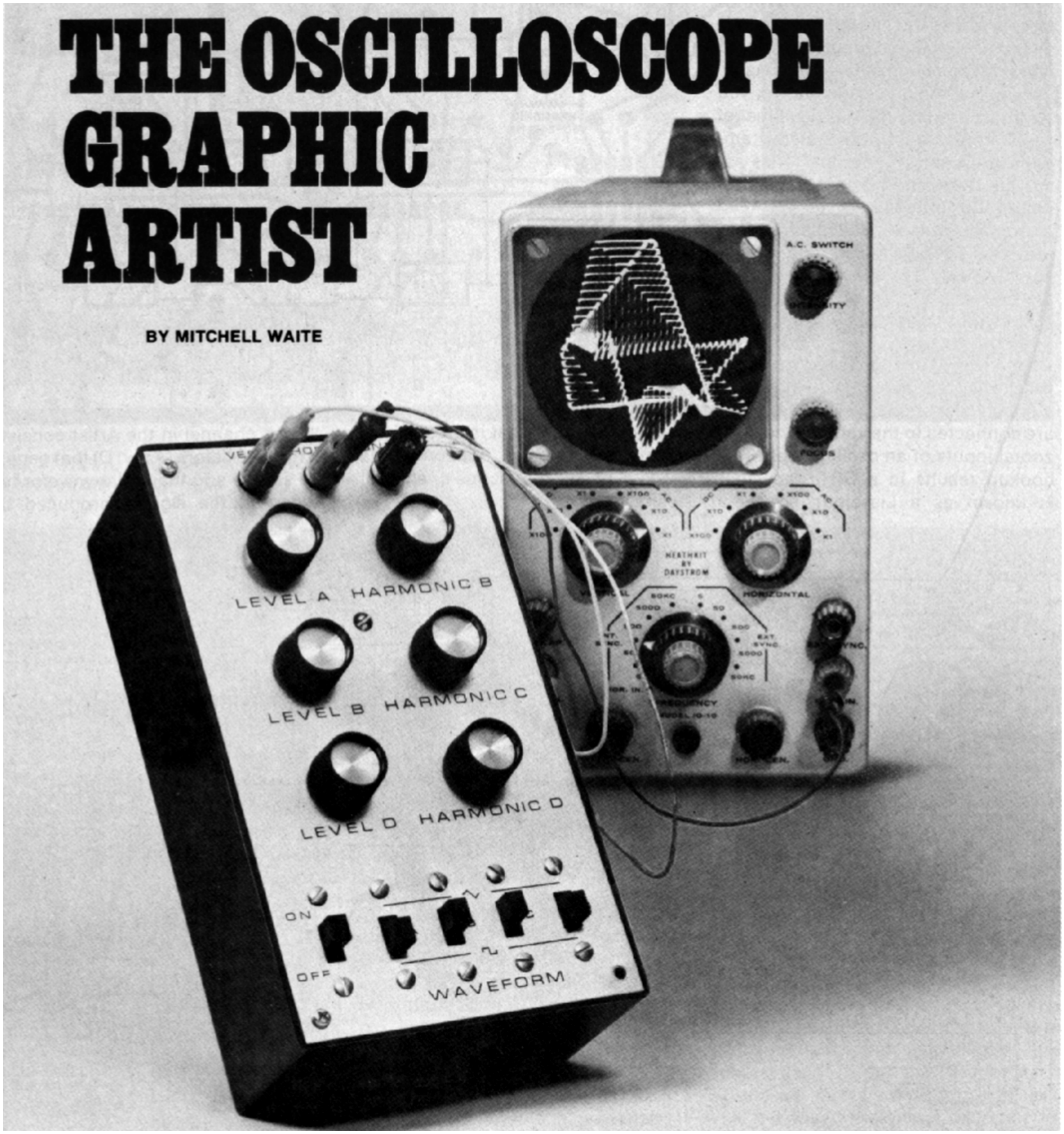
THE OSCILLOSCOPE GRAPHIC ARTIST

BY MITCHELL WAITE



Create exciting, computer generated, three-dimensional drawings on your oscilloscope

A DIM light traces a delicate pattern of geometrical lines on the screen of an oscilloscope. The lines form a rectangle that suddenly tilts back and transforms into a revolving ring of diamonds. You can produce these, plus many more, effects by operating the controls on the Graphic Artist project described here. You can easily make an image rotate in three dimensions, compress and expand, break up into other shapes, or slowly oscillate.

The Graphic Artist is a visual pattern generator that is designed to use the CRT screen of an oscilloscope as a "canvas" and its electron beam as a high-speed "brush." The real-time three-dimensional display on the CRT screen has all the delicate geometric beauty and detail of the computer-generated three-dimensional drawings with which we are all familiar.

The beam in an oscilloscope is forced to follow two complex, harmonically related signals in producing the geometric patterns. Phase-shift networks, working in concert with a simple modulator, in the Graphic Artist add a signal that produces a depth and volume cue for the scope image.

If you're into electronic music, you might try feeding the output signal of the Graphic Artist into a stereo amplifying system to hear the tones associated with the on-screen images. Even more interesting, you can feed harmonics from a music source into the Artist's circuit in place of the oscillator signals. This allows you to view the patterns created by harmonically related musical notes.

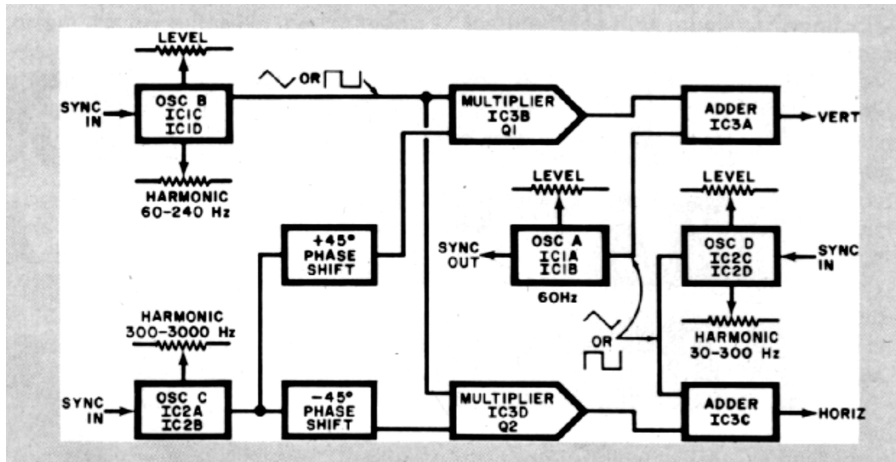
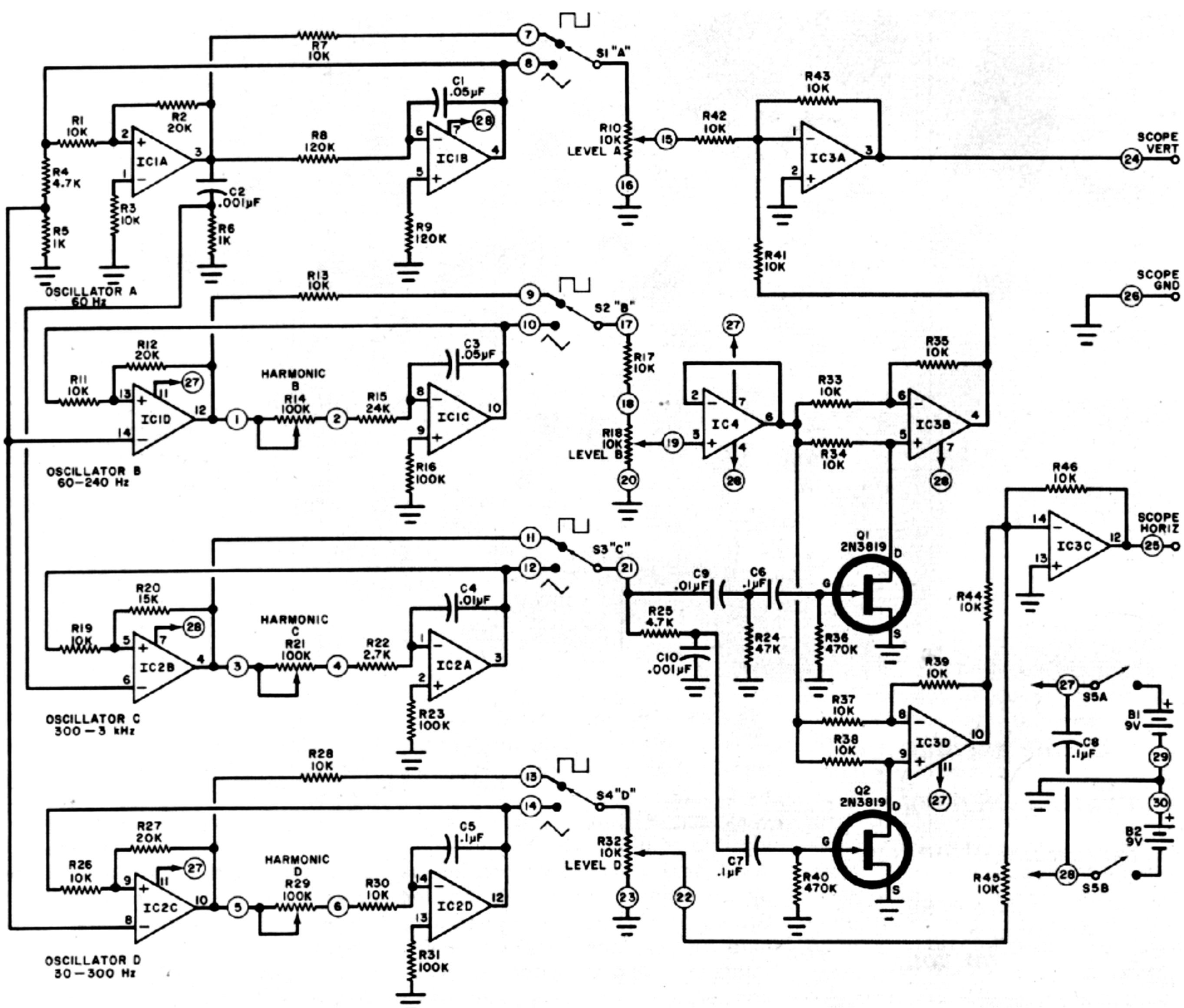
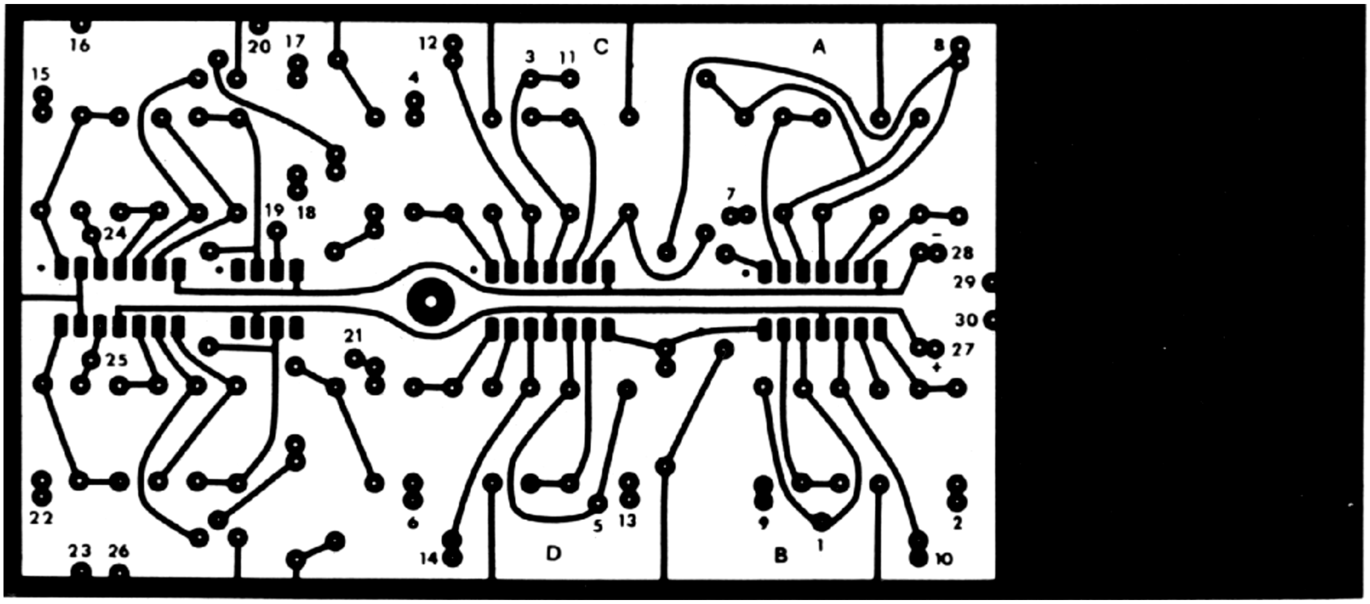


Fig. 1. Block diagram of Graphic Artist.

About the Circuit. As shown in the block diagram in Fig. 1, two almost identical signal channels in the Artist are connected to the vertical and horizontal inputs of an oscilloscope. This hookup results in a CRT trace that is known as a Lissajous figure—a circular-like trace that is proportional to the vertical and horizontal displacement of the scope's electron beam.

Each channel in the Artist consists of two oscillators (A and D) that generate square and triangular waveforms. Added to the signals produced by these oscillators is a common modulated signal derived from oscillators B and C. The overall shape of the Lissajous pattern is set by the signals from





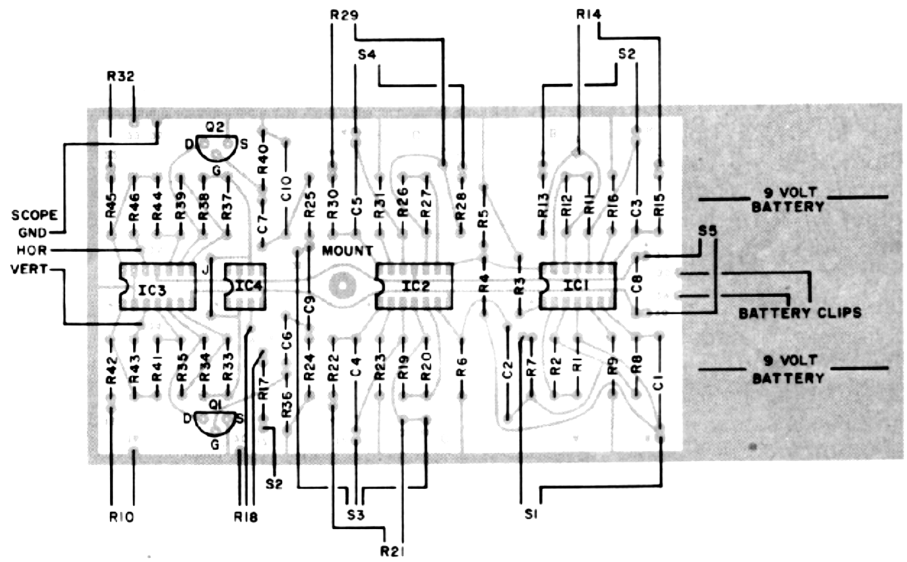


Fig. 3. Etching and drilling (above) and component (right) guides.

PARTS LIST

B1,B2—9-volt battery
C1-C3—0.05-µF Mylar capacitor
C2,C10—0.001-µF Mylar capacitor
C4,C9—0.01-µF Mylar capacitor
C5,C6,C7,C8—0.1-µF 100-volt Mylar capacitor
lC1,IC2,IC3—Quad 741 operational amplifier integrated circuit (Raytheon RC4136DB)
IC4—741 operational amplifier integrated circuit
J1,J2,J3—Five-way binding post
QI,Q2—2N3819 junction field-effect transistor
The following resistors are 1/4-watt 10% tolerance:
R1,R3,R7,R11,R13,R17,R19,R26,R28,R30, R31,R34,R35,R37,R38,R39,R41,R42,R43, R44,R45,R46—10,000 ohms
R2, R12, R27—120,000 ohms
R4,R25—14700 ohms
R5, R6—11000 ohms
R8, R9—1120,000 ohms
R15—124,000 ohms
R16,R23,R31—1100,000 ohms
R20—115,000 ohms
R27—12700 ohms
R24—147,000 ohms
R36,R140—1470,000 ohms
R10,R18,R132—110,000-ohm linear taper potentiometer
R14,R21,R29—1100,000-ohm linear-taper potentiometer
S1 thru S4—1Spdt slide or toggle switch
S5—1Dpdt slide or toggle switch
Misc.—Printed circuit or perforated board; 7-1/2"L x 4-1/4"W x 2"D (19 x I I x 5.1 cm) case; knobs (6); battery clips (2): lettering kit; hookup wire; machine hardware; solder; etc.
Note: The following are available from CalKit, P.O. Box 38, San Rafael, CA 94901: Complete kit #GA-1 (includes components, board, case, but not battery) at $55: p.c. board #GA-3 at $7.50. All orders postpaid. California residents. add 6% sales tax.

oscillators A and D. (For example, a simple rectangle results when triangular waveforms make up these signals.)

The modulation component is comprised of a variable high-frequency carrier from oscillator C and a variable medium-frequency envelope from oscillator B. The carrier is shifted in phase by ±45°. The +45° component is modulated by waveform B in the multiplier and summed with the waveform from oscillator A in an adder. Likewise, the -45° carrier is modulated by waveform B but is summed with the waveform from oscillator D. When the phase-shifted components interact in the scope. they form another Lissajous pattern that is perpendicular to the major rectangle pattern, creating the three-dimensional illusion of volume.

Each oscillator can be switched to generate square waves. Depending on which oscillator is switched to square waves, the pattern will either break up into multiple images or change the character of its surface composition. There are three level controls, which tilt or expand the image and change the relative sizes of the modulating components. The harmonic controls are frequency setting potentiometers that are used to adjust the ratio between the various harmonic signals. The ratios of the signals in turn control the "family" of images you see.

To prevent the patterns from revolving on the screen (this occurs whenever the patterns are derived from uncorrelated oscillators), one of the four oscillators is fixed in frequency. The output from this "master" oscillator is used to synchronize the remaining oscillators, forcing them to run at an exact multiple of the syncing frequency.

In addition to using the controls on

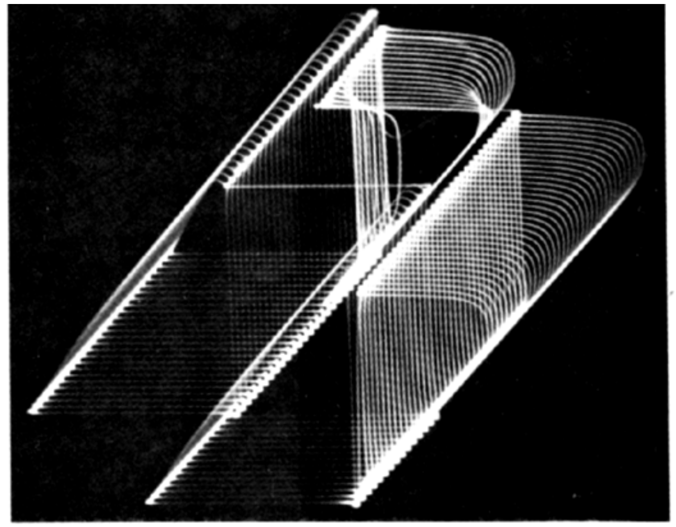
the project, you can also use the vertical- and horizontal-gain controls on the scope to adjust the width and height of the images.

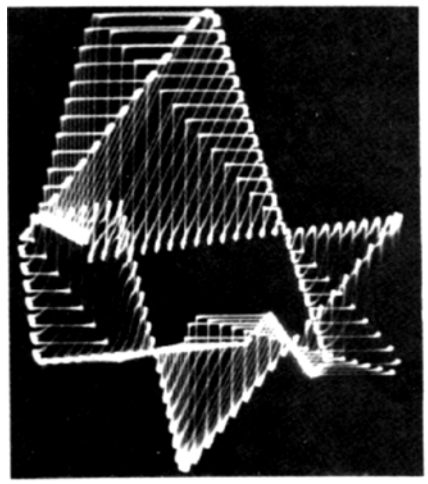
Circuit Details. As shown in Fig. 2, the four oscillators are identical except for their frequency-determining elements. Oscillator A is fixed at approximately 60 Hz by R8 and C1; oscillator B is variable from 60 to 240 Hz; oscillator C is variable from 300 to 3000 Hz; and oscillator D is variable from 30 to 300 Hz. The oscillators are arranged in a classical comparator-integrator configuration.

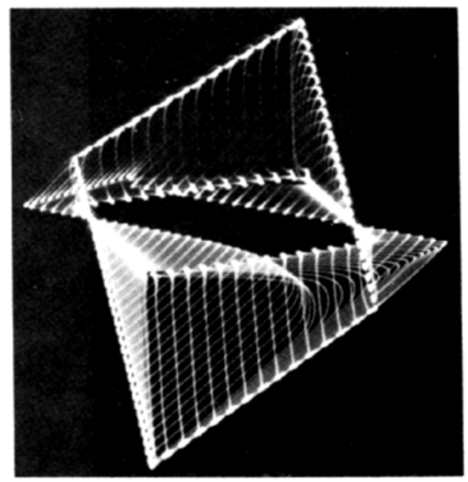
Taking oscillator A as an example, 1C1A uses R1 and R2 to set the trip point at about $\pm V_{cc}/2$. The output of this comparator connects to integrator IC1B, which in turn, connects back to lC1A's input. When lC1A's output Is at -9 volts, 1C1B linearly charges C1 through R8. Hence, the output of 1C1B is a positive-going ramp. As soon as the ramp reaches $V_{cc}/2$, IC1A changes to the positive state and IC1 B linearly discharges C1 to initiate a negative-going ramp. When this ramp reaches $-V_{cc}/2$, IC1A trips to the negative state and the cycle repeats itself.

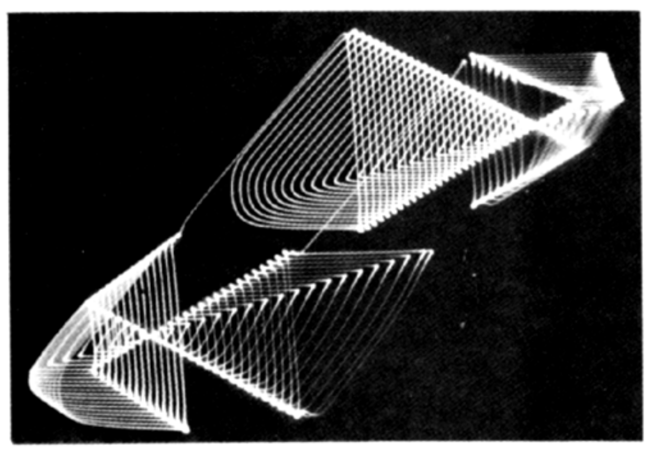
Potentiometers are used to set the frequencies in the three variable frequency oscillators by varying the charging currents. The outputs from the comparators (IC1D, IC2B, and IC2C) are symmetrical square waves, while the outputs from the integrators (IC1C, IC2A, and IC2D) are triangle waves. Resistor R10 in fixed-frequency oscillator lC1A/IC1B sets the amplitude of the two waveforms. Level controls are provided for all but oscillator C. Oscillator C has no level control because only one signal need be variable if both signals go to the inputs of a multiplier to cause the output of the multiplier to vary.

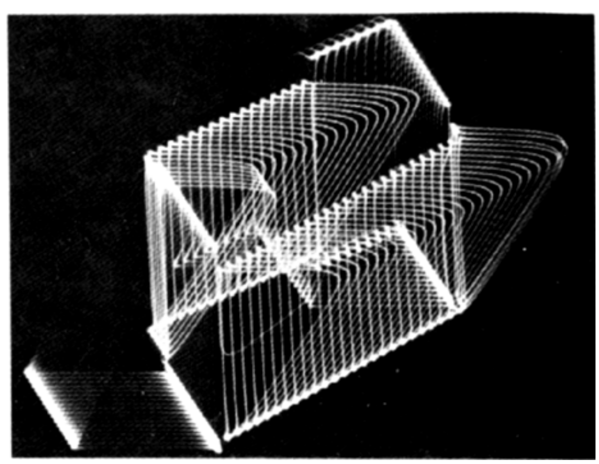
The square-wave output from oscillator A is differentiated by C2 and R6 to create a sync pulse. This pulse is fed to the inverting (-) input of IC2B to force oscillator C's operating frequency to be an exact multiple of the operating frequency of oscillator A. To sync the remaining oscillators, the triangle-wave output from oscillator A is attenuated by R4 and R5 and fed to the inverting inputs of IC1D in oscillator B and 1C2C in oscillator D. The 60-Hz triangle wave forces oscillators B and D into exact sync. Resistor R7 in oscil-











Photos illustrate only five of the countless varieties of waveform displays possible.

lator A makes the square and triangle waves in this oscillator equal in amplitude. Switches S1 through S4 provide means for selecting the desired waveforms.

Integrated circuit IC4 is an op amp follower, used here to reduce the source impedance to chopper-type multipliers IC3B and IC3D. In this type of multiplier, a bipolar transistor or JFET is used to switch the op amp between a noninverting (+) and an inverting (-) unity-gain buffer. Transistor Q1 serves this purpose in this circuit.

When the signal in oscillator C goes positive, Q1 conducts and IC3B reverts to an inverting amplifier. When oscillator C goes negative, Q1 starts to cut off, and IC3B becomes a noninverting amplifier with unity gain. This switching action results in suppression of the carrier, and the output of 1C3B is a balanced four-quadrant signal.

The signal from oscillator C is shifted in-phase by +45° in network C9-R24 and by -45° by network C10-R25. So, the waveform to each JFET (Q1 and Q2) is out-of-phase. resulting in a modulated output from the multiplier also being out-of-phase. Networks C8-R36 and C7-R40 provide dc restoration for Q1 and Q2.

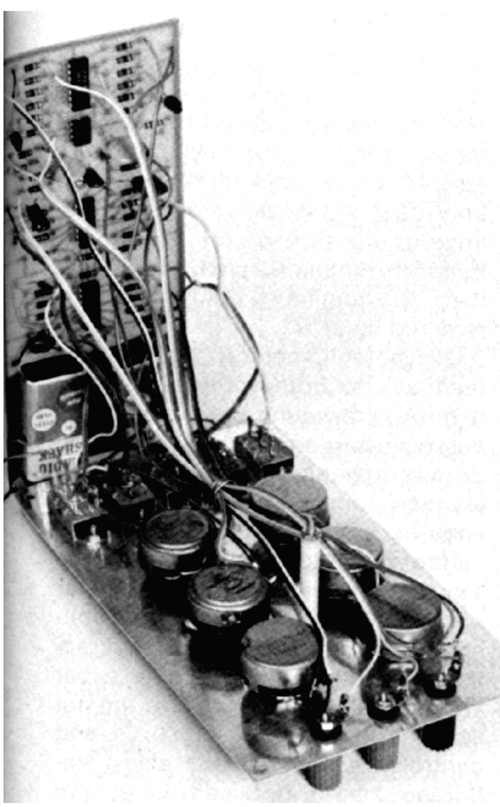


Fig. 4. Construction details.

The output from multiplier IC39 is summed with the signal from oscillator A in adder IC3A. The output from multiplier IC3D is summed with the signal from oscillator D in adder IC3C. Finally, the outputs from the two adders are fed to the oscilloscope to form the complex Lissajous patterns.

Power is supplied to the Artist by two standard 9-volt batteries (BI and B2). Capacitor C8 aids in reducing instability in the IC op amps.

Construction. The project can be built on either printed circuit or perforated board. The actual-size etching and drilling guide and components-placement diagram are shown in Fig. 3. After preparing or buying a ready-to-use pc board (see Parts List for supplier), mount the components on it as shown in the placement diagram, paying particular attention to the orientations of the IC's and transistors. Place B1 and B2 on the blank end of the board, terminals pointing away from the components, and fasten them in place with loops of wire passed between the batteries. Temporarily set aside the board assembly.

Next, machine the front panel for the six potentiometers, five switches, three binding posts. and a No. 6 machine screw. The last hole should line up exactly with the large hole in the pc board assembly. Mount the pots, switches, and binding posts in their respective locations (see Fig. 4). Pass a 6-32 x 2" machine screw (to support the circuit board assembly) through the remaining hole, slip over its threads a length of plastic spacer, and follow with a No. 6 machine nut. The spacer should be just long enough that, when the nut is in place, about 1/4" of screw thread is still visible. Label the controls, switches, and binding posts.

Referring back to Fig. 2 and Fig. 3, finish wiring the project.

Operation. The oscilloscope used with the Graphic Artist must have an external horizontal input. Connect test-lead cables from the output binding posts on the Artist to the appropriate inputs on the scope. Set all waveform switches to triangle. Switch on the project and scope.

Set time LEVEL B control fully counterclockwise (off). Because oscillator B connects to both multipliers, making LEVEL B zero eliminates the modulated component on the screen. You should now see a simple rectangular or square Lissajous pattern. Adjust the horizontal- and vertical-gain controls on the scope so that, when LEVEL A and LEVEL D controls are set to midrange. the image just fills most of the screen.

Slowly turn Up LEVEL B. This adds the modulated waveform to the existing pattern. Readjust LEVEL A and LEVEL D for a pleasant balance and to keep the image from drifting offscreen. Adjust HARMONIC B to sync the modulated envelope with the image. In essence, this control sets the number of “lobes” riding on the primary Lissajous pattern.

Next, adjust HARMONIC C so that the high-frequency carrier is in sync with the image. You should now have a display similar to those shown in the photos. The next thing we can do is alter the Lissajous "family" by using combinations of the waveform switches. For example, switching WAVEFORM A to the square-wave position and setting WAVEFORM D to the triangle-wave position causes the image to break up into separate shapes. There are 16 combinations for the four waveform switches. Add to this the effects of the six HARMONIC and LEVEL controls, and chances are you will never see the same pattern twice.

After you've familiarized yourself with the operation of the controls (it does take some skill), you might try connecting a pair of stereo headphones to the two output channels. The sounds of the four oscillators mixing and adding produces beat notes that are fascinating in themselves. You can even “play” the sounds by twisting the various controls.

Some very different and interesting effects can be produced by running the Graphic Artist in reverse. Take a signal from an external source, such as an electronic organ, and connect it in place of one of the oscillators. You can do this by disconnecting one waveform switch input and connecting your signal in its place. Choose your notes to be exact even or odd harmonics of oscillator A, which operates at approximately 60 Hz. The images will appear to stop their motion and their actual shape will depend on the particular waveform of the note being played.