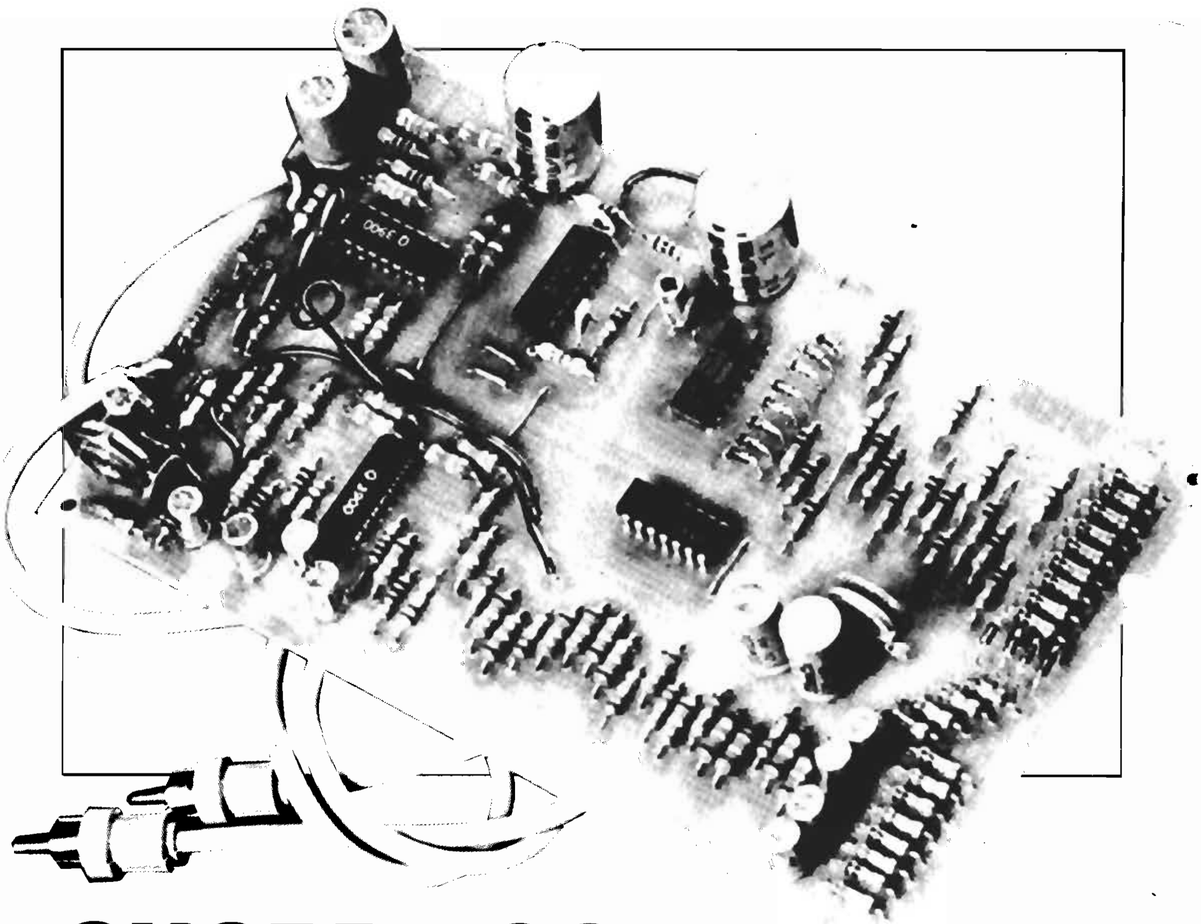
PARTS LIST

¼ W 5% unless noted

R1 – 22kΩ
R2, R49 – R52, R58, R61 – R81, R85, R96 – 10kΩ
R3, R11 – 330kΩ
R4, R8, R12, R16, R20, R24 – 1MΩ
R5, R6, R9, R10, R13, R14, R17, R18, R21, R22, R25, R26 – 3M9
R7 – 470kΩ
R15, R28, R31, R35, R36 – 270kΩ
R19, R90, R95, R100 – 680 kΩ
R23, R29, R32, R33, R37, R39, R40, R43, R44, R53, R56 – 150kΩ
R27, R30, R34, R38, R41, R42, R45 – R48 – 56kΩ
R57 - 680Ω
R59 - 47Ω
R60 – 1kΩ
R82 – R84, R86, R87 – 4k7
R88, R92 – 82kΩ
R89, R93 – 100kΩ
R91, R94 – 68kΩ
R97 - 10kΩ vertical trimmer
R98 – R99 – 2k2

C1 – 500 pF ceramic
C2, C4, C18 – C21 – 0.01µF ceramic
C17 – 0.05µF ceramic
C3 - 10µF, 15V electrolytic
C5, C6, C15, C16, C24 - 100µF, 15V electrolytic
C7 – C14, C25 - 33µF, 15V electrolytic
C23 - 2µ2, 10V electrolytic

D1 – D15 1N914 or 1N4148 diode
IC1 – MK50240 top-octave divider
IC2, IC3 – 4001 quad NOR gate
IC4, IC5 – 3900 quad Norton amp



CHORD EGG

That's EGG as in Encephalo-Gratification Generator. Produces one musical chord after another.

JOHN S. SIMONTON, JR.
and CRAIG ANDERTON

QUESTION: WHAT DO YOU GET IF YOU COMBINE THE LSI heart of a modern electronic organ using synthesizer-type processing elements with digital logic and randomizing circuits for control, and stereo for spatial effects?

Answer: A mind-boggling piece of technology called the Chord EGG (*E*ncephalo-*G*ratification *G*enerator).

Here's what it does: The Chord EGG randomly selects one of four pre-programmed major triads (C, F, the first inversion of G and the second inversion of C, in the version described) and just as randomly selects and accentuates single notes or intervals from the triad. Simultaneously, other random circuitry is independently sweeping a pair of subtle bandpass filters back and forth over the entire output. Each filter's output drives a stereo channel.

This all sounds incredibly busy, and describing it in words may leave the impression of frenetic electronic and musical activity. In reality, just the reverse is true. The result is an exceptionally pleasing background to conversation, meditation or work, or just nice listening too. It's not organ-like, and it's not the typical synthesizer sound. It's something entirely different.

And when experienced through a set of headphones, the effect is unique to the point of being unearthly and potentially illegal. The tones and chords have body and *exist*, and gently flow and sweep and pan their way through your mind; never repeating, never predictable.

Circuit description

A first glance at the schematic of the Chord EGG (Fig. 1) may be a little intimidating. But, like most complex things, it's only a collection of simple ones. To illustrate this we'll divide the EGG into seven simple parts and analyze each individually. These will be: 1) Tone generator, 2) Chord randomizer, 3) Chord decoder, 4) Note randomizer, 5) Control-voltage summing matrix, 6) Voltage-controlled attenuators and 7) Voltage-controlled filters.

Tone generator: The tone-generator portion of the EGG uses two gates from a CMOS quad NOR package (IC2-a & -b) configured as an astable multivibrator with a frequency of approximately 250 kHz. This clock frequency is applied to the input of IC1, a MK50240

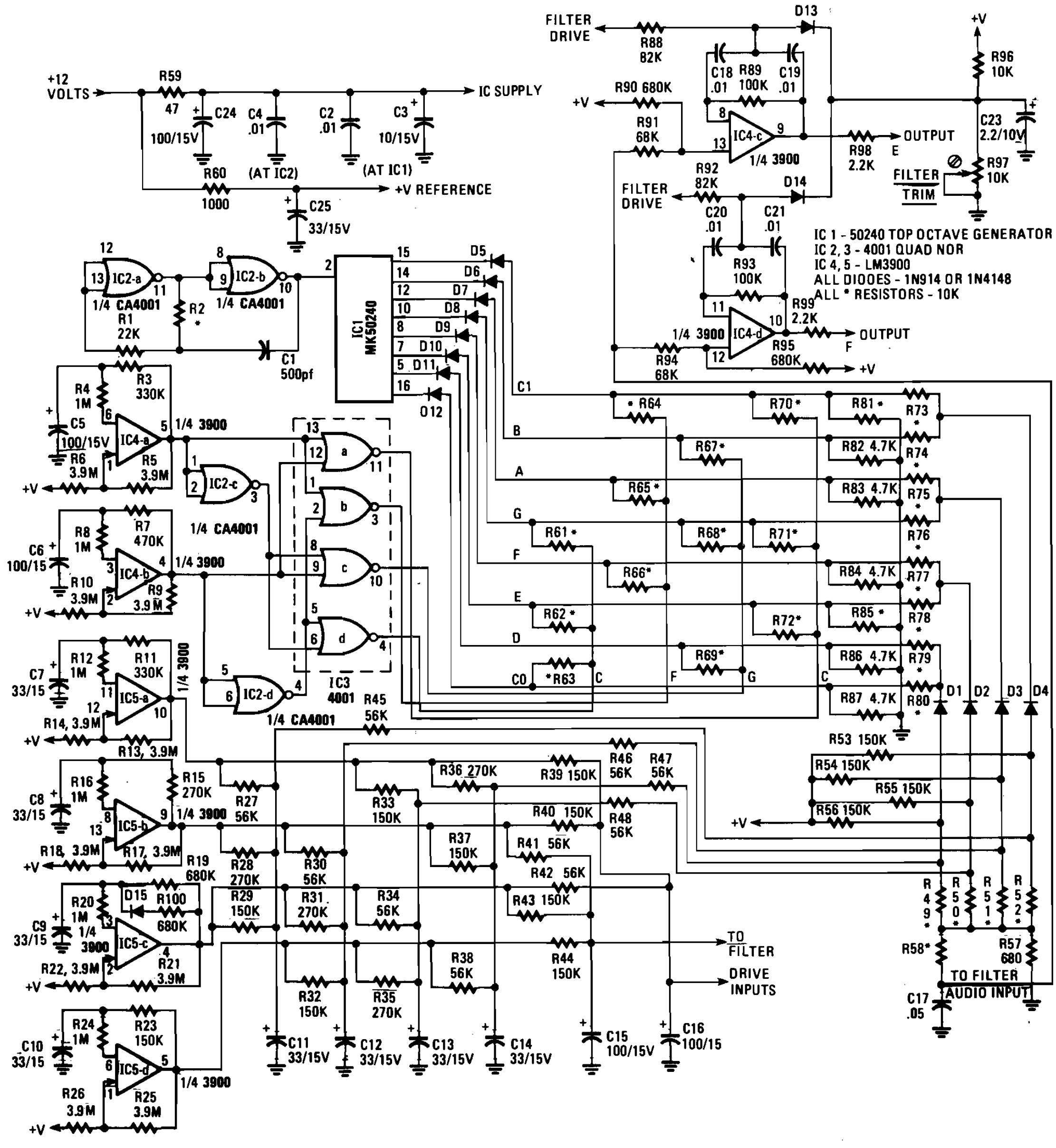


FIG. 1—COMPLETE CIRCUIT OF THE CHORD EGG. It is far from a simple device, but thanks to the circuit board, it is not difficult to assemble. If you look at it as several separate circuits wired together, its operation is easier to understand.

top-octave generator, which in turn produces at its 13 outputs a complete octave (plus one note) of equally tempered musical tones. The frequency of the multivibrator is determined by the R2/C1 time constant, while C4 and C2 provide high-frequency bypassing on the supply lines of IC's 1 and 2. Electrolytic capacitor C3 provides low-frequency bypassing for the power supply to the top-octave generator.

Chord randomizer: Essential to the operation of the chord randomizer is the long-period astable multivibrator, a circuit used extensively in this project. The one built around IC4-a is typical of all of them. Resistor R6 is a biasing resistor, R5 provides positive feedback for hysterisis, R4 converts the voltage appearing across the timing capacitor, C5, to a current that the amplifier can work with and R3 sets the time required for C5 to charge to the threshold voltages established by the rest of the components. Two of these circuits are built around two of the four amplifier stages in a single LM3900 quad current-differencing amplifier package (IC4-a and IC4-b). Their periods are about 15 and 25 seconds respectively, and naturally (since their periods are different), they run asynchronously. We can think of the outputs of these two circuits as representing a two-bit, ever changing binary number which drives the 2-to-4 decoder consisting of the six NOR gates—IC2-c & -d and IC3-a—d.

When the two asynchronous astable multivibrators are combined with the 2-to-4 decoder, we have a circuit that selects one of four lines in a pseudo-random manner and raises that line to a high state while leaving the other three output lines low. All four lines go to the...

Chord decoder, where they select one of four possible chord structures. Each tone from output-line from the top-octave divider is connected to a diode (D5—D12). The diodes are used as switches that allow the notes needed for a particular chord to pass while blocking the unused notes. If, for example, the F chord is selected, diodes D5, D7 and D9 are forward-biased by the voltage applied to resistors R64—R66 and the positive portions of the square waves generated by the top-octave chip on the F, A and C lines can pass. Because the remainder of the resistors in the chord-decoder matrix are grounded (either directly or through the 2-to-4 decoder), they are reverse-biased and block the unwanted outputs of IC1. Resistors R81—R87 are provided to compensate for the fact that, while some lines in the chord decoder have a single selecting resistor attached to them, others have two or three. Without these compensating resistors, lines that connect to a single selecting resistor would carry a signficantly higher signal-level than the rest.

Resistors R73—R80 mix the selected notes onto three of the four audio busses which are in turn connected to the...

Voltage-controlled attenuators. We need a separate line for each tone because we don't want all the notes in a chord to rise and fall in volume simultaneously, but, rather, we want the individual notes that make up the chord to rise and fall independently. The voltage-controlled attenuators work in essentially the same manner as did the switching diodes in the chord decoder with one important exception. Instead of being biased on with a constant voltage and mixed to a single output, they are controlled by a voltage which varies at (pseudo-)random, and whose source we will investigate shortly. As the time-varying control voltages applied to R45—R48 increase, the point at which the diodes clamp also increases, thereby increasing the amplitude of the square wave on that line.

Control voltages for the attentuators begin their existence in the:

Note randomizer, which is in all important aspects identical to the chord randomizer. The differences are that, instead of two astable multivibrators, we have four (all sections of IC5) and these have shorter periods (in the 5-to-10 second range) than the others. The conversion of the binary numbers generated here to a smoothly varying control voltage is handled by the:

Control-voltage summing matrix, resistors R27—R44, and integrating capacitors C11—C16. A total of six control voltages, four for VCA's (Voltage-Controlled *Attenuators)* and two for VCF's (Voltage-Controlled

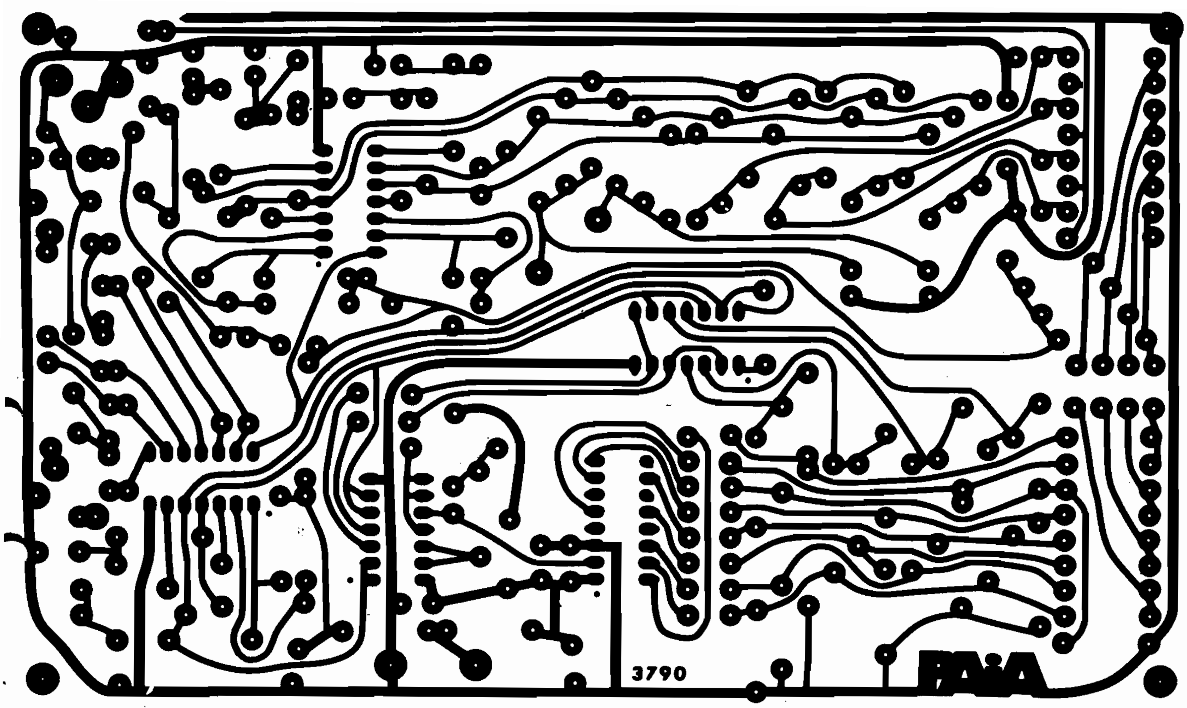


FIG. 2—ACTUAL SIZE DIAGRAM OF THE FOIL PATTERN Chord EGG. Single-sided board makes it an easy one to duplicate.

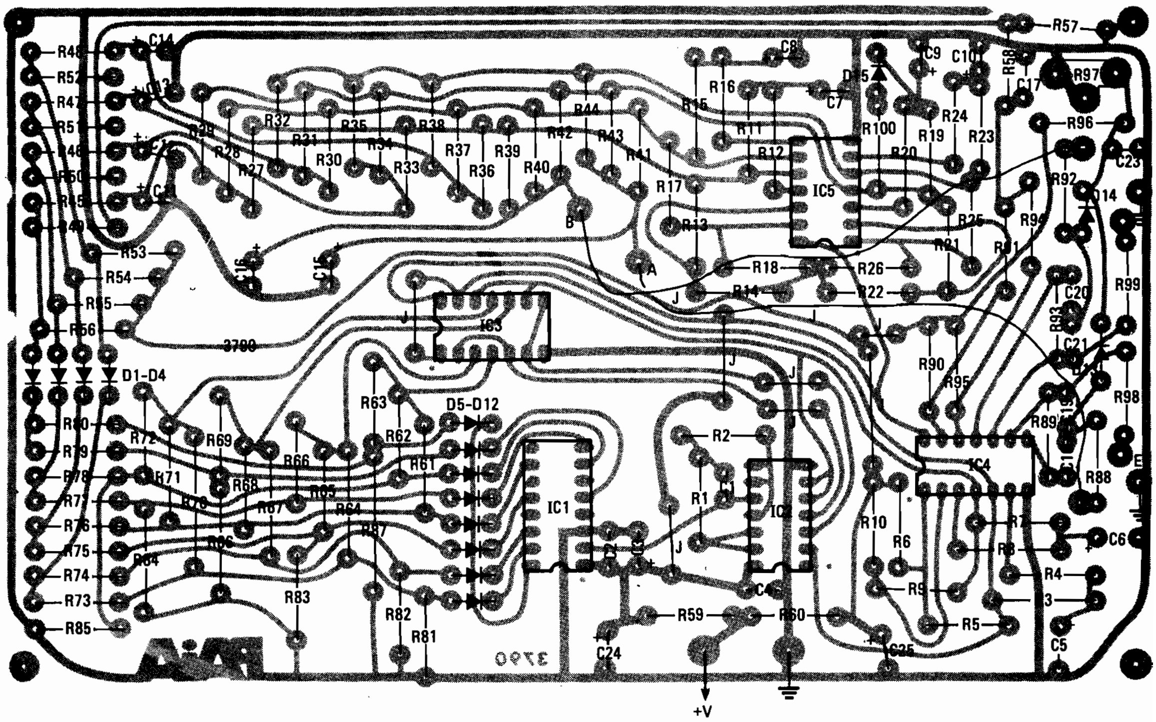


FIG. 3—PARTS PLACEMENT DIAGRAM shows exactly where every component is mounted on the circuit board.

Filters), are produced by this matrix and all six are the result of charging and discharging a capacitor through one of three resistors which may be either at the positive supply-voltage or ground depending on the states of the multivibrators; for example, C11 charges and discharges through resistors R27, R28 and R29. The important thing to note here is that each of the four voltages produced for the VCA's is unique because the outputs of the 4 multivibrators are combined three-at-a-time in the matrix. The two voltages that will be applied to the filter are not unique because of the *combinations* of astable outputs that produce them, but are unique because of the *resistor values* used in the matrix.

R-2R ladders could have been used as the basis of these matrixes but that would have been significantly more complicated and would not have yielded significantly better results.

The circuitry, as described so far, is interesting; chords are randomly produced and individual notes randomly emphasized. But, if we stop here, we have a device with a definite "Gardens of Eternal Peace" quality to it. Morticians would love it, but those of us who are interested in more lively applications would be less than enchanted.

There are still two sections of current-differencing amp left over (IC's 4-c and 4-d) and we can make the transition from dirge to delight by turning them into:

Voltage-controlled filters of the bridged-T, bandpass type. These filters are tuned by putting diodes D13 and D14 into the circuit at positions which would ordinarily be occupied by a frequency-determining resistor. By changing the DC current flow through these diodes we can change their AC impedance and, consequently, the tuning of the filter. Note that the diodes terminate at a point (the junction of R96 and R97) that is above ground potential. The tuning voltage applied to the filters must exceed this voltage level before the tuning will change.

The outputs of these two filters are the stereo outputs of the EGG and the subtle differences in the center frequency and attenuation of the filters provide the apparent motion of the sound in the stereo field. It is interesting to note that, while listening to the EGG, the apparent motion of the sound source is not constrained to the horizontal plane.

Construction procedures

If you are going to build the EGG on a circuit board such as that shown in Fig. 2, construction is a snap. You only have to make sure that the parts are in the proper locations as indicated in the parts-placement diagram (Fig. 3) and that the electrolytic capacitors, diodes and IC's are properly oriented.

If you've worked with it before, perforated prototyping board would be an excellent construction medium (if you haven't, build something simpler first). There are no extremely high frequencies wandering around, so wiring lengths are not critical in that respect, but for the sake of your sanity keep the wire runs *short*—particularly those going to the audio control-voltage inputs of the filters, otherwise the CB'ers will drive you buggy (it's most difficult to meditate with "Breaker, breaker" running through your mind—unless, of course, that's your mantra). If you're going to run the EGG from a power supply other than batteries, make sure that it has *as little ripple as possible*—some of the audio paths are dividers directly across the supply lines and the ripple can really get into them. The EGG, as illustrated here, has a total current drain of about 30 mA so batteries are not out of the question.

Use it well

The EGG is easier to use than a radio—you don't have to waste a lot of time deciding what station to listen to. Make the connections between the EGG and your amplifier using shielded cable terminated in plugs that are appropriate for the input of your amplifier. The ubiquitous "auxiliary" amplifier inputs should be your first choice but just about any input will do.

To use the EGG in mono, you can either use just one of the outputs or tie both outputs directly together—whichever is most pleasing to you. You won't really get the full benefit of the EGG, though, until you hear it in stereo—especially through headphones.

If you wish, there are a number of points at which the EGG may be customized. For instance, you may for some reason want to tune the EGG exactly to the key of C. This is just a matter of changing the frequency of the clock and is most appropriately handled by adjusting the value of R2. (Don't go any lower than about 2200 ohms. For higher frequencies, lower the value of C1.) Resistors R53—R56 determine the "on" time of the notes and chords. By lowering these values slightly (not more than 33%) the EGG will be producing sound a great percentage of the time. Raising the values of these resistors will make the EGG "quiet" a greater percentage of the time.

Changing the value of R97 changes the point at which the voltage-controlled filters come into play. Lowering the value makes the action of the filters more evident and, conversely, increasing it makes the action less noticeable.

You can even change the chord structures if you wish. Just make sure that only one note from a chord terminates on any one audio line at a time or the notes will not be free to change independently. **SP**