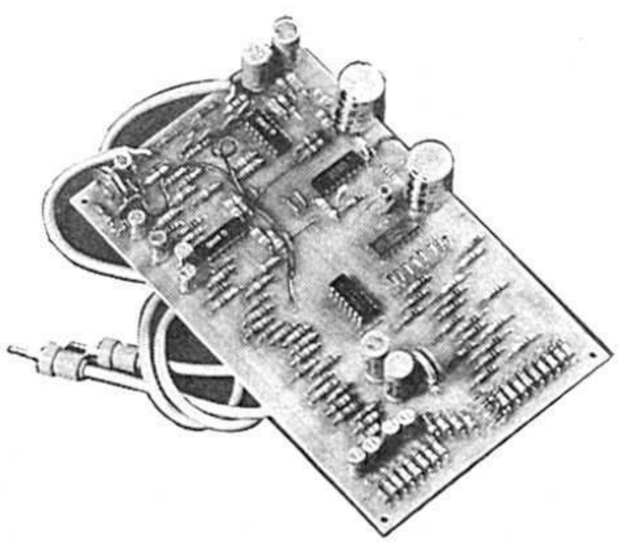
PAiA ELECTRONICS, INC.

3790

STEREO CHORD EGG



The EGG plugs into any stereo amplifier to create soothing, flowing environmental sound textures - and through headphones it's incredible. The chords and notes EXIST in your mind, they pan and swell and phase their way through your psyche in unpredictable patterns, never repeating.

The combination of LSI organ technology with synthesizer-type processing and digital randomizing/control elements make the EGG an altogether intriguing package from either technological or metaphysical viewpoints.

POWER

The EGG is designed to operate from a nominal 12 volt DC supply and we recommend that such a supply be realized by series connecting 8 "AA" or "C" size flashlight cells.

The EGG will operate on as little as 9 volts, but its hefty 40 ma. typical current drain will exhaust the average 9v. "transitor" battery in short order. Also, low operating voltages manifest themselves as an increase in the percentage of the time that the circuitry is completely silent.

The high limit on supply voltage is 18 volts. Above this level there is the danger of destroying some of the integrated circuits. Higher supply voltages than the 12 volts recommended will also tend to decrease the prominence of single notes that would otherwise be accentuated during the EGG's random pattern generation.

When power is first applied to the EGG, you should immediately hear a swelling chord from the amplifiers speakers or headphones. After a second or so the chord will begin to undergo subtle changes as single notes from the chord spelling come and go in prominence. On the order of 20 seconds after the power is applied the first chord change should occur. If it occurs during a period in which the EGG is producing a full chord, this change will be heard as an instantaneous key change. If the EGG happens to be in a silent period, the change may not be at all noticeable.

From the time of the first chord change, the operation of the circuitry is for all practical purposes unpredictable.

TONE TRIMMER

The EGG's only operating control is the trimmer resistor R97 which is an adjustment of the control voltage required to change the parameters of the two filters. The setting of this control is personal preference and should be guided by these facts:

At the extreme counter-clockwise rotation of the control (as viewed from the nearest edge of the circuit board) the filters are at their highest frequency setting and are undergoing the maximum change possible.

While it may seem contradictory, the panning effect will become less noticeable as the control is rotated in a CCW direction. At some point between the extremes of the controls rotation will be a point which is most pleasing to you for both it's panning and filtering characteristics.

CHANGES YOU CAN MAKE!

If you don't like your EGG just like it is, here are changes you can make to achieve different effects.

EFFECT	CHANGE	SIDE EFFECTS
Increase prominence of single notes within chord structure	R57-Lower values (down to 100 ohms) increase single note prominence. Higher values (3.3K max) make chord structure prominent.	Lower resistor values lower total output signal level; produce greater apparent filter noise.
Completely silent too much/not enough	R53 - R56-Lower values make EGG completely silent a smaller percentage of the time. 1 meg max. 47K min.	Lower values make single notes less prominent.
Pitch change	R2-Increasing (100K max) lowers pitch; decreasing (2.2K min) raises pitch.	Possible voltage instability, clock may stop at low values.
More filter action	R88 &R92-Lower values (27K min) produce greater filter changes; higher values (680K max) produce less.	Filter tends to "ring" at higher frequencies.
Altered random time constants	(See design analysis) Capacitors C5-C16, R3, R7, R11, R15, R19, R25, R100	Astables may "lock" to one another.
Different chords	Everything	Possible nervous collapse.

DESIGN ANALYSIS

At first glance at the schematic of the CHORD EGG (figure 1) may be a little intimidating. But, like most things technical, it's only a collection of simple things. To illustrate this we'll divide the EGG into seven simple things 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 comprises two gates from a CMOS quad NOR package (IC-2 a & b) configured as an astable multivibrator with a frequency of approximately 250kHz. This clock frequency is applied to the input of IC-1, a 50240 type top-octave generator, which in turn produces at its 13 outputs a complete octave (plus one note) of equally tempered musical pitches. The frequency of the astable is determined by the R2/C1 time constant while C4 and C2 provide high frequency by-passing on the supply lines of IC-1 & 2. Electrolytic capacitor C3 provides low frequency by-passing on the supply to the top-octave generator.

Chord Randomizer - Essential to the operation of the chord randomizer is a circuit used extensively in this project, a long period astable multivibrator. The astable built from IC-4a is typical of all of them; 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 up from 2 of the 4 amplifier stages in a single LM-3900 quad current differencing amplifier package (IC-4a and IC-4b). Periods of these two astables 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 the 4 states of a 2 bit binary number which drives the 2 to 4 decoder consisting of the 6 NOR gates IC-2c & d and IC-3a & d.

When the two asynchronous astables are combined with the 2 to 4 decoder we come up with a circuit that selects one of four lines in a pseudo-random pattern and raises that one 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 note output that we are going to use from the top-octave divider immediately connects 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 un-used 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 positive excursions of the square waves provided 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 terminate at ground (either directly or through the 2 to 4 decoder), the remainder of the diodes are reverse biased and block the un-used outputs of IC-1. 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 it others have two or three. Without these compensating resistors, lines that connect to a single selecting resistor would have a significantly higher signal level than the rest.

Resistors R73 - R80 serve to passively 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 audio buss for each note because we don't want the chord to rise and fall in volume as an entity, but rather we want the individual notes that spell the chord to, themselves, rise and fall independently of one another. 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, all mixed

to a single output, they are controlled by a pseudo-randomly time varying voltage whose source we will investigate momentarily. 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 attenuators begin their existance in the:

Note Randomizer - which is in all important aspects identical to the guts of the chord randomizer. The differences are that instead of 2 astables we have 4 (all amplifiers of IC-5) and these astables have shorter periods (in the 5 to 10 second range) than the previous examples. The conversion of binary data that these astables represent to a smoothly varying control voltage is handled by the:

Control Voltage Summing Matrix - R27 - R44 and integrating capacitors C11 - C16. A total of six control voltages, 4 for VCA's and 2 for VCF's 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 astables; for example, C11 charges and discharges through resistors R27, R28 and R29. The important thing to notice here, is that of the four voltages produced for the VCA's, each is unique because the outputs of the 4 astables 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. An R-2R ladder could have been used as the basis of this matrix but would have been significantly more cumbersome without producting significantly better results.

The circuitry, as described to this point, is interesting; chords are randomly selected and individual notes randomly accentuated. But, if we stop here, we have a device with a definite "Gardens of Eternal Peace" quality to it. Morticians love it but thoses of us interested in more light hearted applications would be less than enchanted.

There are still two stages of current differencing amp left over and we can make the transition from dirge to delight by turning them into:

Voltage Controlled Filters - of the bridged T, band-pass type. These filters are tuned by putting diodes D13 and D14 into the circuit topology at positions ordinarily 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 these diodes terminate at a point (the junction of R96 and R97) that is removed from ground. The tuning voltage applied to the filters must exceed this offset voltage 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 device in the stereo field. It is interesting to note while listening to the EGG the number of times that the apparent motion is not constrained to the horizontal plane.

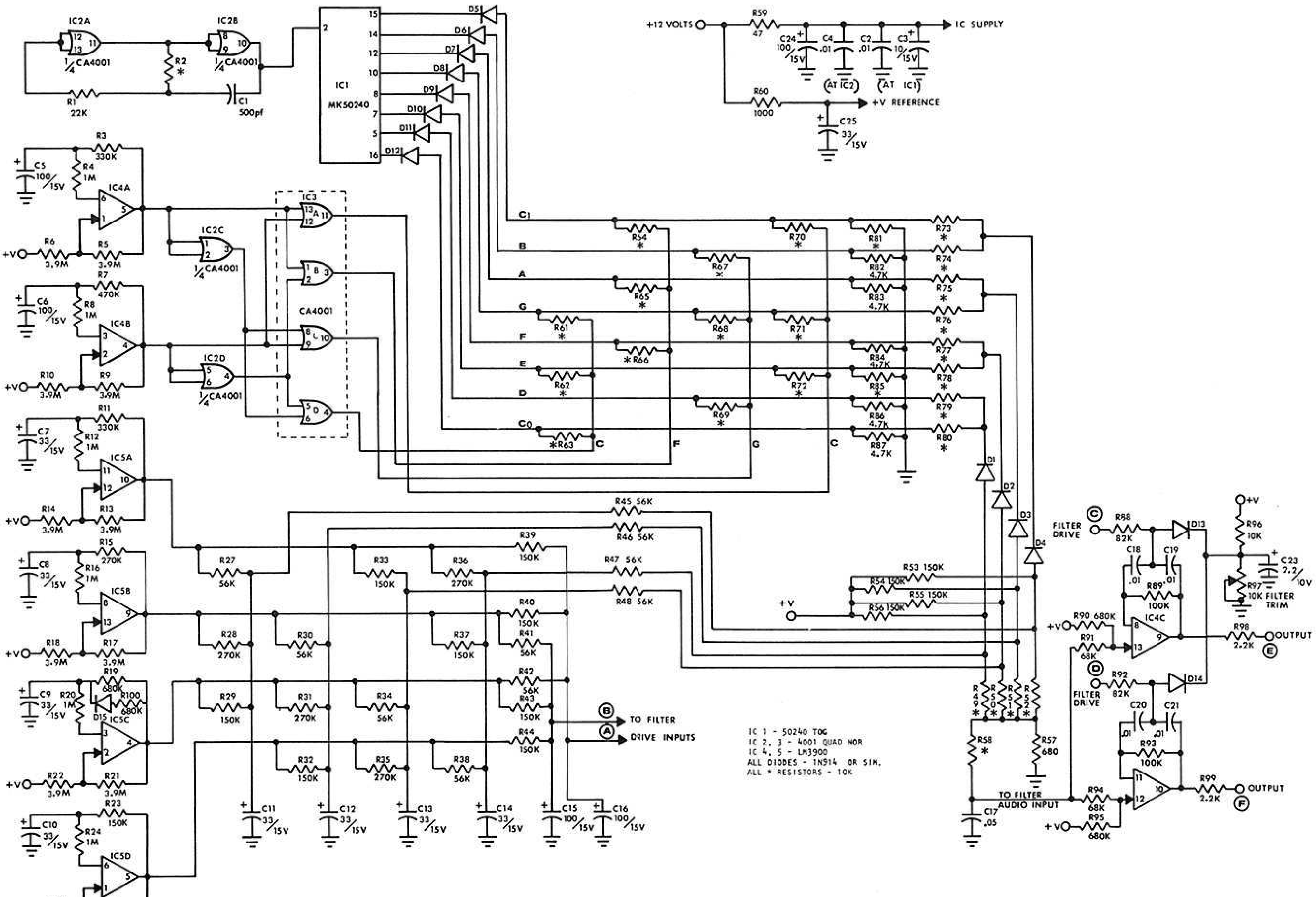


Figure 1 - Schematic