocks found in digital logic: the AND gate, the OR gate, and the Inverter. With these gates, any circuits such as adders, counters, multipliers, dividers, and an entire computer can be constructed. Knowing their operation will give us a solid background from which we can build our digital knowledge.

The AND gate is a device whose output is a logic 1 if all of its inputs are a logic 1. Figure 1(a) shows the switch

analogy of a two input AND gate. In this drawing we see two switches A and B which are in series. You can probably figure out that the only way current will flow through the load, and develop a voltage across it, is when both switches are closed. Seems too simple, doesn't it? Don't worry though, the equivalent logic circuit is just as easy. The accepted symbol for the AND gate is shown in figure 1(b). If we apply a value of voltage equal to +V with respect to ground to both inputs A and B, then the output of the gate (X) will have a value of V with respect to ground. The value of +V is



Where's Walter?

called the high or 1 level. This value is between 2 and 5 volts in the 7400 series TTL logic which operates at a supply voltage of 5 volts. The value of the low or 0 level is between 0 and .8 volts. The 4000 CMOS series logic is the same when operated at a supply voltage of 5 volts. CMOS logic can be operated from a supply voltage between 3 and 15 volts. Any value of voltage between the accepted 1 or 0 states is invalid and undesirable.

For the AND gate we can write a Boolean expression and a "truth table". Both are shown in figure 1(c). The expression is usually read as "X equals A and B" or "X equals AB". The truth table is just a tabular form of stating the value of X for all possible combinations of A and B. The two input AND gate is available in various DIP packages with different switching speeds and power consumption. (Figure 2) shows a 7408 quad 2 input AND gate package. The

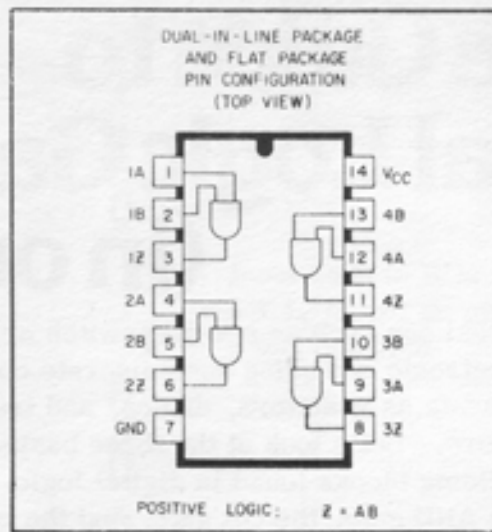


Fig: 2

7408 only costs about 25 cents from any surplus dealer, so why not buy one and experiment with it to see if I'm telling the truth.

The next gate I would like to talk about is the OR gate. Continuing on with

the switch analogy, look at the circuit of figure 3(a). Here we see two switches, A and B in parallel. We know that if we close either or both switches, current will flow through the load resistor and the voltage across it will be +V or a logic 1. Figure 3(b) shows the accepted symbol for a 2 input OR gate while figure 3(c) contains the Boolean expression and truth table. The expression is usually read as "X equals A or B". The + symbol is read as OR and should not be confused with the mathematical addition symbol. The 2 input OR gate is available in a quad package in both CMOS and TTL with the TTL 7432 shown in figure 4.

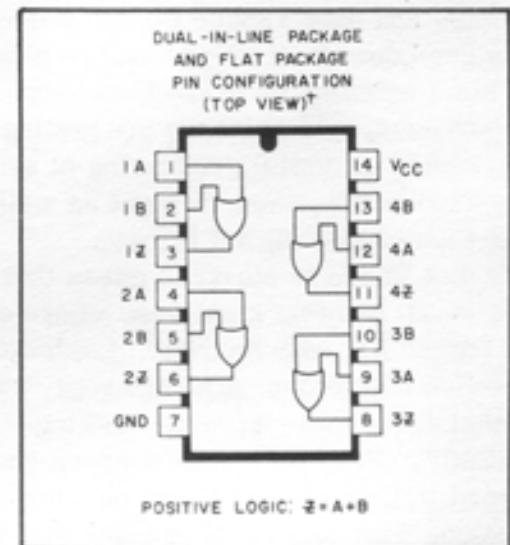


Fig: 4

The third and simplest gate so far is the Inverter or "Not" gate. Two accepted symbols for the Inverter are shown in figure 5(a). The Inverter doesn't really make any decision as do the AND and OR gates. The inverter has only one input and the output X is always the inverse of A. If we apply a logic 1 and A, then the output X will be a 0, while a 0 at A will cause X to be a 1. This is shown in the truth table of figure 5(b) along with its Boolean expression. The equation is read as "X equals A not" or "X equals not A". The Inverter is available as a "six pack" in both CMOS and TTL, with the TTL 7404 shown in figure 6.

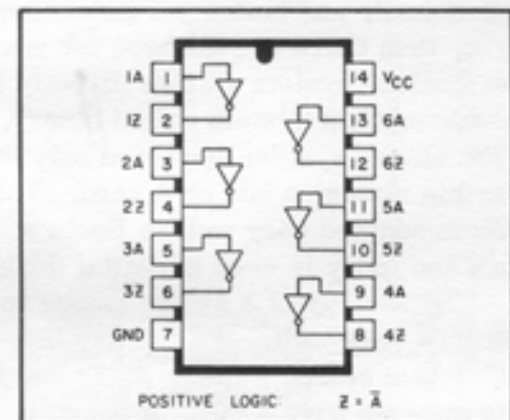
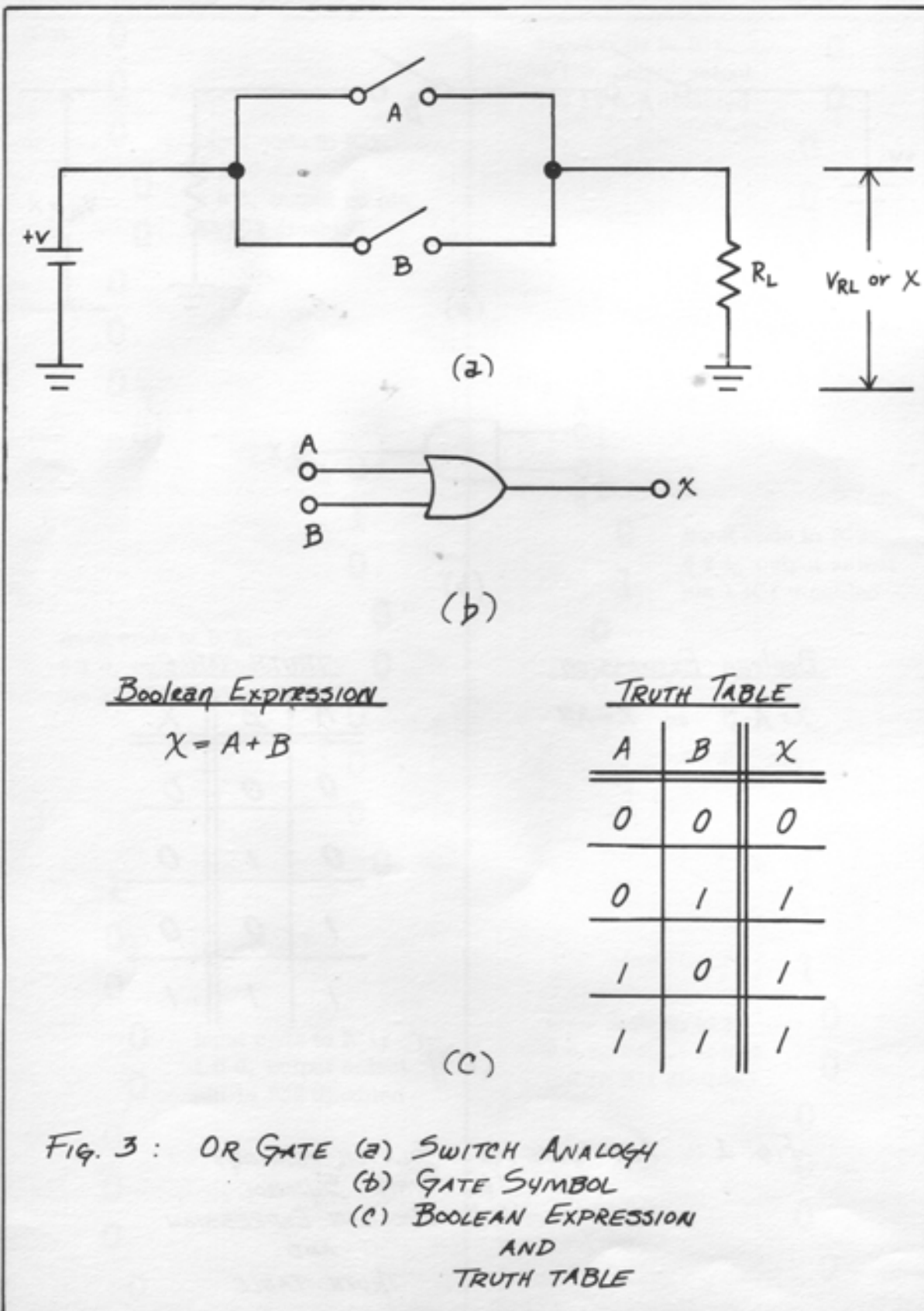


Fig: 6

Well there you have it, the three digital gates that form the basis for any logic function. I bet you're saying "I don't believe it!". I am sorry, but that is all there is to these gates. Let's see



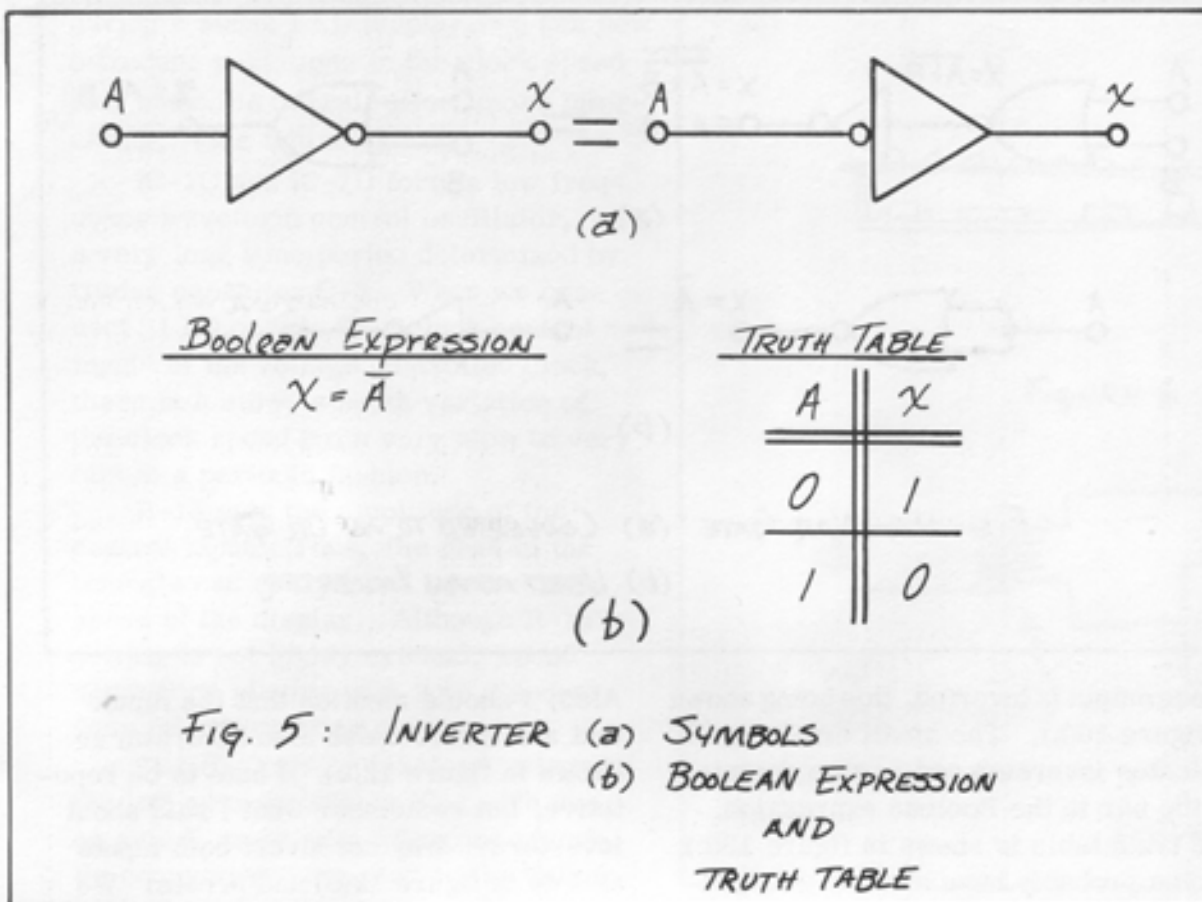


Fig. 5: INVERTER (a) SYMBOLS  
 (b) BOOLEAN EXPRESSION AND TRUTH TABLE

if you have absorbed some of the things I have said, so take a look at the gates in figure 7. Try writing down the name

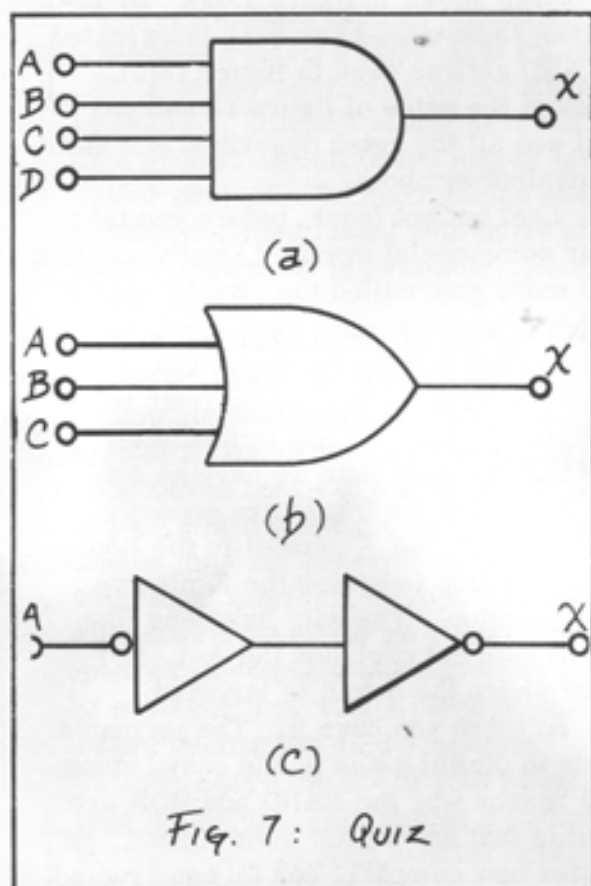


Fig. 7: Quiz

and Boolean expression for each drawing without reading any further. If you have written for (a) 4 input AND and  $X=ABCD$ , (b) 3 input OR and  $X=A+B+C$ , (c) two inverters and  $X=A$ , then you are doing great. If you had any right for that matter, congratulations! See, even you can understand some digital logic. Tomorrow, the world. You see that no matter how many inputs there are, you just expand the expression to fit the extra inputs. For the inverter circuit you can see that by inverting something twice, you arrive right back where you started! This is a very important point and you should try to remember it.

I suppose you have been wondering

about the result of combining these gates together. Well, the next two gates I'll talk about, you probably have seen in most logic circuits you've looked at. The first combination we'll look at, shown in figure 8(a) is called a NAND gate. If you think the English language is taking a beating don't worry, because for the sake of brevity, it is an abbreviation for "Not And". Look at figure 8(b) and you will soon understand. The NAND gate consists of an AND gate whose output is inverted, with inversion indicated by the small circle at the output of the gate. The Boolean expression shown has a bar across the top of the equation to represent inversion of the AND function. Looking at the truth table of figure 8(c) we see that the output is similar to the AND gate but everything is inverted. Remember what I said about the inverter?

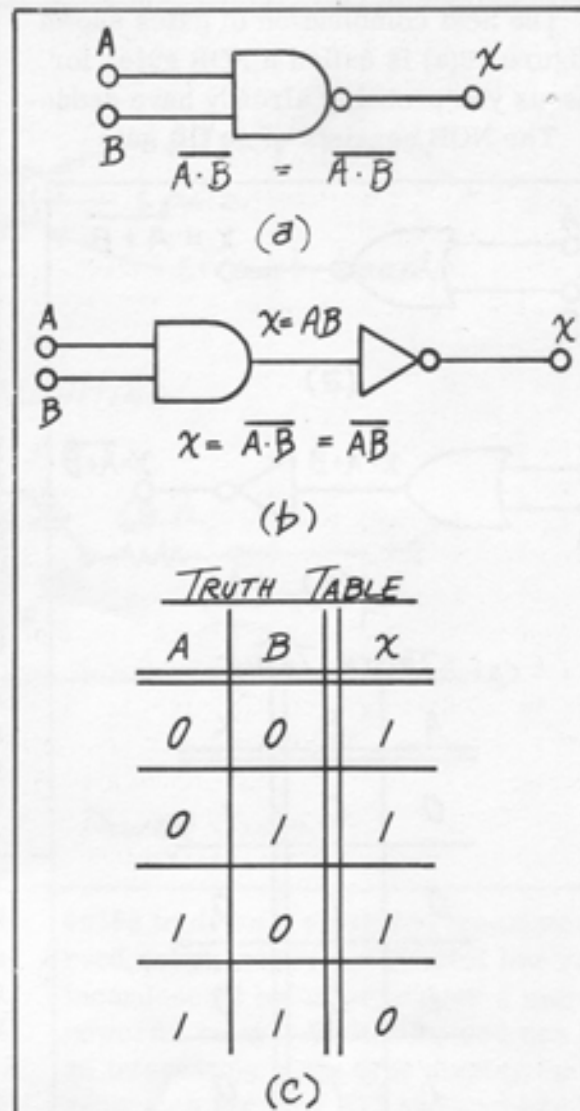


Fig. 8: NAND GATE  
 (a) SYMBOL AND BOOLEAN EXPRESSION  
 (b) GATE EQUIVALENT  
 (c) TRUTH TABLE

Put an Inverter on the output of a NAND gate as in figure 9(a) and we obtain an output equivalent to the AND gate. Pretty neat, eh! Figure 9(b) shows how to make an Inverter using a NAND gate. With both inputs tied together, the result is that whatever is applied at A is inverted at the output X.

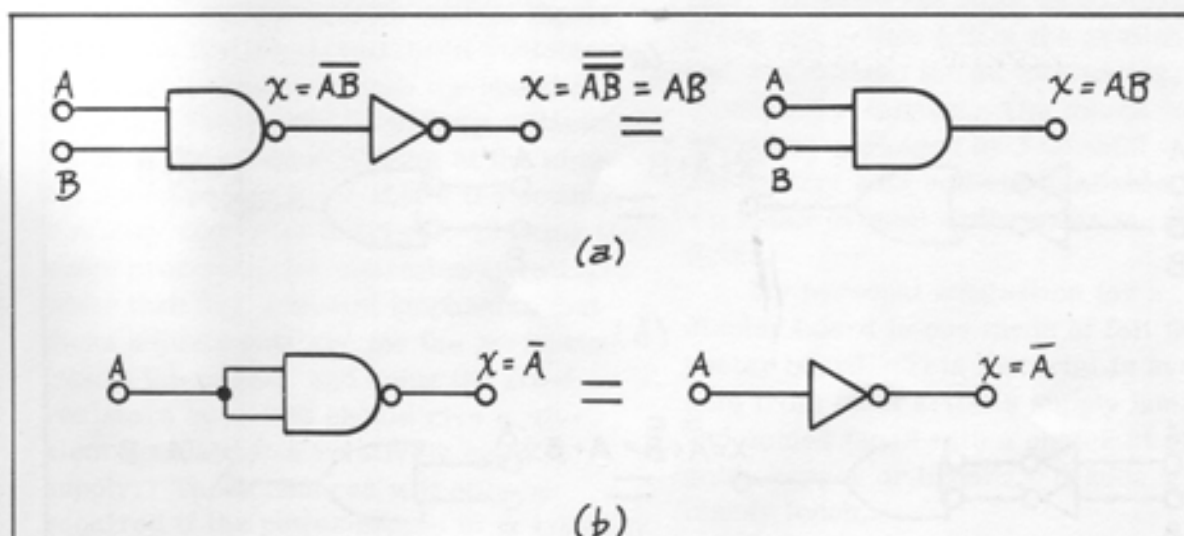


Fig. 9: NAND GATE  
 (a) CONVERTED TO AN AND GATE  
 (b) USED AS AN INVERTER

The next combination of gates shown in figure 10(a) is called a NOR gate, for reasons you probably already have deduced. The NOR consists of an OR gate

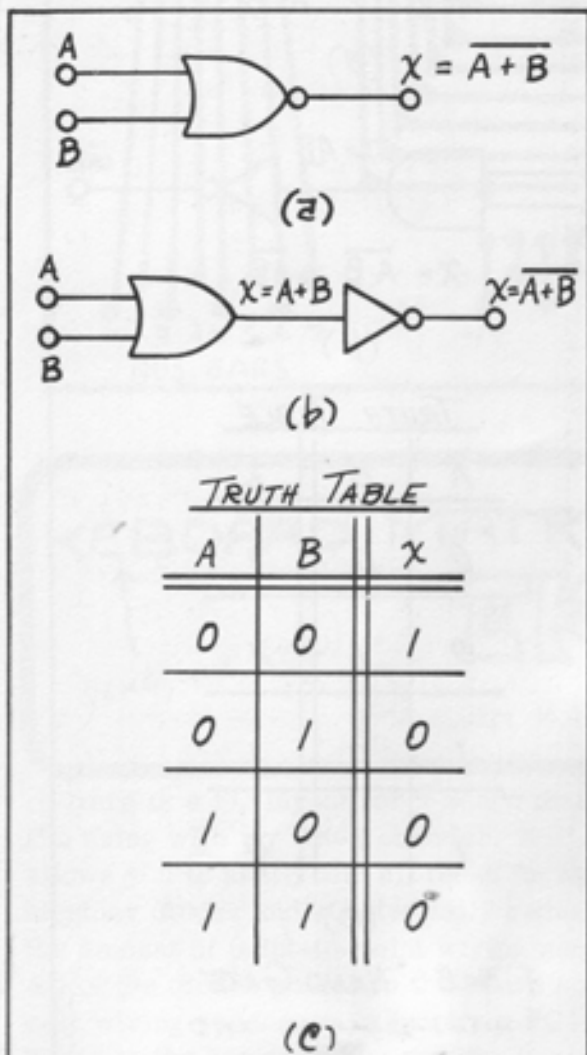


FIG. 10: NOR GATE  
(a) SYMBOL AND BOOLEAN EXPRESSION  
(b) GATE EQUIVALENT  
(c) TRUTH TABLE

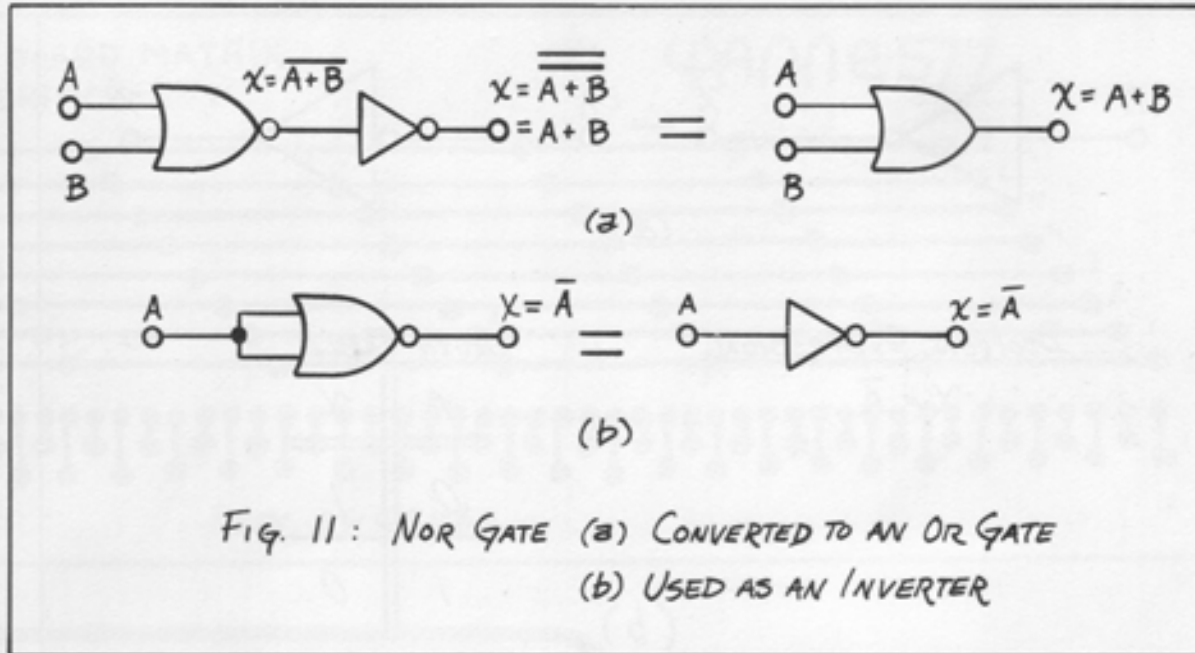


FIG. 11: NOR GATE (a) CONVERTED TO AN OR GATE  
(b) USED AS AN INVERTER

whose output is inverted, this being shown in figure 10(b). The small circle again indicates inversion and is also depicted by the bar in the Boolean expression. The truth table is shown in figure 10(c). As you probably have already guessed the NOR can also be converted to an OR gate by inverting the output (figure 11(a)) and an Inverter with the two inputs tied together (figure 11(b)).

Both the NAND and NOR gates are available in various number of inputs and gates in DIP packages. The reason for making these gates with the NAND and NOR is that when building logic circuits, the inverter is often used. Here comes the big clincher. We can draw the NAND and NOR two different ways without changing the operation of the gate. Figure 12 (a) shows the NAND gate and you'll find if you run through a set of input conditions the result for both will be the same.

Also, I should mention that the inputs that are inverted can also be drawn as shown in figure 12(b). I hate to be repetitive, but remember what I said about inverters? Why not invert both inputs as I do in figure 12(c) and presto! We have created an OR gate, and you thought it could never be done. The same is true for the NOR gate with the two equivalent drawings shown in figure 13(a). By inverting the two inputs we have now created an AND gate as seen in figure 13(b). Look at the gates of figure 14 and you will see all the gates described and their equivalent symbols.

Last but not least, before you take your commercial break, I should mention one more gate called the "Exclusive OR" which is used in many logic circuits. The symbol for the Exclusive OR is shown in figure 15(a) and its truth table in figure 15(b). We can immediately see that the only time we have an output X is when the inputs are opposite each other. The + symbol in the Boolean expression indicates the Exclusive OR operation. The gate functions like an OR gate but excludes the A=1, B=1 state where the output is inverted.

So there you have it. The layman's guide to digital gates in one easy lesson. The reason why the NAND and NOR are used is that any digital logic circuit, no matter how complex, can be constructed using AND and Inverter gates or OR and Inverter gates. So if you have to convert a NOR to an OR, NAND to an OR, etc., you now have some idea how to do it. Some of the terminology might be a little strange at first, but after reading this article over a few times, "no sweat". If you're interested in learning more, maybe you can pick up a book on the subject at your local library, or better still buy one of those available from digital IC manufacturers such as RCA or National Semiconductor. These latter books usually have something on theory, specifications, and applications. Who knows! Maybe the next "million-dollar-IC-do-nothing-circuit" will be your own.

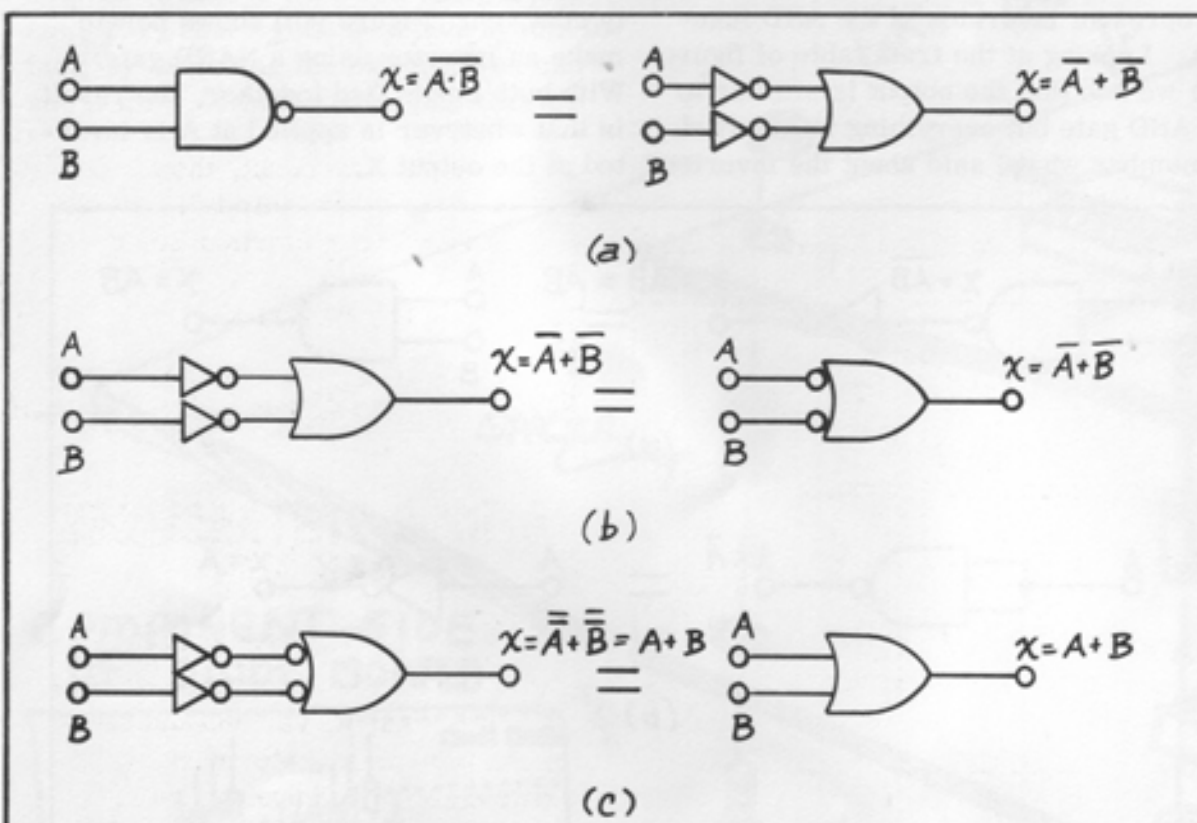


FIG. 12: NAND GATE (a)(b) EQUIVALENT CIRCUITS  
(c) DOUBLE INVERSION EQUIVALENCY

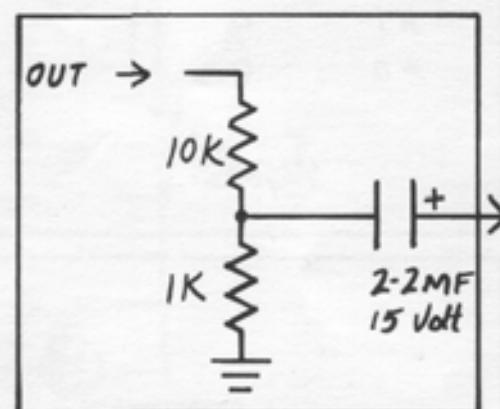
# CORRECTION

Oops! It seems that the gremlin struck the "Random Tone Generator" article, *Polyphony*, July 1977. We offer our apology and the following corrections supplied by the author...

There are a few corrections to the schematic diagram I think you (or your readers) may like to know about.

- 1) The .22pf capacitor should be .22uf
- 2) The 4.7pf capacitor should be .47uf.
- 3) The unlabelled fixed resistor in series with the "rate" pot should be marked 100K ohm.

Another item I should have mentioned in the article (but neglected to) is the following: the auxiliary output (labelled 'to synthesizer') is a 9 volt square wave which is a bit too high for input to PAIA modules. Though it will still work, I'd recommend lowering the amplitude with a resistive divider something like this:



AUX. OUTPUT

Otherwise, no doubt, the module would probably "clip it"... it will function, but distortion would no doubt result.

-Kenny Winograd-



## STRING SYNTHESIZERS CAN BE:

JUST strings, OR they can have things like electric piano with separate output, variable modulation, pipe organ, stereo string output option, computer control option, separate foot switch OR pedal control of sustain for piano AND strings, synthesizer interface

...You're gonna' love it!

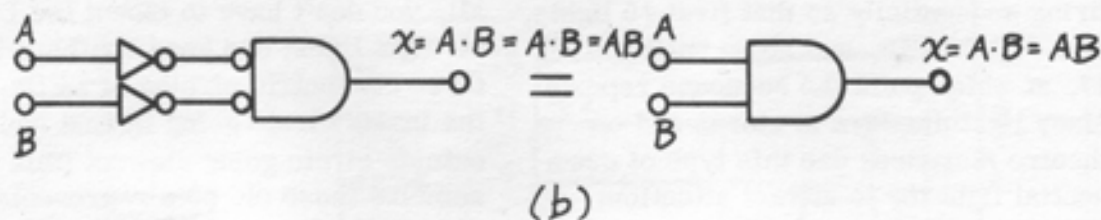
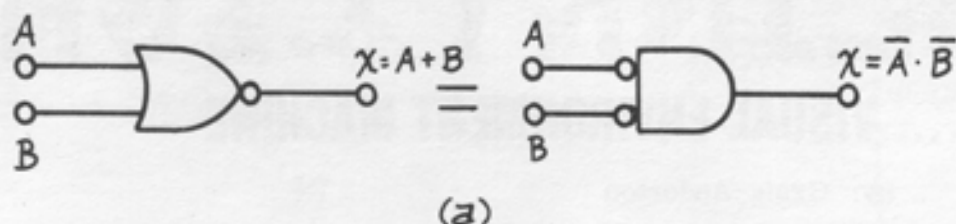


Fig. 13: NOR GATE (a) EQUIVALENT CIRCUITS  
(b) DOUBLE INVERSION

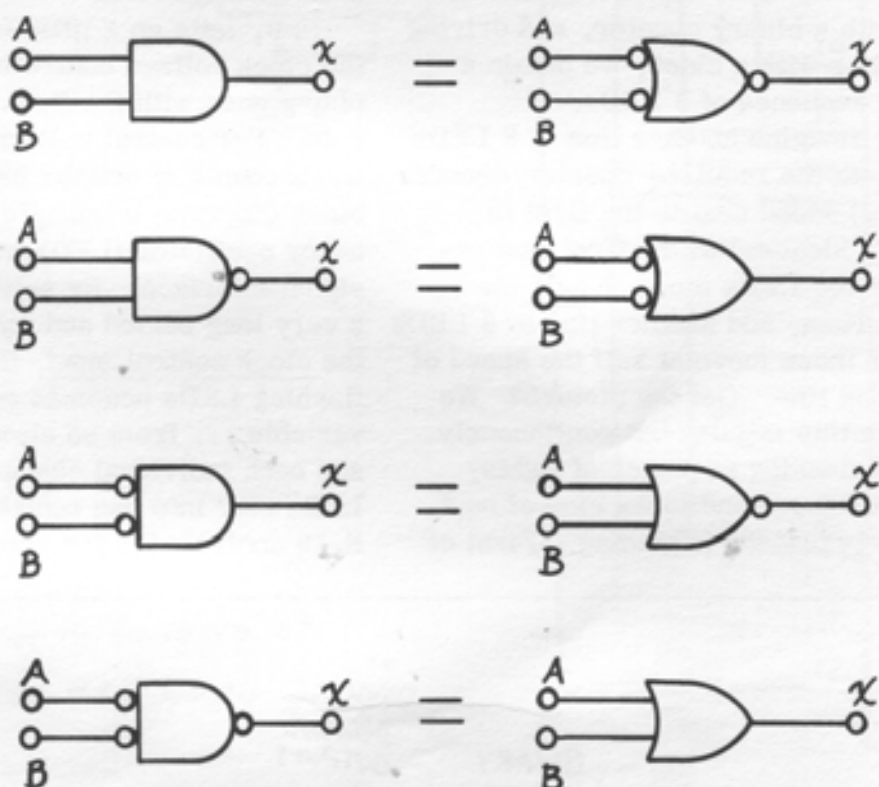
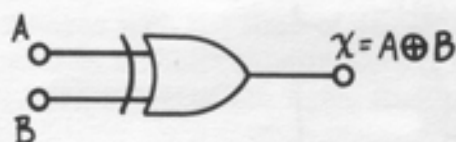


Fig. 14: EQUIVALENCY CHART



(a)

TRUTH TABLE		
A	B	X
0	0	0
0	1	1
1	0	1
1	1	0

(b)

Fig. 15: EXCLUSIVE OR;  
(a) SYMBOL AND  
BOOLEAN EXPRESSION  
(b) TRUTH TABLE

# THE ULTIMATE

# BLINKY LIGHT

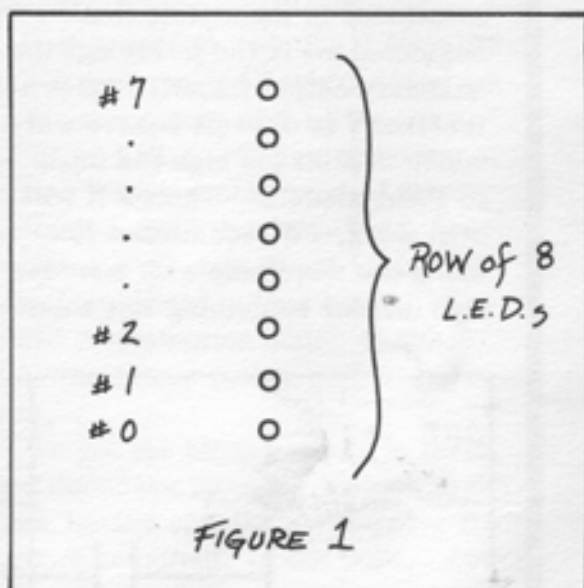
## LED WALL ART .....VISUAL ENVIRONMENT MACHINE

By: Craig Anderton

I love electronic toys. Blinky light boxes, random music generators, surf synthesizers, Chord Eggs ... these are the things that keep electronics continuously entertaining for me. One day a few months ago I got tired of doing semi-meaningful circuits, and decided to come up with a toy... this project is the result.

What does it do? Well, it's hard to describe something visual on paper, but I'll do my best.

Imagine a line of 8 LEDs, arranged as in figure 1. Now, imagine them

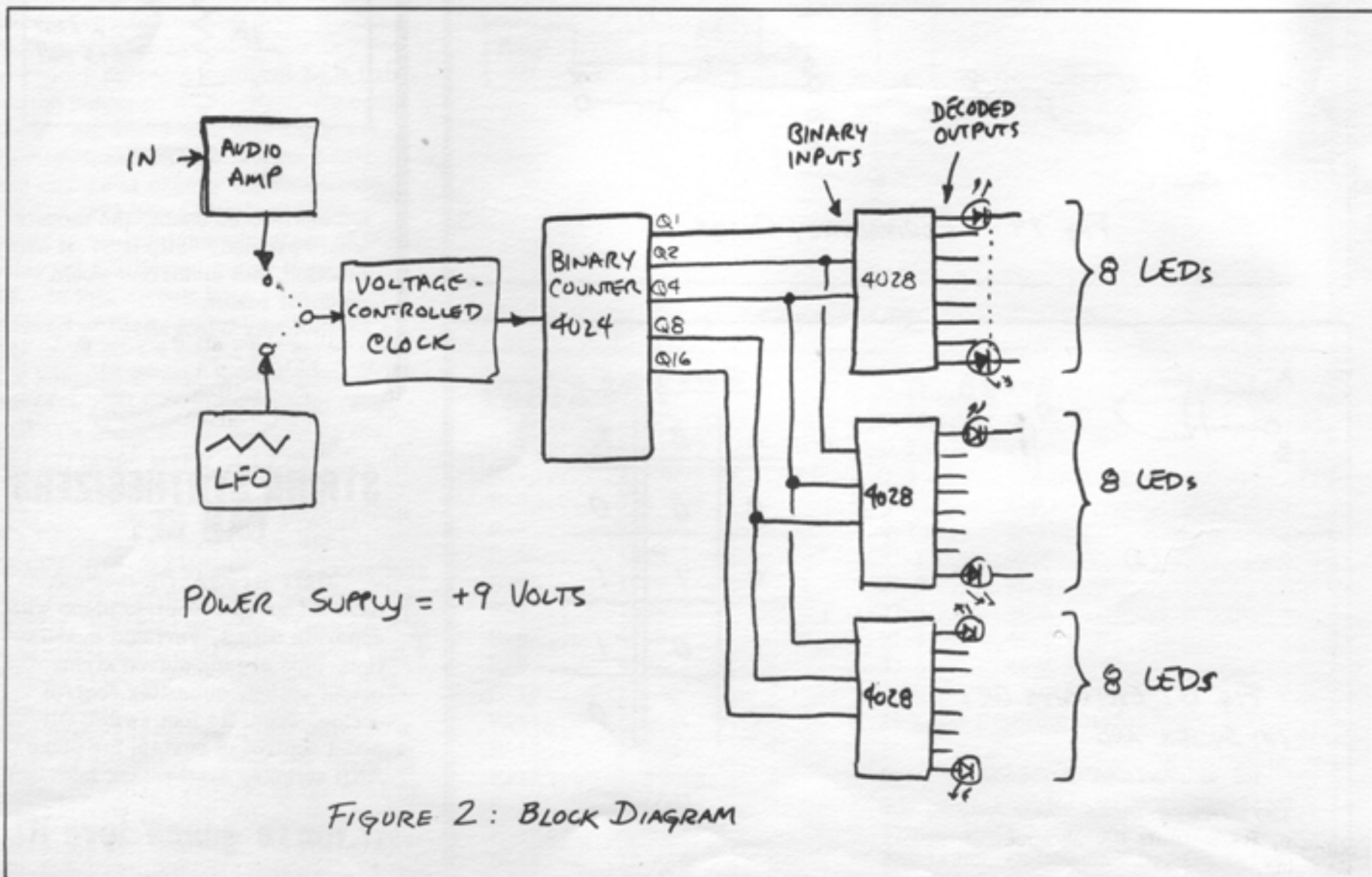


firing sequentially so that first #0 lights, then #1, then #2, and so on until you hit #7, at which point the sequence repeats. Many light displays in stores and on theatre marquees use this type of sequential light toy to attract attention; these high wattage circuits require a klunky mechanical stepping relay. The way we implement our low power circuit is to drive each LED directly from the output of a 4028 CMOS 1-of-8 decoder, which when driven with a binary signal decodes that binary signal into an appropriate output. By driving the decoder with a binary counter, and driving the counter with a clock, we obtain a flashing sequence of 8 LEDs.

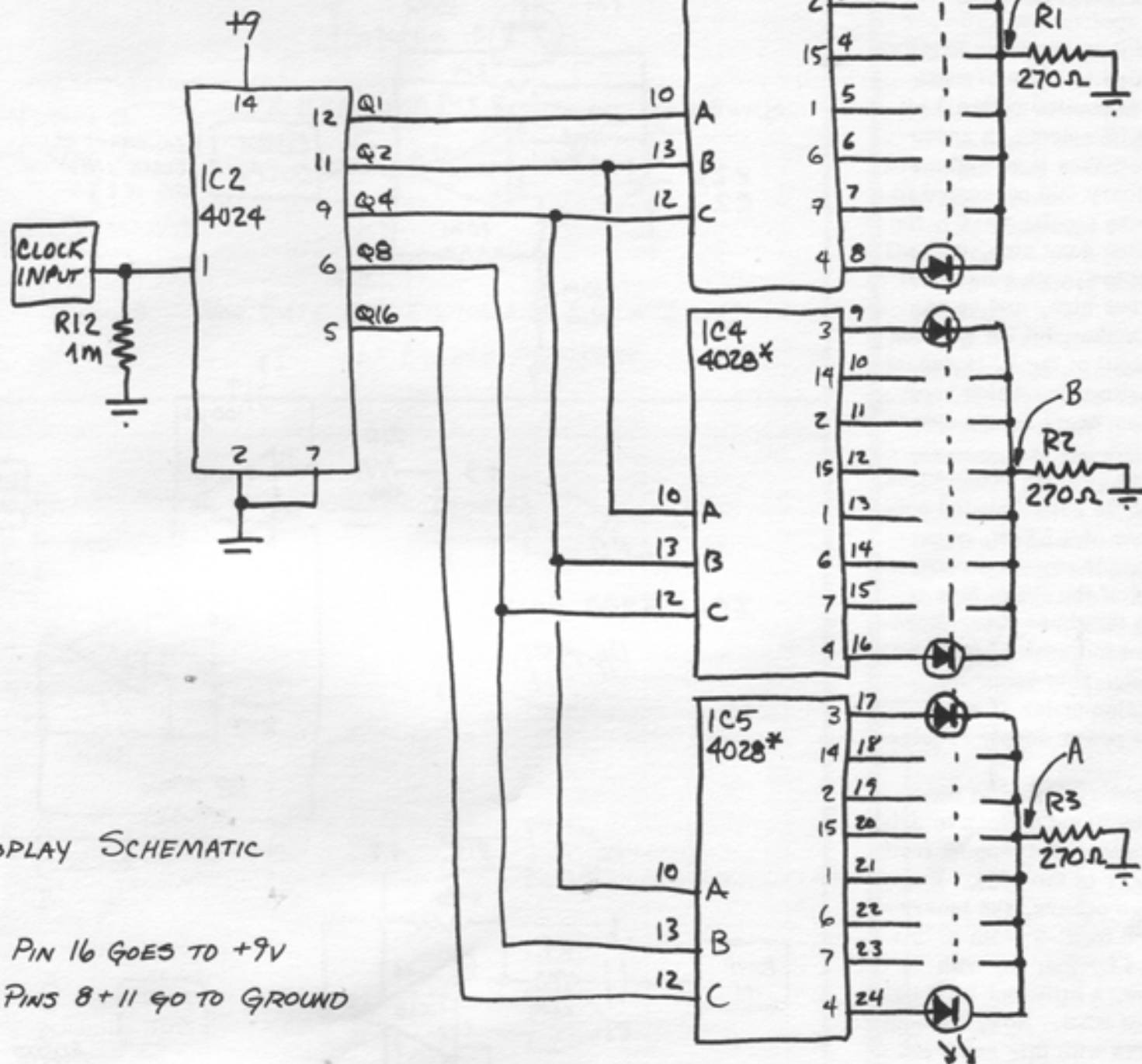
Now, imagine another line of 8 LEDs (along with the required counter/decoder circuitry) added next to the first in parallel, identical to the first line except that the LEDs move at half the speed. Then, add another line of 8 LEDs and have those move at half the speed of the second line. Get the picture? We now have this regular but continuously variable flashing sequence of lights, which sits there and looks kind of neat. But this is just the beginning. First of

all, you don't have to mount the LEDs in straight lines; one good configuration is three concentric circles of LEDs, with the inside circle going fastest and the outside circle going slowest (this resembles those old 50's representations of atoms). Or, you can just spread the 24 total LEDs (driven by the 3 decoders) around randomly and let them flash in any old way ... or wire one line to go in the opposite direction of another line ... we could go on. Figure 2 shows the block diagram for all this stuff we've been talking about.

Now, let's go a little farther and make the clock voltage controlled, so we can play games with the flash or sequencing rate. For control voltage sources, we'll add a couple of options indicated on the block diagram: a triangle wave low frequency oscillator (LFO) and an audio signal interface. By setting the LFO for a very long period and injecting it into the clock control input, the rate of the flashing LEDs becomes continuously variable ... from so slow you can easily see each individual change, to so fast the LEDs blur into one continuous pattern. R-18 controls the top speed of the flash-







DISPLAY SCHEMATIC

\* PIN 16 GOES TO +9V  
PINS 8+11 GO TO GROUND

FIGURE 1

ing in this mode. If you want a pattern that changes with the time of day, you can parallel a photoresistor along with R-11. The brighter the light, the faster it goes.

There is yet another option, though, that offers many possibilities: the audio interface. It takes an audio signal and acts like a pseudo envelope follower, allowing audio signals to control the clock. With the parts values shown on the schematic, it is very sensitive. By connecting the amp out to the clock control input and connecting a microphone to amp in, the pattern will change speeds in accordance with the loudness of your voice. A guitar pickup can also drive the audio interface directly. As before, R-18 limits the top speed of the flashing.

This circuit is also useable with hi-fi and musical instrument speakers, and makes a different and interesting kind of color organ. For this application, you should probably add an attenuator at the input of the amp in as shown in figure 3.

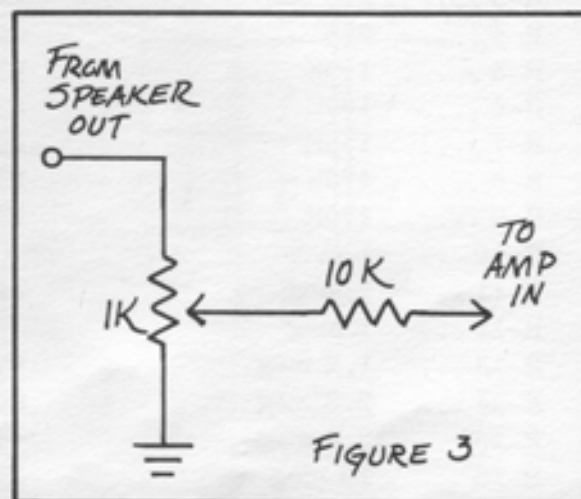


FIGURE 3

This will prevent strong signals from saturating the amp and causing the display to alternate between fast or slow, with no in between speeds. By turning the attenuator down so that peaks of the music give the fastest flash speed, you obtain the nicest effects. This attenuator and R-18 interact to a certain extent; but a little bit of practice, keeping the preceding in mind, will allow you to obtain a wide variety of display reactions to music and sound. Because of the extreme sensitivity of the amp, you can easily insert lossy, passive filters to give separate hi, lo, and mid range outputs to 3 separate LED wall art units, and still have enough drive for the audio interface. A tip: one of my favorite patterns is having three straight lines of LEDs arranged vertically, but with the

LEDs moving downward. The effect is like some novel kind of red rain or something equally bizarre.

## DESIGN ANALYSIS

The heart of this design is a CMOS IC, the 4028, which is a one of eight decoder. When presented with a 3 bit binary input, the IC selects an appropriate output and makes it go high. For example, with binary 000 presented to the 3 control inputs (A, B, and C), the first output location goes high, with all others remaining low; with binary 001 the next output goes high, and so on until binary 111 makes the 7th location go high. The output of the IC is capable of driving LEDs directly, which helps keep down the component count. (See figure 4).

In this circuit, we use three 4028s, which means that we have decoded outputs for three sets of 8 LEDs, or a total of 24 LEDs. At any given moment, only one LED out of the set of 8 is illuminated; with the three sets, therefore, at any given moment we have 3 LEDs illuminated. This keeps the current consumption under 40 mA, which minimizes power supply requirements.

We get the binary inputs to these 1 of 8 decoders by using a clock to drive a 4024 binary counter and tapping from appropriate outputs of the 4024. Every time a clock pulse occurs, the binary number presented to IC-3 from IC-2's outputs increases by one; so, with every clock pulse, a different LED lights up at the output of IC-3. Now, we could drive all the 4028s with this same set of binary lines; but then all the LEDs would change at exactly the same rate. Since the 4024 has multiple outputs available, we can take advantage of that and tap off a different set of lines for IC-4. In this circuit IC-4 runs at half the speed of IC-3, so that a different LED lights up at IC-4's output for every two clock pulses. Similarly, we drive IC-5 at half the speed of IC-4, so it in turn requires 4 clock pulses to light up the next LED in the string of LEDs connected to IC-5's outputs.

In this basic form, our little circuit makes a pleasing piece of kinetic art. However, it's nice to add some variations to this basic theme; here is where we get into IC-1, the quad op-amp. Op amp A is a straight square wave oscillator that produces clock pulses, except that it is voltage controllable by putting a transistor in the current path that charges the timing capacitor. Thus, by changing the control voltage present at the base of the transistor, we can change the speed of the clock and hence the rate at which the various LEDs flash.... instead of

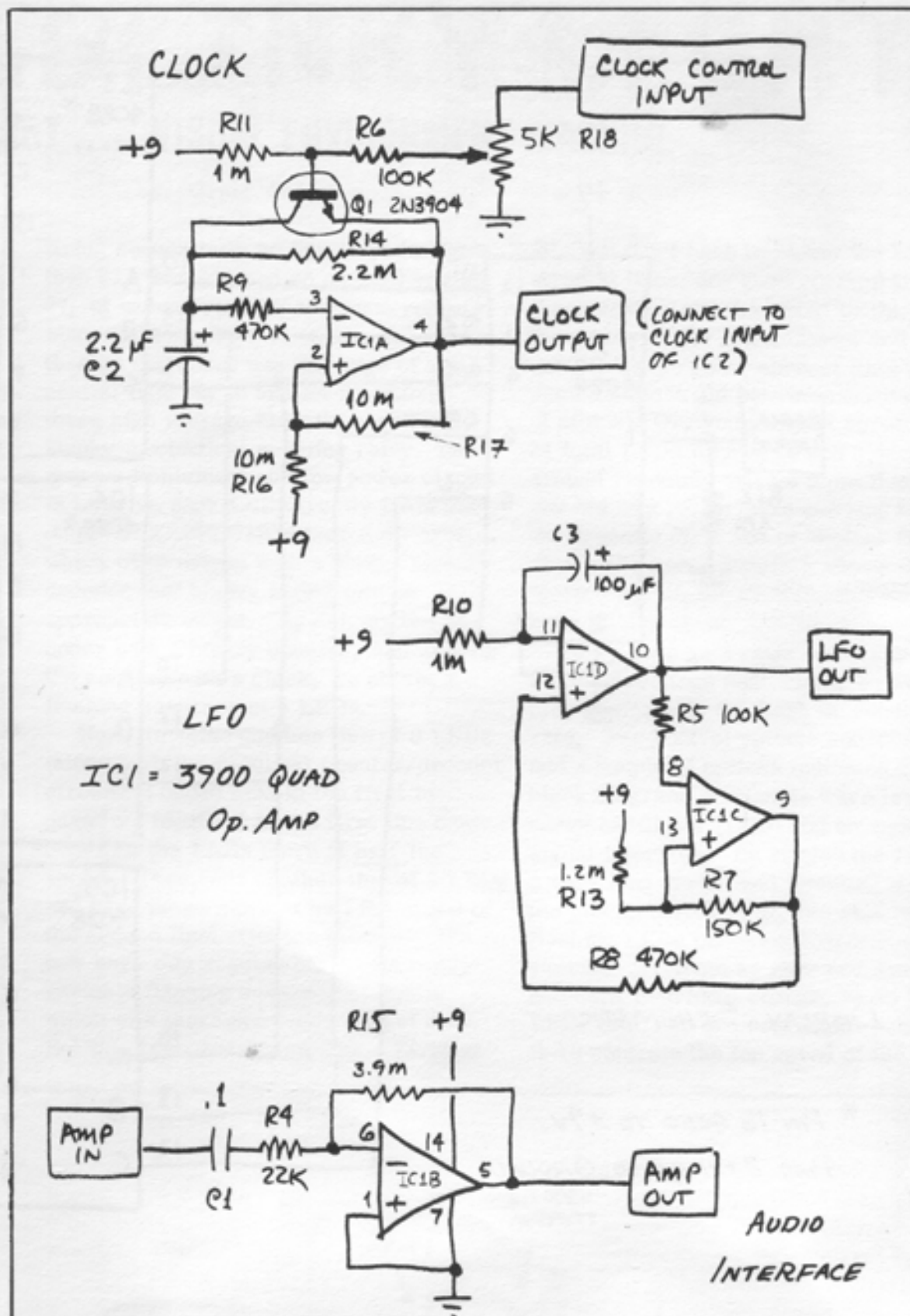


FIG. 5: CONTROLLER SCHEMATICS

## PARTS LIST

R-1 ....	270 ohm
R-2 ....	270 ohm
R-3 ....	270 ohm
R-4 ....	22K
R-5 ....	100K
R-6 ....	100K
R-7 ....	150K
R-8 ....	470K
R-9 ....	470K
R-10 ...	1 meg
R-11 ...	1 meg
R-12 ...	1 meg
R-13 ...	1.2 meg
R-14 ...	2.2 meg
R-15 ...	3.9 meg
R-16 ...	10 meg

R-17 ...	10 meg
R-18 ...	5K
C-1 ....	.1 mf.
C-2 ....	2.2 mf.
C-3 ....	100 mf.
Q-1 ....	2N3904
IC-1 ...	3900
IC-2 ...	4024
IC-3 ...	4028
IC-4 ...	4028
IC-5 ...	4028

24 Light Emitting Diodes

Printed Circuit Board available for this project ... No. BL-1... \$6.95 ppd. From: PAIA Electronics, Inc. Box 14359, Oklahoma City, OK 73114

having a static LED display, we can now introduce variations in the clock speed that make the overall effect more interesting. (See figure 5).

IC-1C and IC-1D form a low frequency waveform control oscillator, with a very long time period determined by timing capacitor C-3. When we connect "LFO out" to the "clock control input" of the voltage controlled clock, there is a slow, smooth variation of the clock speed from very slow to very fast in a periodic fashion.

R-18 sets the amplitude of the control input. Thus, the peak of the triangle can correspond to maximum speed of the display. Although R-18's setting is not highly critical, spend some time playing with it to discover your favorite setting.

Our final option takes advantage of the left over op amp in IC-1. We use op amp B as an amp with gobs of gain. By connecting "amp out" to the "clock control input", we can vary the speed of the LEDs by varying the audio signal presented to "amp in".

## CONSTRUCTION NOTES

Most any method of construction is suitable, although either perf board or a printed circuit board makes for a neater project. To make things easier, a printed circuit board with parts placement designators is available. (See parts list)

First, mount and solder all components. Once that's done, it's time to join the board with a suitable display for the LEDs. One approach is to connect the board to a like-sized piece of perf board via angle brackets. This makes for easy construction and access to optional features; the completed unit also stands up nicely on a desk or table. Another possibility is a sandwich type of construction, with a piece of perf board holding the LEDs mounted directly above the board with spacers (see figure 6). This makes a compact arrangement for wall hanging applications. And of course, you can let yourself go and stick the LEDs into a wooden structure or piece of plexiglass, perhaps covered with a red theater gel or piece of red plastic to accent the redness of the LEDs.

The separate electronics / LED board setup gives maximum flexibility for choosing your display pattern, although it takes a bit of time to connect 24 wires to the anodes of 24 different LEDs. Be patient and you

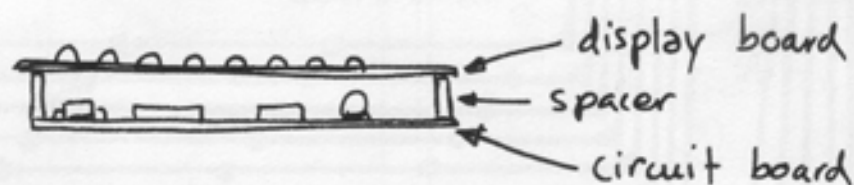


FIGURE 6: MOUNTING

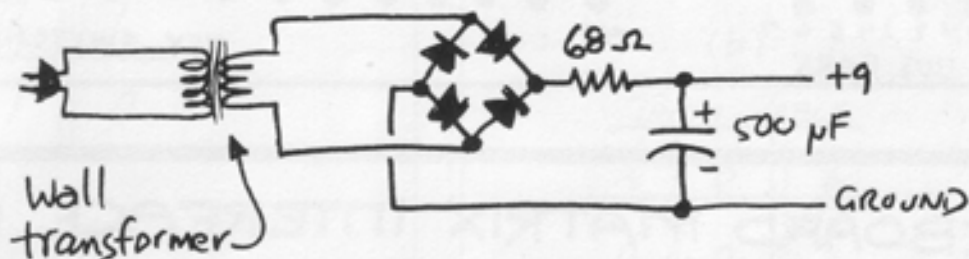


FIGURE 7: POWER SUPPLY

won't have any problems.

## POWER SUPPLY... ... AND MODIFICATIONS

This project is designed to run from a 9v. power supply, although it can handle 12 volts too. Figure 7 shows a typical power supply: the transformer can be the wall type used for clocks, and the resistor serves as a voltage dropping resistor to get the voltage down to 9 volts. Depending upon your specific transformer, you may need to experiment with this a little.

When running from a 12 volt supply, you may need to adjust bias resistor R-11; I have found that 2.2 Meg seems just about right for 12 volt operation. If you want to get fancy, use a 5 or 10 M potentiometer for R-11. Set it by first disconnecting any voltage control inputs; start with the pot at maximum resistance, then slowly decrease until the speed of the LEDs just begins to pick up. Back off until the LEDs are going at the slowest speed possible --- that's the setting. You may also want to trim R-13 using the same procedure for operation at voltages other than 9v. I should emphasize that these adjustments are for the perfectionists in the crowd, and using the fixed resistors specified should give equivalent results for a relatively stable supply. These changes will only be required if the power supply is drastically unregulated or not 9 volts.

One final application before finishing up ... you can use the outputs of the

4028s to drive a saturated transistor and reed relay, which can control low voltage incandescent bulbs or trigger a more powerful relay. With this, you can have an interesting stage type display that generates far less RFI and garbage than dimmer based light games.

So, there you have enough info to start experimenting with your own wall art and LED games. Since you're dealing with something artistic, do a good job on the display; I favor LEDs mounted in plexiglass, myself. If you come up with any really exotic displays... how about sending a photo or description off to Polyphony?

Editor's note:

Light Emitting diodes are available in colors other than the standard red. Although not quite as common, green and yellow LEDs are available and would make for an interesting, mixed color display. The mixed color LEDs are packaged by Fairchild Technology Kits and are available from a number of mail order parts supply firms.

My personal suggestion for a display board is one made of foil faced poster board. This material is available from most artist's supply houses and comes faced with a choice of silver, gold, copper or bronze. It adds a very classy touch.

- Linda Kay Brumfield -

## LETTERS!

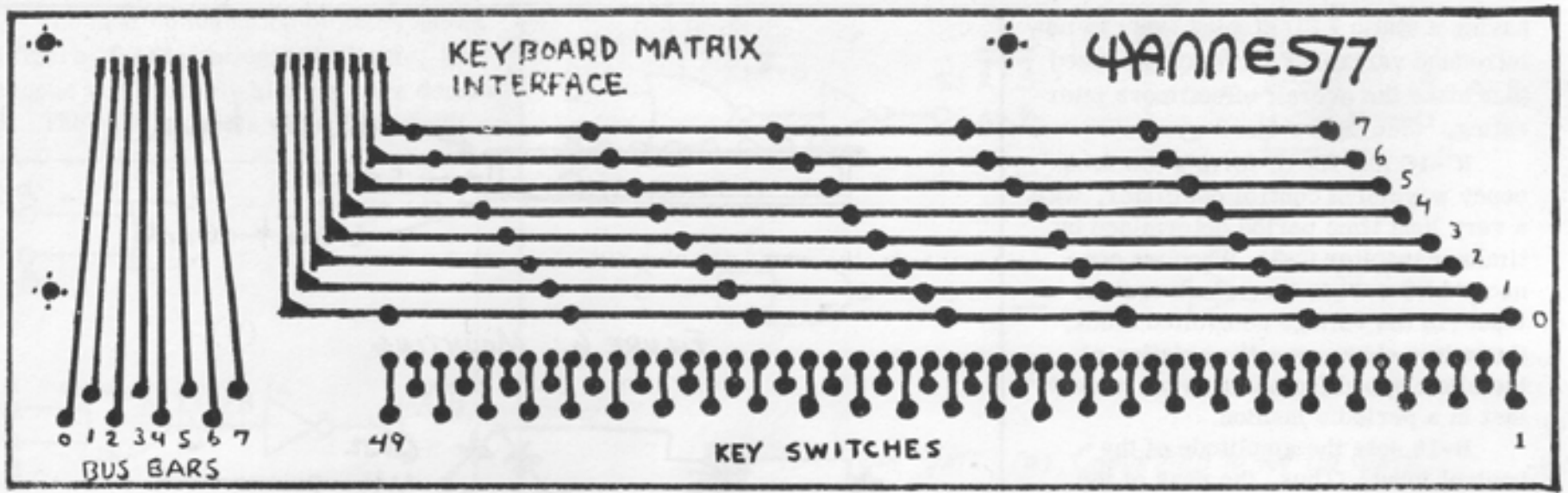
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issue of Polyphony. However, I thought

I would run his letter to see if any of you were interested in his proposed "custom music printing" service. As he said, it would be mandatory that a universally accepted high level music language be

established. After we read his article - on existing music languages, perhaps we can pool all our ideas and arrive at a workable solution.

- Marvin Jones -



# KEYBOARD MATRIX INTERFACE FOR EK-3

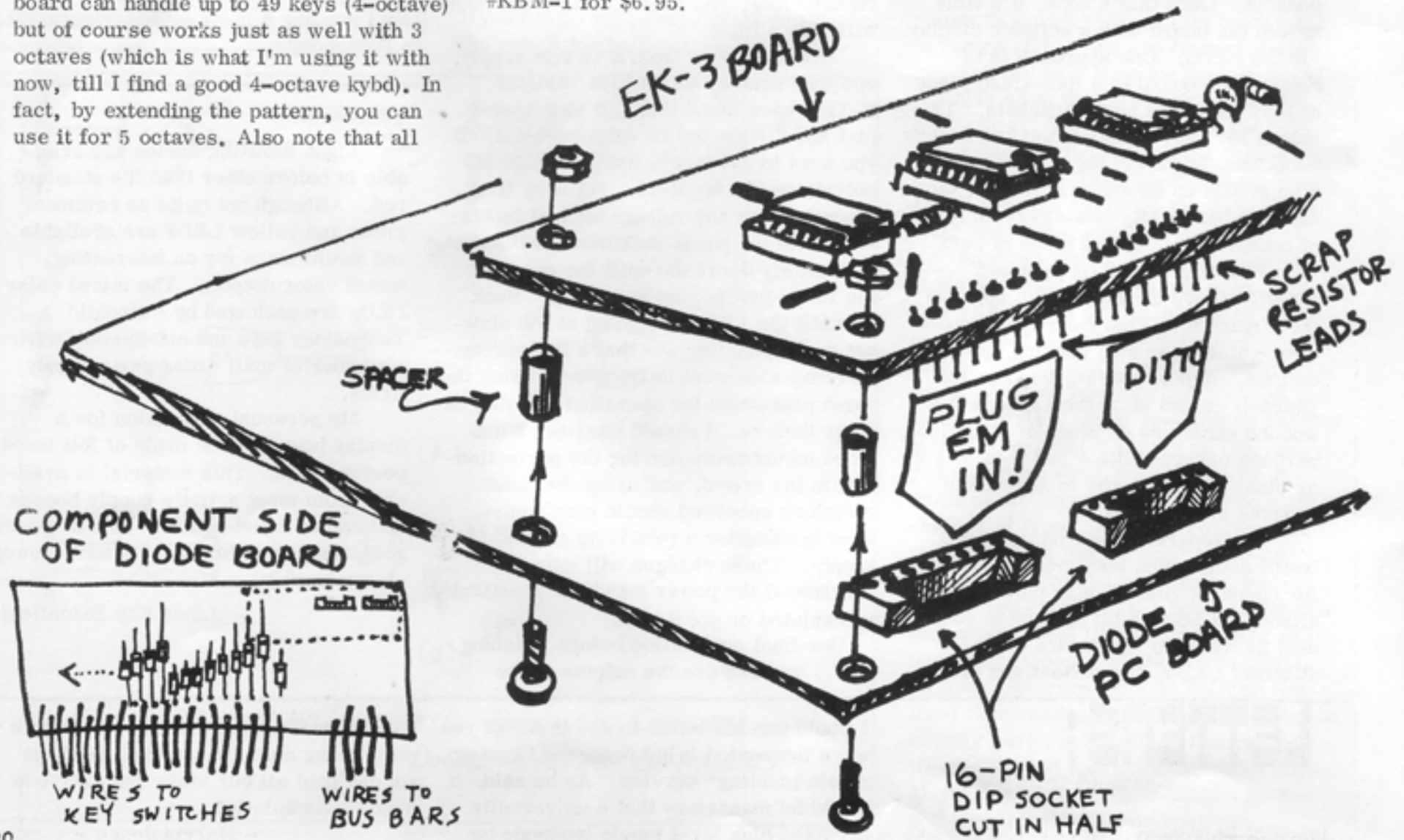
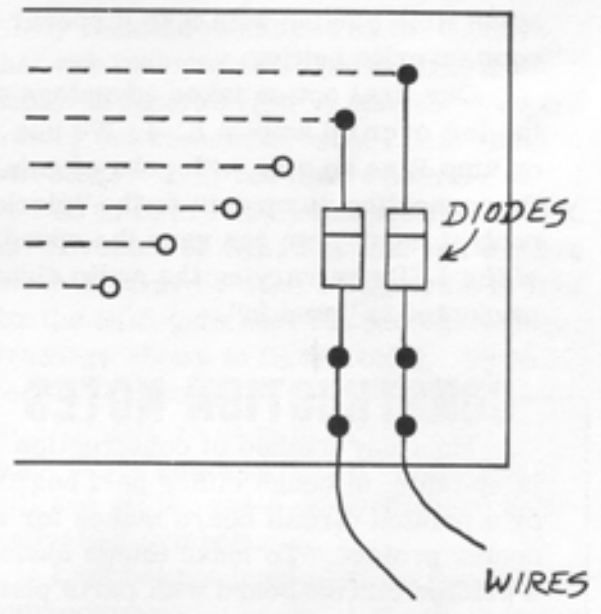
*yeah, we know...*

By: Bob Yannes

Here is a PC layout for a board that I'm using with my EK-3 encoder. It allows you to neatly add all those furschlugginer diodes and substantially reduces the amount of point-to-point wiring needed. All of the diodes solder to the board so the only wiring necessary is from my PC board to the key switches and bus bars. Transposing the keyboard up from 000000 is simply a matter of attaching the wires from the bus bars to the appropriate pads on my PC board. You'll notice that the board can handle up to 49 keys (4-octave) but of course works just as well with 3 octaves (which is what I'm using it with now, till I find a good 4-octave kybd). In fact, by extending the pattern, you can use it for 5 octaves. Also note that all

keyboard connections are brought out to a dual readout connector. By sawing a 16-pin DIP socket in half and soldering the two halves into the connector holes on the component side of my board, and then soldering bits of excess resistor lead into the connector holes on the EK-3, the two boards just plug together, no point wiring involved!

PAIA has available a full 64-note version of Bob's matrix board. Order #KBM-1 for \$6.95.



# BUILDING A BIONIC SAX

By: Greg Leslie

One of the first things that irked me about synthesizers was the fact that they were originally designed for keyboard players and keyboard players ONLY. Now, I took piano lessons for about a month like everyone else, but my main axe is alto sax. Why couldn't I play synthesizer, too?

Then it started happening. I saw a Lyricon advertised. (A Lyricon is a synthesizer with a controller that can be fingered like a sax or clarinet.) It's about time, I thought. However, when I got down to the bottom line, well, the price was a bit beyond my reach. Similar controllers came out, aiming toward brass and percussion, but again, the price wasn't in my range. Now my question was (and still is): Why can't I play the synthesizer at a reasonable cost? Of course, I bought a keyboard synthe-

sizer eventually, and I can pick out tunes with it and make beeps and bwadn's with the electronics, but my question still nagged me, until one day...

One day I was fooling around, talking to another synthesizer user - this guy had built a percussion controller - and I presented the idea of a cheapo sax controller. He helped me out with the circuit design, and I put the thing together.

Figure 1 is the schematic for the bionic sax.

I found it difficult to make a controller that could be used with linear VCO's, so I incorporated a top-octave generator chip as the built-in tone source. The two 4051 chips are multiplexer-demultiplexers, and a description and pin-out can be found in Polyphony No. 4. The nine switches change the input codes

to the 4051's, and for each code a "gate" opens, letting one tone from the TOG through to the output. Only one 4051 is on at a time to prevent two notes from getting out. Figure 2 contains saxophone fingerings and the equivalent binary input codes to the 4051. The other part of the circuit is the audio portion, which is essentially identical to the TOG circuit in the Oz. It provides continuous tuning and a 5-octave switch.

The circuit can be built on perf-board and stuck in a small box, with ribbon or other cable connecting it to the sax body. Here is where problems crop up. First you need a piece of plastic pipe about 2-1/2 feet long. Carefully saw it right down the middle so it splits into two curved pieces of plastic (a bandsaw would be helpful here). Now, drill and mount the switches and tuning

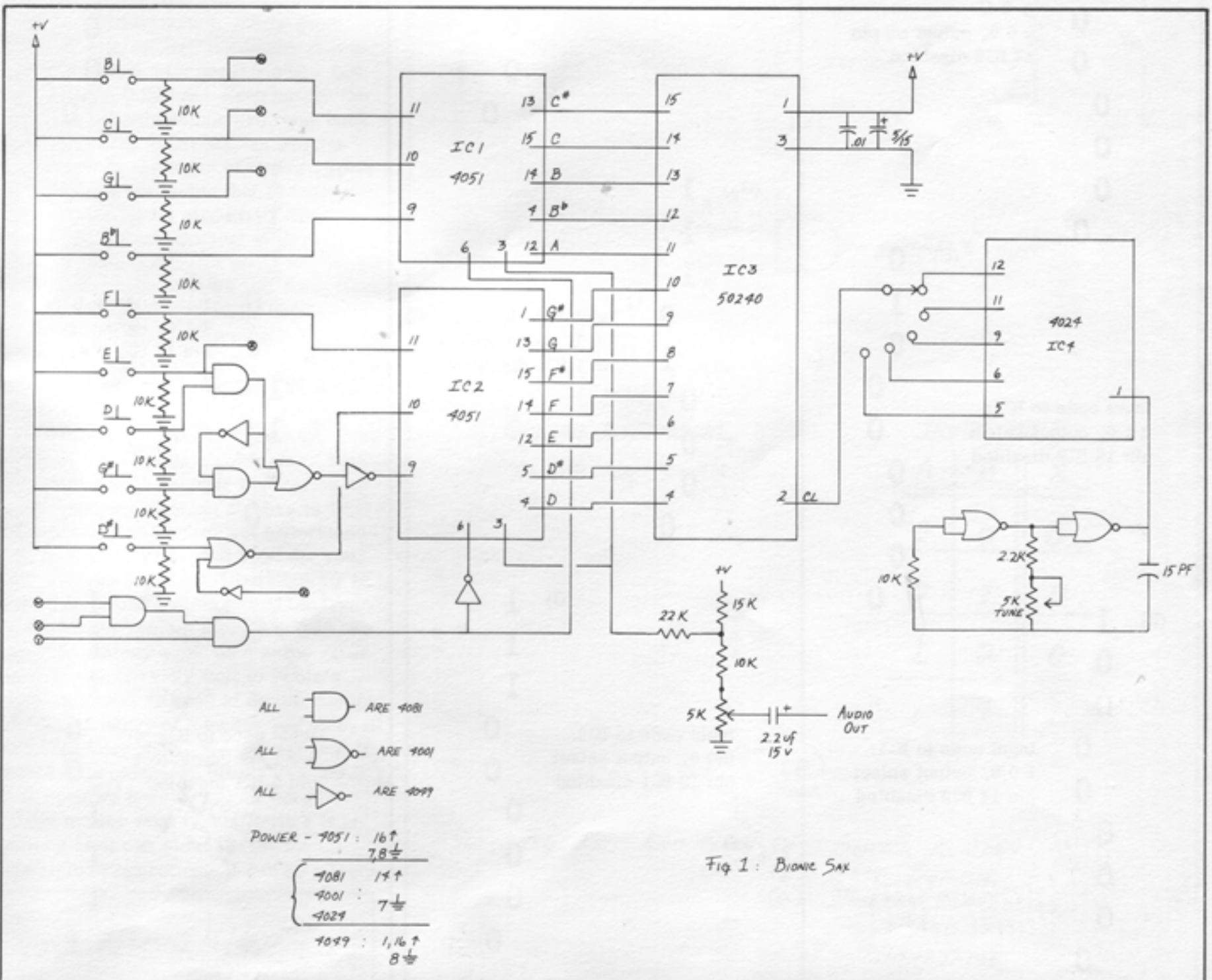


Fig 1: Bionic Sax

Figure 2 - Fingering Chart

0 indicates a not-pressed key, or ground.  
 1 indicates a pressed key, or supply voltage.

- 0 - B
- 0 - C
- 0 - G
- 0 - Bb
- 0 - G#
- 0 - F
- 0 - E
- 0 - D
- 0 - D#

(C#) 0  
 0  
 0  
 0 input code to IC1:  
 A B C  
 0 0 0, output on pin  
 13 IC2 disabled  
 0  
 0  
 0  
 0

(C) 0  
 1  
 0  
 0  
 0  
 0  
 0

input code to IC1:  
 0 1 0, output select  
 pin 15 IC2 disabled

(B) 1  
 0  
 0  
 0 input code to IC1:  
 1 0 0, output select  
 pin 14 IC2 disabled  
 0  
 0  
 0  
 0

(Bb) 1  
 1  
 0  
 1 input code to IC1:  
 1 1 1, output on pin  
 4 IC2 disabled  
 0  
 0  
 0  
 0

(A) 1  
 1  
 0  
 0  
 0  
 0  
 0

input code to IC1:  
 1 1 0, output select  
 pin 12 IC2 disabled

(G#) 1  
 1  
 1  
 0 input code to IC2:  
 0 0 1, output select  
 pin 1 IC1 disabled  
 1  
 0  
 0  
 0  
 0

(G) 1  
 1  
 1  
 0  
 0  
 0  
 0  
 0

input code to IC2:  
 0 0 0, output select  
 pin 13 IC1 disabled

(F#) 1  
 1  
 1  
 0 input code to IC2:  
 0 1 0, output select  
 pin 15 IC1 disabled  
 0  
 0  
 1  
 0  
 0

(F) 1  
 1  
 1  
 0  
 0  
 1  
 0  
 0  
 0

input code to IC2:  
 1 0 0, output select  
 pin 14 IC1 disabled

(E) 1  
 1  
 1  
 0 input code to IC2:  
 1 1 0, output select  
 pin 12 IC1 disabled  
 0  
 1  
 1  
 0  
 0

(D#) 1  
 1  
 1  
 0  
 0  
 1  
 1  
 1  
 1

input code to IC2:  
 1 0 1, output select  
 pin 5 IC1 disabled

(D) 1  
1  
1  
0  
0  
1  
1  
1  
0

input code to IC2:  
1 1 1, output pin  
select 4 IC1 disabled

Three of the "keys" are staggered because they are on a real sax, too. Many alternate fingerings are not provided. Some fingerings produce no output, others give tones. What fingerings give what notes can be discovered by following the circuit diagram and using the appropriate input code. Depressing B, C and G simultaneously inhibits IC1 and enables IC2. NOTE: The A, B, and C inputs on the 4051 chips actually correspond to inputs 2, 1 and 0 on the pinout respectively. You may want to rearrange the codes I give to clarify matters.

pot where you think they should go, or make a template from a real sax. Use calculator switches if possible. They may be hard to mount, but they're easier to play on in the long run. For the neck, I used a plastic pipe diameter reducer that has a 1-inch hole on the side, and whatever size pipe you use for the body on the other. I bent a 8-inch length of 1-inch diameter plastic pipe in the oven to match the curvature of a real sax neck, and fastened one end in the fixture. If you don't play sax and can't

get a real mouthpiece, don't worry - it's mostly for the convenience of the user. Place a small microphone element (from a cassette recorder mike or something similar) in the neck near the end you blow in and drill a few holes in the neck in front of the mike to let air out. Run the mike cable through the

KEYS B <sub>b</sub> B C G	A B C	OUT
0 0 0 0	0 0 0	C <sub>#</sub>
0 0 0 1	0 0 0	C <sub>#</sub>
0 0 1 0	0 1 0	C
0 0 1 1	0 1 0	C
0 1 0 0	1 0 0	B
0 1 0 1	1 0 0	B
0 1 1 0	1 1 0	A
0 1 1 1	1 1 0	A inhibit
1 0 0 0	0 0 1	X
1 0 0 1	0 0 1	X
1 0 1 0	0 1 1	X
1 0 1 1	0 1 1	X
1 1 0 0	1 0 1	B <sub>b</sub>
1 1 0 1	1 0 1	B <sub>b</sub>
1 1 1 0	1 1 1	X
1 1 1 1	1 1 1	X inhibit

NOTE: This chart and the one for IC2 show input coding, but not quite as well as the fingering chart. These may be useful to show alternate and special fingerings, or simply used to double-check. The notes encircled are the proper fingerings for that note. An "X" fingering gives no output.

Figure 3 - IC1 Coding

horn and out with the rest of the cables, then fasten the two body halves together, using some sort of strong tape.

For a completely self-contained instrument, build an envelope follower-trigger (like the 2720-11) into the electronics box and use the mike as the input. Your breath against the mike will make a trigger. That, plus the audio from the

future paths taken by our existing entertainment industries. I hope you will get involved in this exciting new field,

KEYS D <sub>#</sub> F E D G <sub>#</sub>	A B C	OUT
0 0 0 0	0 0 0	G
0 0 0 1	0 0 1	G <sub>#</sub>
0 0 1 0	0 0 0	G
0 0 1 1	0 0 1	G <sub>#</sub>
0 0 1 0 0	0 1 0	F <sub>#</sub>
0 0 1 0 1	0 1 1	X
0 0 1 1 0	0 1 1	X
0 0 1 1 1	0 1 1	X
0 1 0 0 0	1 0 0	F
0 1 0 0 1	1 0 1	D <sub>#</sub>
0 1 0 1 0	1 0 0	F
0 1 0 1 1	1 0 1	D <sub>#</sub>
0 1 1 0 0	1 1 0	E
0 1 1 0 1	1 1 1	D
0 1 1 1 0	1 1 1	D
0 1 1 1 1	1 1 1	D
1 0 0 0 0	0 0 0	G
1 0 0 0 1	0 0 1	G <sub>#</sub>
1 0 0 1 0	0 0 0	G
1 0 0 1 1	0 0 1	G <sub>#</sub>
1 0 1 0 0	0 0 0	G
1 0 1 0 1	0 0 1	G <sub>#</sub>
1 0 1 1 0	0 0 1	G <sub>#</sub>
1 0 1 1 1	0 0 1	G <sub>#</sub>
1 1 0 0 0	1 0 0	F
1 1 0 0 1	1 0 1	D <sub>#</sub>
1 1 0 1 0	1 0 0	F
1 1 0 1 1	1 0 1	D <sub>#</sub>
1 1 1 0 0	1 0 0	F
1 1 1 0 1	1 0 1	D <sub>#</sub>
1 1 1 1 0	1 0 1	D <sub>#</sub>
1 1 1 1 1	1 0 1	D <sub>#</sub>

Figure 4 - IC2 Coding

sax circuit can be run to a three-conductor plug and interfaced with the Gnome the same way the Oz can. An Oz-type battery pack (12 volts DC) can also be used to power the sax. If more versatility is desired, the sax can be interfaced with any PAIA equipment. Granted, it's not fancy, but it's a good start.

"Next time: The Bionic Trumpet"

# Editorial

...continued from page 3

number of musicians who are getting interested in buying multitrack recorders and mixing boards, modifying their instruments to better suit their needs or playing style, or even designing/building new types of equipment which aren't available on the commercial market. This can't help but breed a new generation of music which is written, arranged, produced and performed by small groups of people. Hopefully, there will be an increasing number of these types of albums. I feel that they give a breath of fresh air to an entertainment industry which unendingly jumps from rut to rut. Also, whether you realize it or not, these "struggling underdogs" have a very strong indirect influence on the

and give it whatever support you honestly feel.

- Marvin Jones -

### ATTENTION NEW YORK / NEW JERSEY SYNTHESISTS

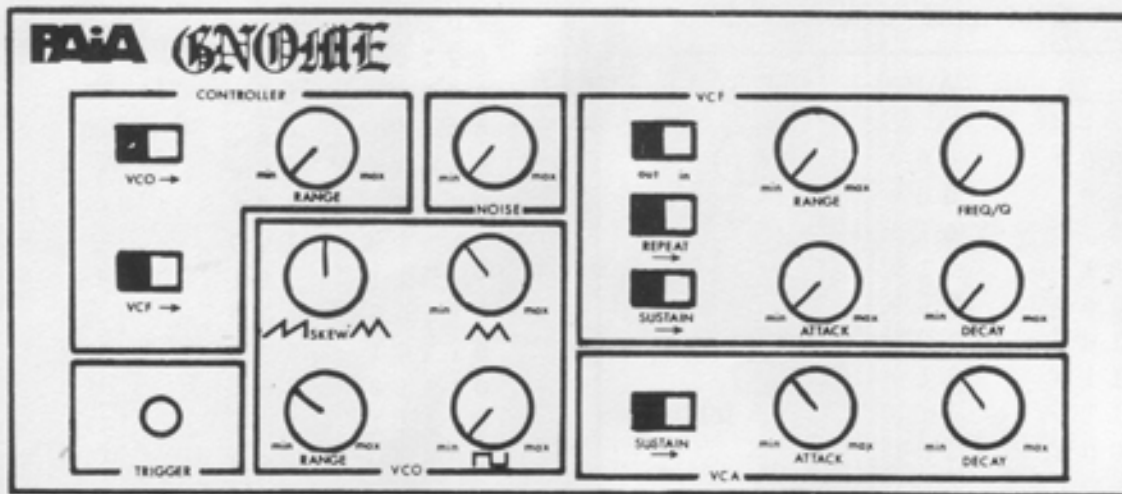
HAVE YOU HAD A CHANCE TO MEET PAIA'S NEW SERVICE REPRESENTATIVE FOR YOUR AREA? SEE THIS ISSUE'S SPOTLIGHT ARTICLE ON PAGE 5.

Those of you in other parts of the country—sorry—we're looking for service reps to help you. Watch Polyphony and you'll be the first to know about them.

OR Should we say: Who's Walter?

# PATCHES

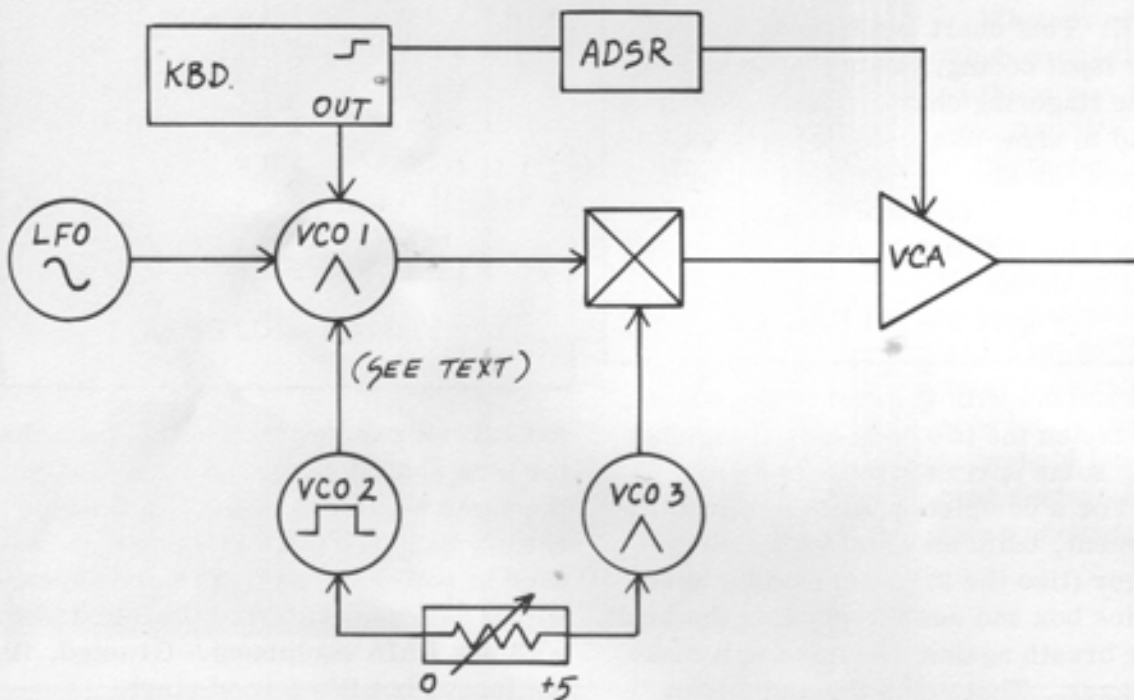
## BULL FROG



Set Range to about 20-30 Hz. (Set range pitch to taste). Skew - 50%. Triangle - 30%. Hit and hold trigger, then repeat.

Submitted By: Ron Ruggiero  
Erie, PA.

## NIGHT SOUNDS



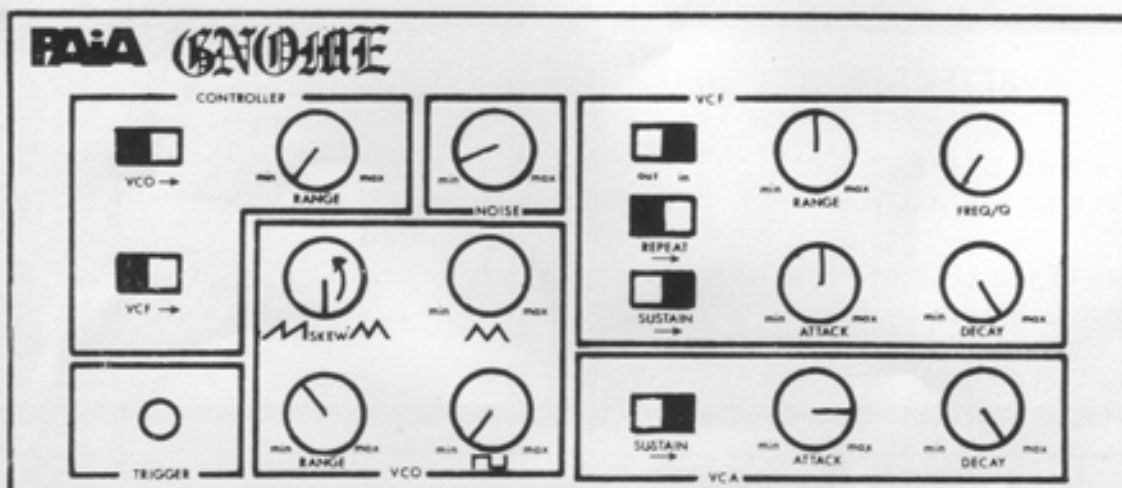
Keyboard: high range, no glide.  
VCO-1: init. pitch - 50%  
VCO-2: init. pitch - 25% - 75%  
VCO-3: init. pitch - 25% - 75%  
LFO: 2 - 20 Hz.; 10% amplitude  
Bias: minimum voltage that will trigger oscillation of VCO-2 and VCO-3.

The connection from VCO-2 (audio out) to VCO-1 (control voltage in) is via an attenuation patch cord such as that described in the 4730 filter handbook.

As with any patch involving this many variables, minor adjustments will produce considerably different results.

Submitted By: James R. Wood  
Santa Fe, N. M.

## CAR OR MOTORCYCLE PASSING YOU BY



VCO - Range - 20-30 Hz.  
Triangle - 25%

Set attack and decay in both VCF and VCA as shown. Noise set slightly off minimum. Start with Skew at maximum. Hit trigger and when VCA reaches peak, rotate skew to 50% and after it reaches 50% release trigger. It takes some coordination for proper effect.

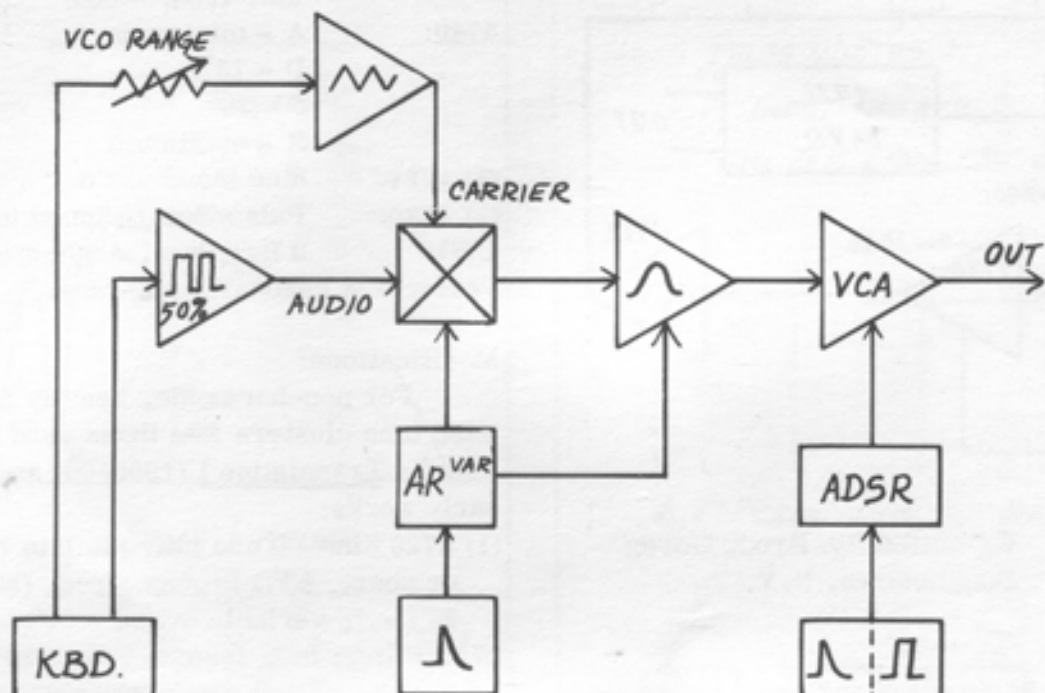
Submitted By: Ron Ruggiero  
Erie, PA.

more...



# PATCHES

## TONE WARP I



### Tone Warp I

- 1) Keyboard set at the upper range.
- 2) Modulation frequency offset slightly less than one octave.
- 3) Adjust balanced modulator modulation control.
- 4) B.P. filter "Q" at maximum.
- 5) AR expand off, A. 50%, R. 30%.
- 6) ADSR, A. 20%, D. 20%, S. 75%, R. 50%.
- 7) Adjust keyboard pitch to tune completed patch.

### Tone Warp II

#### I. Basic

- 1) Set keyboard to desired range.
- 2) Patch in desired carrier waveform (try a triangle first).
- 3) Adjust modulation control.
- 4) B.P. filter "Q" at maximum.
- 5) Trigger AR and ADSR with step trigger.
- 6) AR expand off, A. 50%, R. 30%.
- 7) ADSR - A. 20%, D. - 20%, S. -75%, R. - 40%.
- 8) LFO P.W.M. approx. 4Hz., pulse to 50% duty.

#### II. Down Tone

- 1) ADSR full output to VCO.
- 2) Adjust bias for mod. at OV ADSR output (try using keyboard instead).

#### III. Up Tone

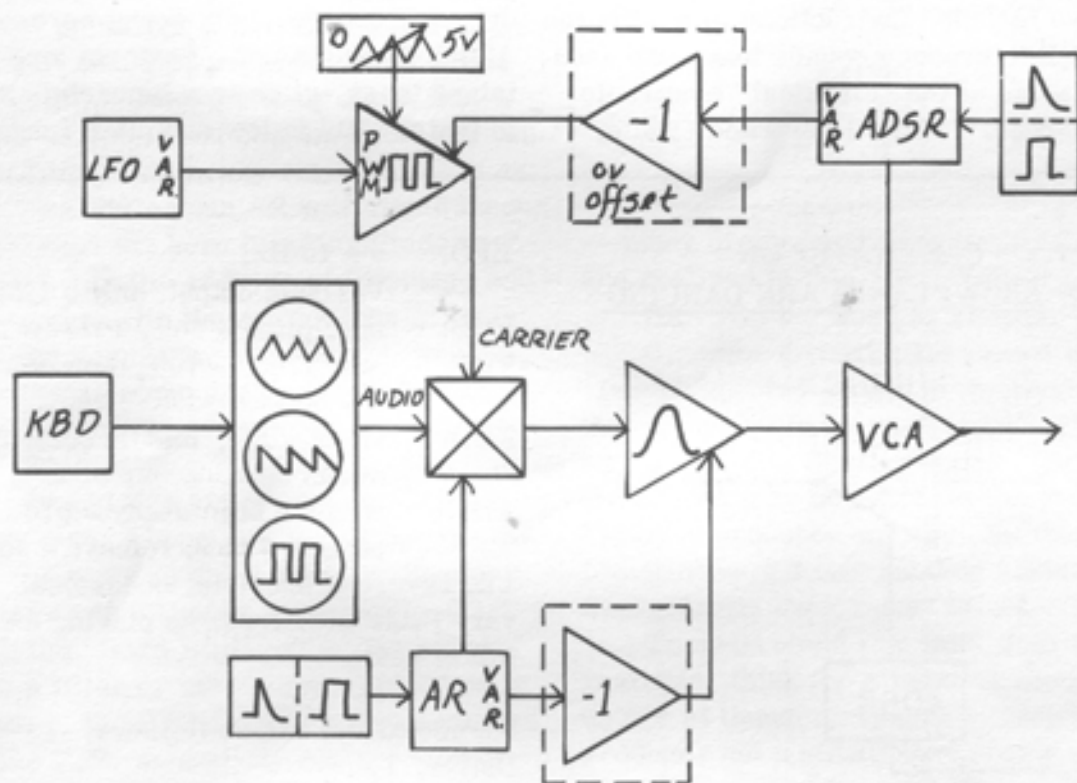
- 1) 5v. bias.
- 2) Invert and adjust ADSR output for mod. when ADSR is on.

#### IV. Variations

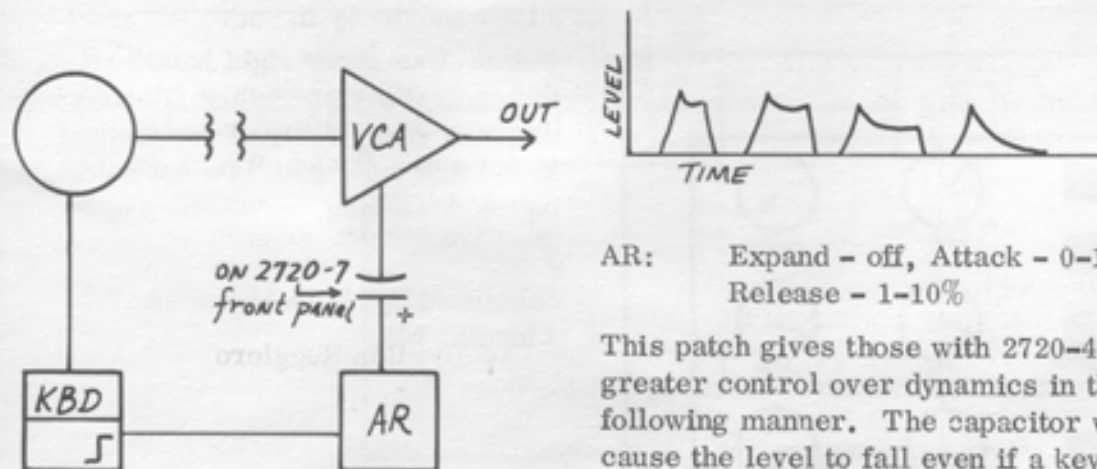
Invert the filter control, sweep the filter, change the AR profile for mod. before the tone, change the triggers, vary the PWM, use a function generator for PWM, etc.

Submitted By: Mark Schweter  
Parma, OH.

## TONE WARP II



## PIANO TYPE ENVELOPE with a 2720-4 AR



AR: Expand - off, Attack - 0-100%,  
Release - 1-10%

Submitted By: Kenneth Keeler  
Houston, TX.

This patch gives those with 2720-4 AR's greater control over dynamics in the following manner. The capacitor will cause the level to fall even if a key is held down. If it is held down long enough the level will fall almost to ground by

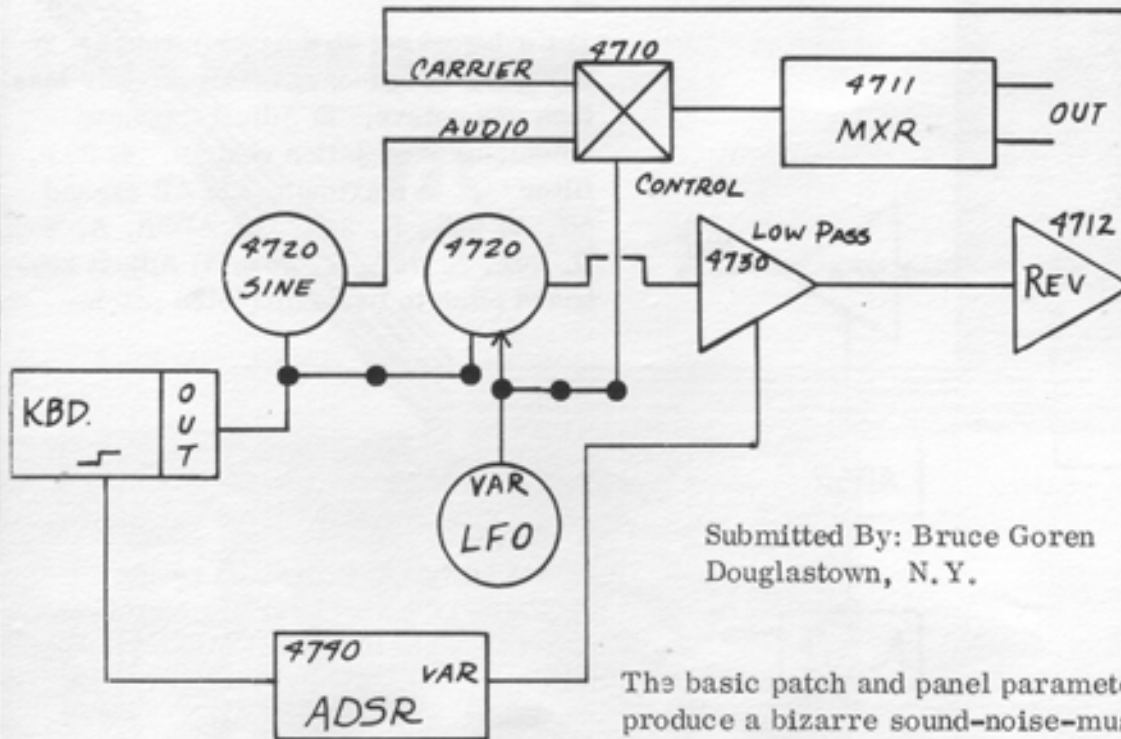
itself. But whenever the key is released, the level will fall to ground at the preset release rate. See diagram.

The dynamics are somewhat like those of a piano, though the setup can be used with any patch going into the VCA.

more...

# PATCHES

## HEAVY METAL POGO STICKS



Submitted By: Bruce Goren  
Douglastown, N.Y.

The basic patch and panel parameters produce a bizarre sound-noise-music that I refer to as "Heavy Metal Pogo Sticks". But on the serious side, I have included instructions to modify the patch to produce sounds that were used by some of the "classical" electronic composers of the 1950's and 1960's.

- Reverb: 30%
- 4730: Lowpass output, track position, high range, max. Q, init. freq. - 80%
- 4740: A - minimum  
D - 75%  
S - 75%  
R - maximum
- (1) 4720: Sine tuned to C3  
(2) 4720: Pulse/Square tuned to A4  
LFO: 3 Hz.; Var. - 50%
- Perform at keyboard mid-range.

### Modifications:

For non-harmonic, heavily modulated tone clusters like those used in M. Kagel's Transistion I (1959-60) and other early works:

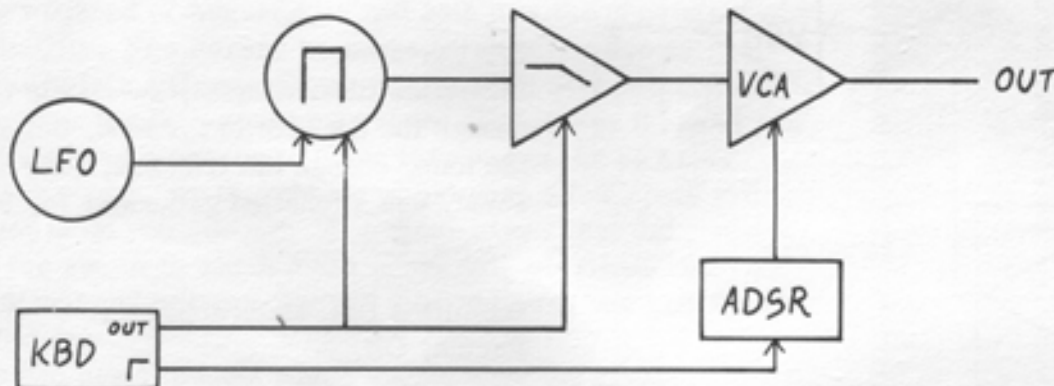
- (1) 4720 Sine - Tune init. pitch to max. or near. LFO to max. freq. (about 25 Hz.), variable output - 50%.
- 4730 Filter: Init. freq. - 50%. Perform in quick atonal progressions.

For opening tones from Transistion I or Summer Idylle (1959) by Schaffer or Objets Lies (1959):

Set LFO var. near but not at zero. 4740 Attack to maximum. Perform long sustained tones, glide may be useful, season to taste. Mid to low end pitch range.

## WOMAN'S VOICE

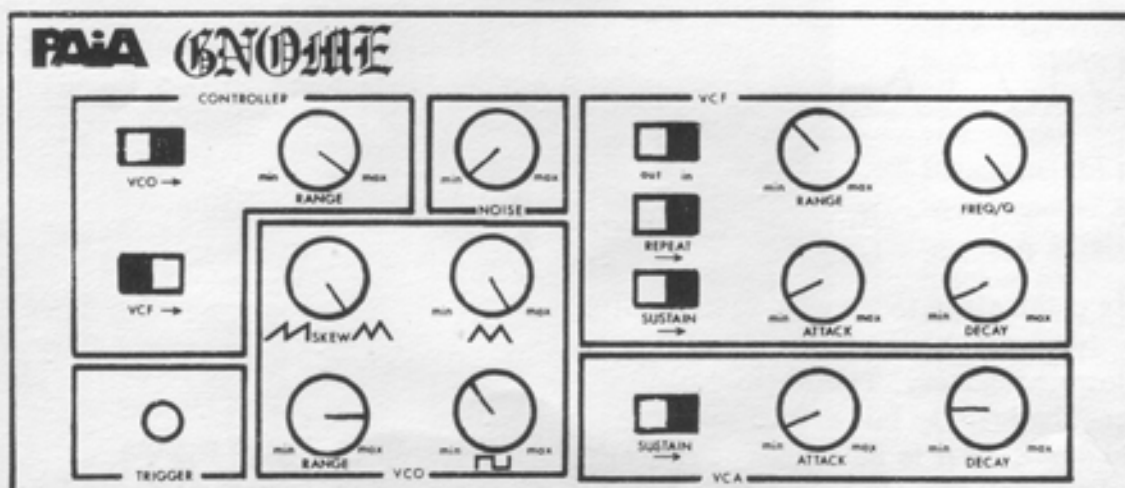
FROM "GOLLIWOGS CAKEWALK" ON  
ISAO TOMITA'S SNOWFLAKES ARE DANCING



- LFO: 9 - 10 Hz.  
Variable output; only slight
- VCO: init. pitch - 35%, PWM - 75%
- VCF: init. freq. - 70%, Low Pass;  
Q - 60%
- KBD: slight glide, middle octave works best.
- ADSR: attack - 50%; decay - 0%;  
sustain - 60%; release - 40%
- Use reverb if possible, occasionally vary filter init. freq. as playing for the full effect.

Submitted By: James Holloway  
Dallas, TX.

## THE GNOME CRICKET



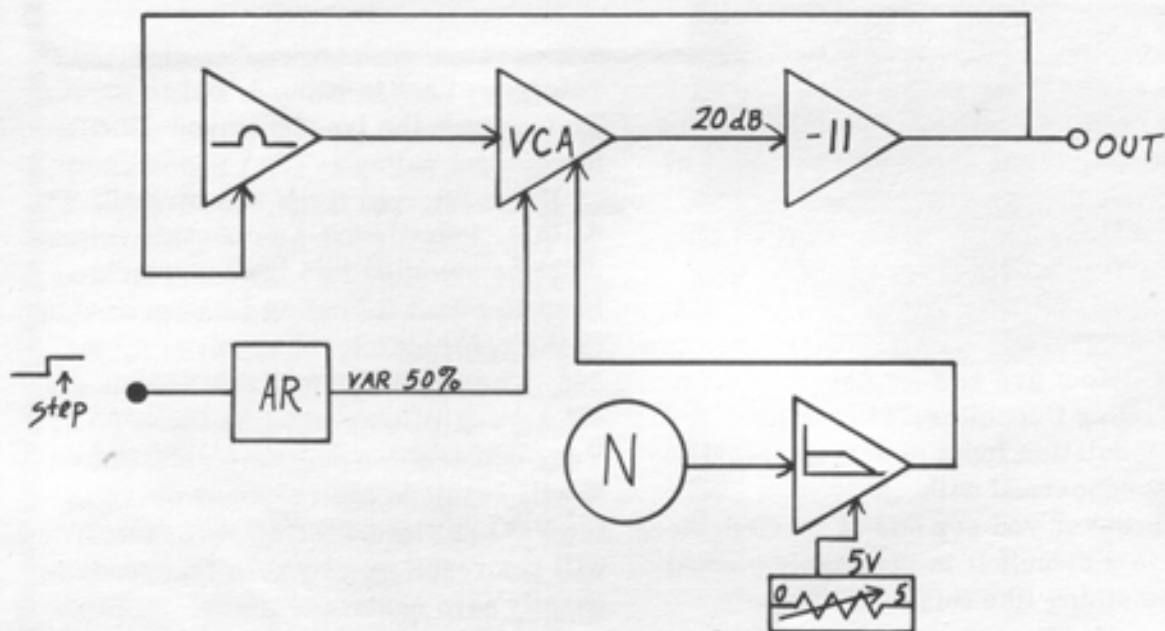
Notes: Use upper right hand portion of the control strip. Adjust filters range, attack & decay controls for the best sound that suits you. Do not hold trigger button down long.

Submitted By: Walt Simmons  
Lincoln, NB.

more...

# PATCHES

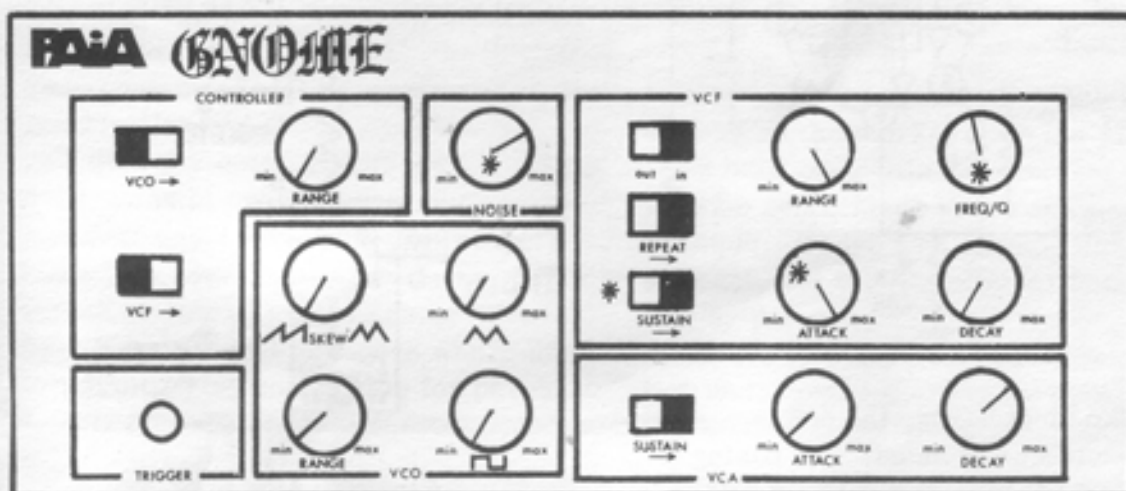
## EAR PIERCING SCREAM



B.P. Filter: Q maximum  
 AR: A - 50%, R - 30%  
 Inverter: 0v. offset

Submitted By: Ron Jones  
 Orange, CA.

## STEAM TRAIN



First set the Noise so that it is barely on and set the VCF attack to minimum. The train is now moving full speed in the distance.

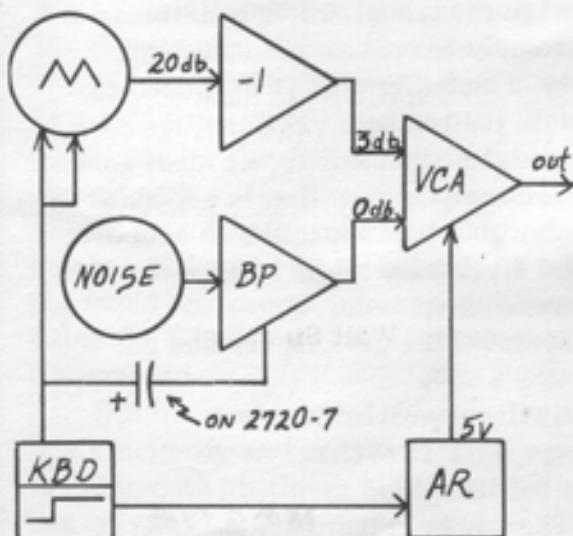
Move both the Noise and the attack clockwise to get the effect of the train slowing down while getting closer to the "train station".

As you "pull" into the station, let go of the trigger as you slide the VCF sustain switch to off. This is the final blast of steam as the train stops.

You should adjust the FREQ/Q switch to your own preference.

Submitted By: David Patterson  
 Regina, Sask., Canada

## EERIE WHISTLE



Pitch: maximum  
 Filter: "Q" maximum  
 AR: Attack - 0%, Expand - off, Release - 0%

The inverter is used only to amplify the triangle wave so it can be heard over the noise. The patch sounds best when played in the top octave, perhaps with some glide. The filter should be grounded at one input. The eeriness derives

from the sweep of the filter by the keyboard through the capacitor on the 2720-7 front panel, which causes the triangle wave to sound somewhat hollow.

Submitted By: Kenneth Keeler  
 Houston, TX.

more next issue...



by  
John S. Simonton, Jr.

At last, our computer is in production.

It took longer than most because it's a more complex thing than most (The amazing PAIA Do-All machine - you may substitute any manufacturer's name for ours). The Assembly And Using manual, for instance, is 64 pages. The programming manual (supplied by MOS Technology) another 200. Lots of detail, lots of drawings and stuff.

Yes it took a while; but it's one of our best efforts and one of the first things that we handled as a team. A very gratifying experience.

I really don't want to rave too much because this is not what we came here for this time. A simple statement - it's slick, it's a bargain, I like it.

Because of the effort devoted to getting this product out of the doors I am caught with my literary pants down (so to speak); I don't have any one thing to do a column on this time. Let's just roam, there are a number of things we can look at.

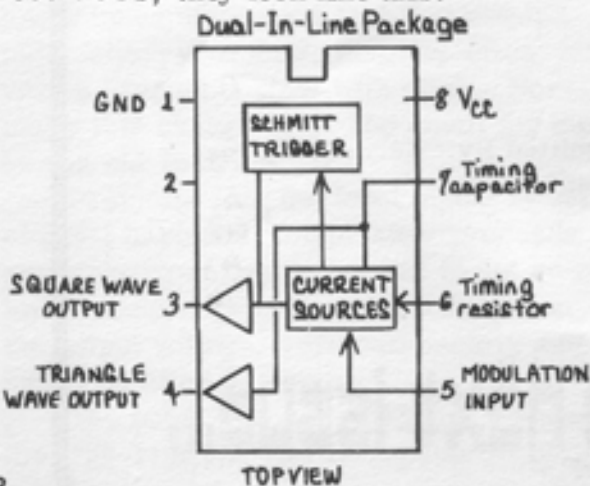
### F'RINSTANCE

I saw a thing the other day, a re-print of Marvin's Radio-Electronics Phlanger story. Someone was selling it as an applications note for analog delay lines(!). Now it's flattering, in a way, to have this happen (when people quote you, you kind of figure that you did something worth noting, anyway) but it also has its frustrating aspects.

### LIKE

One of the things that was appended to this off-print (our mention had naturally been deleted from the parts list) was a statement that 566 type VCO IC's are near useless in music applications because of their limited range, less than perfect linearity, and like that. Let's look at this some.

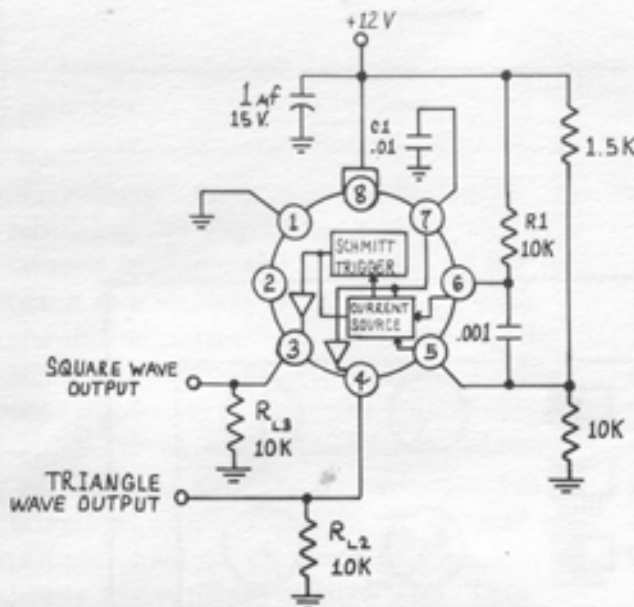
For those of you not familiar with the 566 VCOs, they look like this:



and I have always suspected that they were defective 565 Phase Locked Loops in which only the oscillator portion was operational.

The Vcc pins is the supply (this chip likes to work with from 10-24 volts across it), GND is ground and the pins labeled Square Wave Output and Triangle Wave Output are self-explanatory. It's the Timing Capacitor, Timing Resistor and Modulation Input pins that we are really concerned with.

Whenever you see one of these devices used in a circuit it is invariably hooked up something like this:



Like most VCOs, the 566 is a relaxation oscillator at heart. The timing capacitor charges at a rate set by the timing resistor. As the capacitor charges, the voltage across it increases until an upper threshold set by the internal Schmitt Trigger is reached, at which time the Trigger switches causing the Current Source to provide a discharging current rather than a charging one. The voltage across the capacitor decreases until the lower threshold of the Schmitt is reached, whereupon it switches again and begins once again the charging cycle.

Because the charging and discharging is done with a constant current the voltage across the capacitor is a triangular wave which is buffered by a very simple internal amplifier before appearing at the package's Triangle Wave Output pin. The output of the Schmitt is the Square Wave.

There is some control over the current supplied to the timing capacitor provided by the Modulation Input pin in this configuration, but it's minimal, and it also has some really raunchy problems for our uses.

First, the control voltage input is

referenced not to ground, but to supply. To increase the frequency you DECREASE the control voltage.

No sweat, you think, an inverter will do this. Indeed - but - a constant voltage must be summed into the inverter's input to offset its output from ground up to the reference level required by the 566. The implication of this is that the off-setting voltage must be CONSTANT. Very constant because any variation in it will result in the response curve of the VCO not intersecting zero; i. e. you will not reach exactly zero frequency for exactly zero control voltage.

Secondly, the linearity is not good enough for our purposes for a couple of reasons:

a) The current source (when simplified somewhat) is essentially like every other current source in the world and can be thought of as a single transistor. Like this:

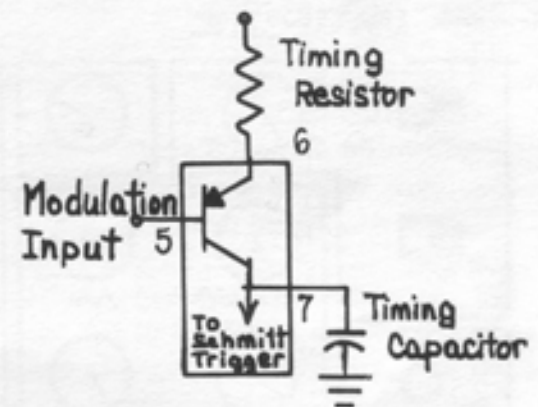


FIGURE A

The actual current source in the chip, unlike the illustration above is bi-lateral (supplies charging and discharging current) but this representation is useful for our purposes. Most of us already know what's wrong with this; the diode equation that governs the current flow through the transistor is non-linear and extremely temperature dependent.

b) The buffer that is supposed to isolate the triangle wave that appears across the capacitor is not ideal so that some of the current that is supposed to be charging this capacitor is actually being diverted into the buffer - and this represents an error.

Most people get this far and go:

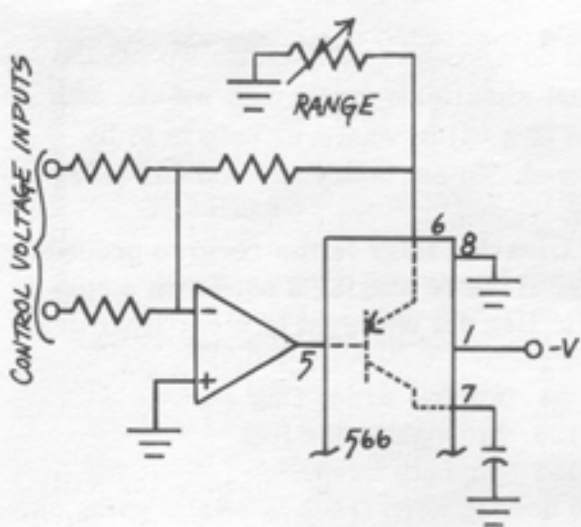
YECH

this will never work.

BUT IT WILL

just not like this.

The key to using these devices in turning the "deficiency" in problem (a) above into an advantage. Like this:

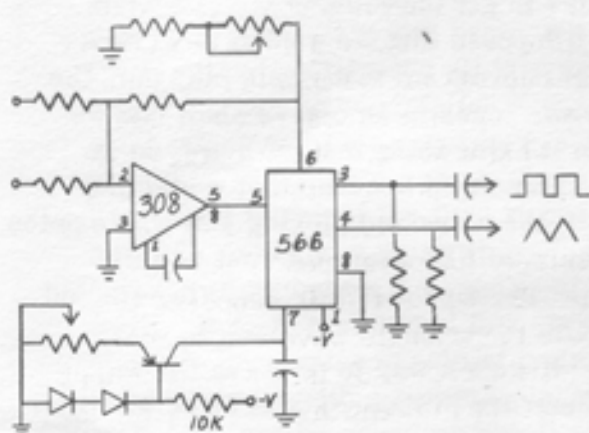


Recognize it? It's a lot like the front end of a 4720 oscillator. Here the operation of the current source has been linearized by placing it within the feed-back loop of the summing amplifier. Happily, this change also permanently ground references the input control voltages without having to worry about off-setting problems.

Notice that the 566's supply pins are slightly different here; the chip is now powered from Gnd and the negative supply.

Better, but if you actually hook one of these up and watch it on a 'scope you'll see some strange things. At higher frequencies you will begin to notice that this waveform is not a triangle anymore, it sort of slumps into a ramp - and pretty soon after that it dies completely.

What you're seeing is the error resulting from that imperfect buffer on the triangle output. It's sinking a constant amount of current that really should be going into charging the capacitor. It's not noticeable at high frequencies because at high frequencies the error current is small compared to the charging/discharging current. We can "fix" this by installing an out-board current source to compensate for the lost current, like this:



and this is a complete VCO producing triangles and squares. With the values shown, total usable frequency range is easily 16 Hz. to 16 kHz, and linearity is adequate for our purposes once the current compensator has been properly adjusted. You adjust it in the same manner as you would a "zero" control on one of our other oscillators.

Oh, and before I forget to mention it; these same tricks will work on the 8038 type VCO chips.

### THE APPLE CONNECTION

The world is beginning to fill with micro-computers. PETs, TRS-80s, H-8s and H-11s; everybody wants to get into the act. The amazing part of this is: **IT HASN'T REALLY EVEN STARTED YET**

The personal computer is as fundamental an addition to mankind's bag of technological tricks as any that has ever happened. As basic as television and radio. A recent issue of Scientific American pointed out that just as the industrial revolution freed men's bodies the personal computer will free their minds. We will keep our fingers crossed that this "freedom" doesn't lead to atrophy. Or worse yet, some sort of intellectual anarchy. The basis for freedom is, after all, discipline.

And, before we get off the subject (what is the subject?) why has no one yet done research on the subjective aspects of computers - their psychological impact. The narcissistic implications

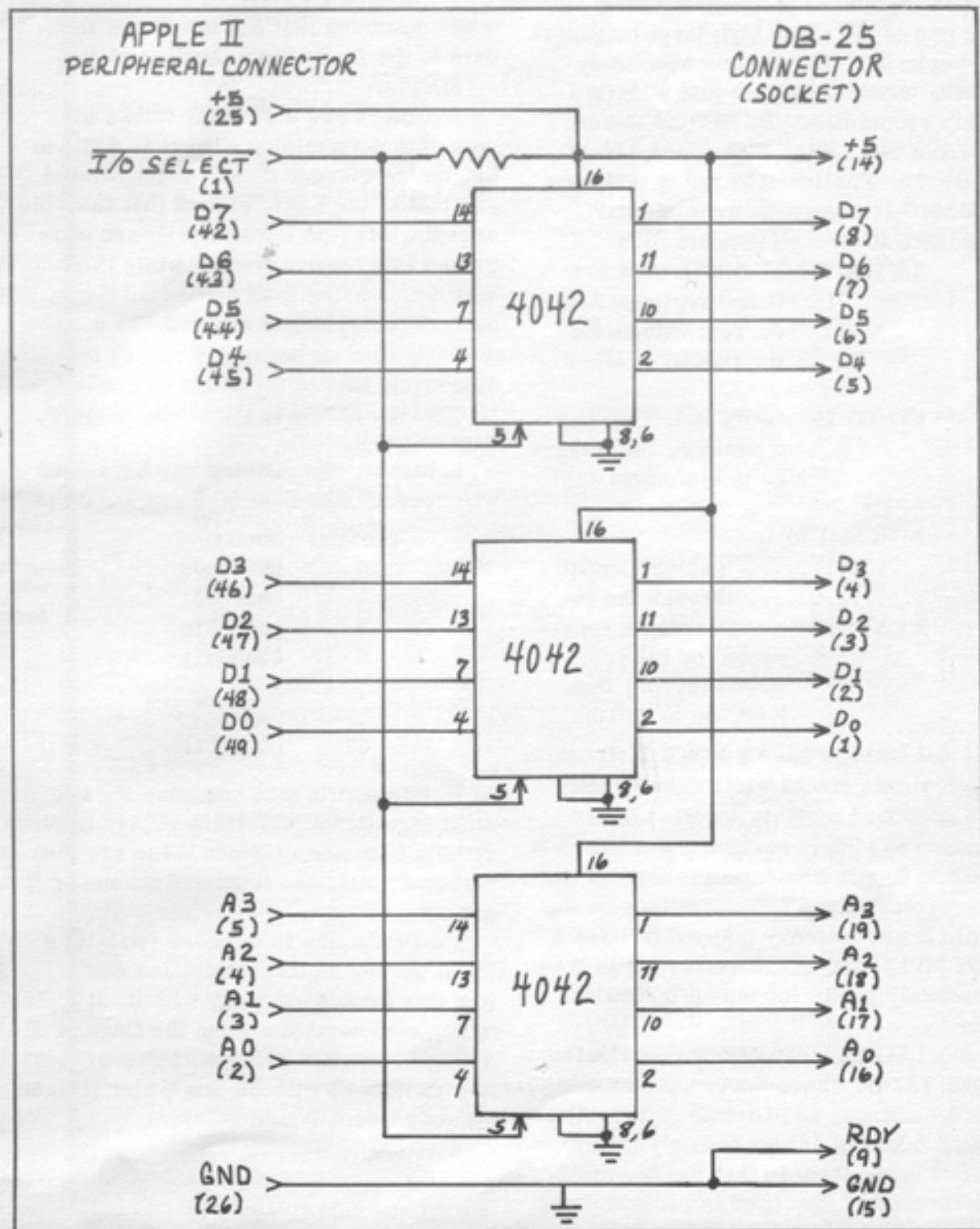
of sitting (by choice) at the terminal of a computer hour after hour. Isn't it this "self-love" that is the basis for our fascination with these things? A very sophisticated window into our souls. The ultimate slave.

Mental masturbation.

That was somehow supposed to lead us into the Apple II interface card (though I now have forgotten how). Oh well, damn the non-sequitor, full speed ahead.

The Apple II is nice. One of the nicer things about it is that it really exists - and has for at least six months. You can really go into your local computer store and see one. And play with it. Don't buy it there, though, buy it from us.

Another nice thing about them is that they are easy to interface to. Inside the case, along the back edge of the circuit board, is a row of eight 50 pin edge connectors. I don't know what-all Apple has in mind to go to these connectors (you would probably be safe guessing things like printers and disk drives) but they absolutely could not have made them any easier to use with our synthesizer stuff. Here's ALL the circuitry you need



The I/O SELECT line on the Apple II peripheral connectors is an active-low signal line that indicates a read or write operation from or to any one of a contiguous block of 256 addresses. Which block is a function of which connector. For example, the I/O SELECT line of peripheral connector #7 (the one we usually use) goes low for the addresses in the range \$C700 to \$C7FF. When low, this line causes new data to be strobed into the 4042 latches. The outputs of these latches are the inputs to peripheral module you are controlling.

If that module is an 8780 D/A, the connections to the D/A's "D" connector should be as shown in the 8780 manual.

For those times when a QuASH is also part of the system, an additional 4042 is used to simultaneously latch the 4 least significant bits of the address line.

Tying into an Apple II buys you quite a few things (color graphics to go with your music, etc.) and one of the biggest of these is a relatively nice BASIC.

BASIC, as most everyone knows by now, is an acronym for Beginners All-purpose Symbolic Instruction Code, and it is one of the nicer high level languages for beginners. If you know absolutely nothing about BASIC (or just a little) I highly recommend "BASIC" by Robert Albrecht and LeRoy Finkel and Jerald R. Brown. Published by Wiley and Sons.

BASIC is a very "conversational" language. It uses statements like:

```
LET A=B+C (which adds B to
           C and replaces A's
           current value with
           the result)
```

```
GO TO 10 (each statement has
          a number, this means
          go to statement #10)
```

```
FOR N=1 to 10
..... (which "loops"
..... through the in-
NEXT N structions repre-
          sented by the .....
          first with N=1 then
          N=2, up to N=10)
```

Most BASICs have a POKE instruction which allows you to write data directly to a specified memory location (as opposed to simply assigning it a variable name to be put who-knows-where by the interpreter). Since I/O operations on the Apple II are memory mapped (it uses a 6502 MPU), the POKE statement is tremendously useful for output operations also.

Most POKE instructions take the form POKE (A, D) where the two arguments are A - address and D - data to be written to that address. About the only tricky part of using them is that the two numbers are invariably specified in programming as decimal numbers. And, the Apple II

can be particularly confusing because numbers greater than 32676 must be expressed as negative numbers. The addresses that we're using as output ports are greater than 32676, but I can save you a little time on the calculations and just list them:

(1)	(2)	(3)
-12311	-12567	-12823
⋮	⋮	⋮
-12056	-12312	-12568
(4)	(5)	(6)
-13079	-14335	-14591
⋮	⋮	⋮
-12824	-13080	-14336
(7)		
-14847		
⋮		
-14592		

I didn't list the address range of slot #0 because it's reserved for something that the Apple folks have in mind.

If I have some note N that I want to play, I can do it with the statement:

```
POKE (-14592, N)
```

which assumes that I'm outputting the data to the first output location slot #7.

Simple.

But there are also some tricks involved in determining what N is going to be, and to discuss these I must remind you that of the 8 bits of data that the 8780 accepts, six (the low-order 6) are converted to a control voltage while the high order 2 are used as control flags. Since 6 binary digits can express a decimal number between 0 and 63 (64 numbers), this is the range of the D/A in semi-tones. 64 is the magic number, remember it.

In binary, the decimal numbers 0-63 will "count" like this:

decimal	binary
0	00000000
1	00000001
2	00000010
3	00000011
⋮	⋮
⋮	⋮
63	00111111

Notice that in this sequence the two most significant bits of the binary number remain both zeros. Since these are the "trigger" bits, the trigger flags never get set.

I'd really like to impress you with a lot of snappy digital magic, but don't feel that I could get away with it. It's pretty obvious that setting the flags is a simple addition process. If we want to play note #3 with the low order trigger bit set we simply add:

decimal	binary
3	00000011
+64	+01000000
67	01000011

and do a POKE (-14592, 67). To set the most significant trigger bit we can add 128 (2 x 64) to whatever note is to be played. To set both flags add 192 (128+64).

Clearing flags is the reverse procedure. If we're playing a note with a specific flag set and want to clear it we can subtract:

```
64 for low order flag
128 for high order flag
192 for both flags.
```

We need to keep track of what's going on, of course, particularly when clearing flags with a subtraction - otherwise we might actually wind up with a negative number as our output. That won't work.

Usually, it is easiest when programming to use the flag-setting addition as an expression directly in the POKE statement's data argument.

This:

```
100 POKE (-14592, N+128)
110 FOR R=1 to 20 : NEXT R
120 POKE (-14592, N)
```

```
.....
.....
```

for instance, is a short program that will cause some note N (determined in previous programming steps) to be played first with the high order trigger flag set and then - after a delay determined by how long the FOR-NEXT loop at statement 110 takes to execute - again with the flag lowered. This would be like playing a note from the keyboard and holding the key down for the duration of the FOR-NEXT before releasing it.

Transposing things into a new key signature is no big problem. To transpose a note up an octave simply add 12 (the number of semi-tones in the equally tempered scale) and to transpose down an octave subtract 12. To transpose up by an interval of a third add --. Down by a third subtract --.

You get the idea.

Suppose that we wanted to write a short program that would play only the whole tones in an octave - how can we do it? One thing that we can't do is simply count because that would play all the notes and playing just whole notes there will be some we want to skip: specifically, the 2nd, 4th, 7th, 9th and 11th.

Here's a way to do it (an OK way, there are probably better) that will also be useful for converting letter-name entries from an ASCII keyboard into the decimal number required to produce the desired note.

First, we define a literal (text-string) variable as follows:

```
20 LET N$="C-D-EF-G-A-B"
```

The spacing of the note names within this variable, you will note, is the same as the distribution of the whole notes on an

AGO keyboard with the hyphens replacing the accidentals. Now the Program:

```
100 FOR N=1 TO 12
120 IF N$(N,N)="-" THEN 150
130 POKE (-14592,N+D+128)
140 FOR R=1 TO 200: NEXT R
150 NEXT N
160 END
```

And since the Apple BASIC is slightly different from most I should point out that the "IF N\$(N,N) . . . ." business is this language's way of dissecting a string. It says, "if the constituent characters of the string N\$ between the Nth character and the Nth character (in other words, the Nth character) . . . etc.". Various BASICs will have various ways of accomplishing this same thing, most of them. Some have no provisions for "string manipulations" at all—avoid them.

When the little block of code above it sets N first equal to 1 (statement 100), checks to see if the first character in the string is a hyphen (120), finds that it is not so does not take the branch to statement 150 and instead POKES the first note (plus some transposing displacement D—plus the flag-setting 128) to the D/A (130), delays (140) and then goes to get the next value for N (150—100). With N now equal to 2, the second character N\$ is found to be a hyphen so the branch at statement 120 is taken to statement 150 (NEXT N) without playing the corresponding note. The variable N increments again (it is now 3) and on going through the program finds that this represents a valid note and plays it.

With a couple of minor changes to this program, it can also be used to convert ASCII keyboard entry of note names into the required decimal numbers. The changes consist of adding a new instruction:

```
90 INPUT "ENTER A NOTE", A$
changing statement number 120 so that it is now:
```

```
120 IF N$(N,N)#A$ THEN 150
and here I need to explain that in Apple BASIC "#" is a symbol for "different from" (most other BASICs use back-to-back "greater than" and "less than" signs—<>).
```

There isn't an appropriate symbol on an ASCII keyboard for flats, so you may want to play every flat at the corresponding sharp and use the "#" symbol. From a programming standpoint, you may want to calculate the decimal equivalent of the sharp by noting if the sharp symbol is part of the note that was input and adding 1 to N if needed. A single statement will do it:

```
IF A$(2,2)="#" THEN N=N+1
```

The Apple II interface card is available from PAIA for \$14.95 postpaid.

# Equipment Exchange

Equipment Exchange allows a place for our subscribers to offer for sale or trade equipment related to music and electronics. If there is equipment you are looking for, we will list it, also. Please keep the listings as brief as possible. Persons responding to ads should write directly to the other party. DO NOT write to PAIA. PAIA is not responsible for any claims made in the ads or results of any transactions. PAIA has the right to edit or refuse any ads submitted.

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For Sale: Complete Paia Synthesizer. 27 Modules in custom built road case, Keyboard with glide. Moving, must sell. Asking \$675. Send SASE for photo and full module listing. Joe Szutarski, 290 N. Railroad Ave.; Staten Island, NY 10304. Phone (212)987-8971 after 6 p. m.

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