

Drawings based on laser lissajous figures
and the lambdoma diagram

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DRAWINGS BASED ON LASER LISSAJOUS FIGURES AND THE LAMBDOMA DIAGRAM
HERO, BARBARA

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LANGUAGE(S): IN ENGLISH

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DRAWINGS BASED ON LASER LISSAJOUS FIGURES AND THE LAMBDOMA DIAGRAM

Barbara Hero*

1.

In an earlier article in *Leonardo*, I described some nonfigurative paintings that I made whose patterns and colors were related in arbitrary ways to relative pitch in music [1]. A more extensive discussion of my work relating visual art and music is given in my book, *Eyes + Ears = Ideas* [2]. The starting point for the pictorial compositions is the Lambdoma or Pythagorean diagram, which dates back to Ancient Greece.

For recent works I use the following procedure: I select a number of tones with the aid of the Lambdoma diagram, produce the tones electronically and make sketches of their Lissajous figures, which are produced by means of a helium-neon laser scanner device and projected onto a wall or screen. Finally, I make a drawing based on the Lissajous figures with colors chosen according to an arbitrary code that identifies colors with frequencies.

2.

A tone of a specific frequency is produced by an electronic sine-wave oscillator (Eico 379 solid state sine/square wave generator, Eico Electronic Instrument Co, Brooklyn, N.Y.). Sinusoidal wave forms may be produced in a frequency range from 20 Hz to 2m Hz, but I do not exceed 1200 Hz. It is essential in my work that tones have wave forms with a minimum of overtones of the harmonic series. Therefore sinusoidal wave forms are preferred to square and triangular ones.

I record the frequencies of the harmonic tones from the Lambdoma diagram (Fig. 1), one of which is a fundamental, separately on each of two channels of a magnetic tape. Later, using a second tape recorder, I make mixtures of these tones, which I record on one channel of a magnetic tape and different mixtures of tones on the second channel. These two channels are used as input to the scanners that produce the Lissajous figures [3,4].

The production of Lissajous figures in response to music by means of a helium-neon laser beam scanner for projection on a screen has been described in *Leonardo* by Wagler [5]. He reported on the use of a Sonavision projector manufactured by Sonavision, Ann Arbor, Michigan. I employ a Metrologic laser (model ML-600, 0.5 mw, Metrologic Instruments, Bellmaur, N.J.).

The tape-recorded tones on two channels, called *X* and *Y* are used as an input to an amplifier (Studio Standard CA-2100, Fisher, Long Island City, N.J.) having four outputs, two of which are speakers, enabling one to hear as well as to see simultaneously the sum of the two tape-

recorded inputs. Two outputs from the amplifier, corresponding to *X* and *Y*, drive two galvanometers for laser scanning [3] (General Scanning, Watertown, Mass.). One, rotating on a vertical axis, carries a mirror 7×7 mm; the other, rotating on a horizontal axis, carries a mirror 7×11 mm. The mirrors oscillate to the beats of the different frequencies received. The helium-neon laser beam impinges on one mirror, is reflected to the next and is finally reflected to a wall or a projection screen.

The power of a laser (0.5 mW) is sufficient to produce a satisfactory image on a wall at a distance of 3–4.5 m. I calibrate the system so that the Lissajous figures can be analyzed, although I do not attempt to do so myself.

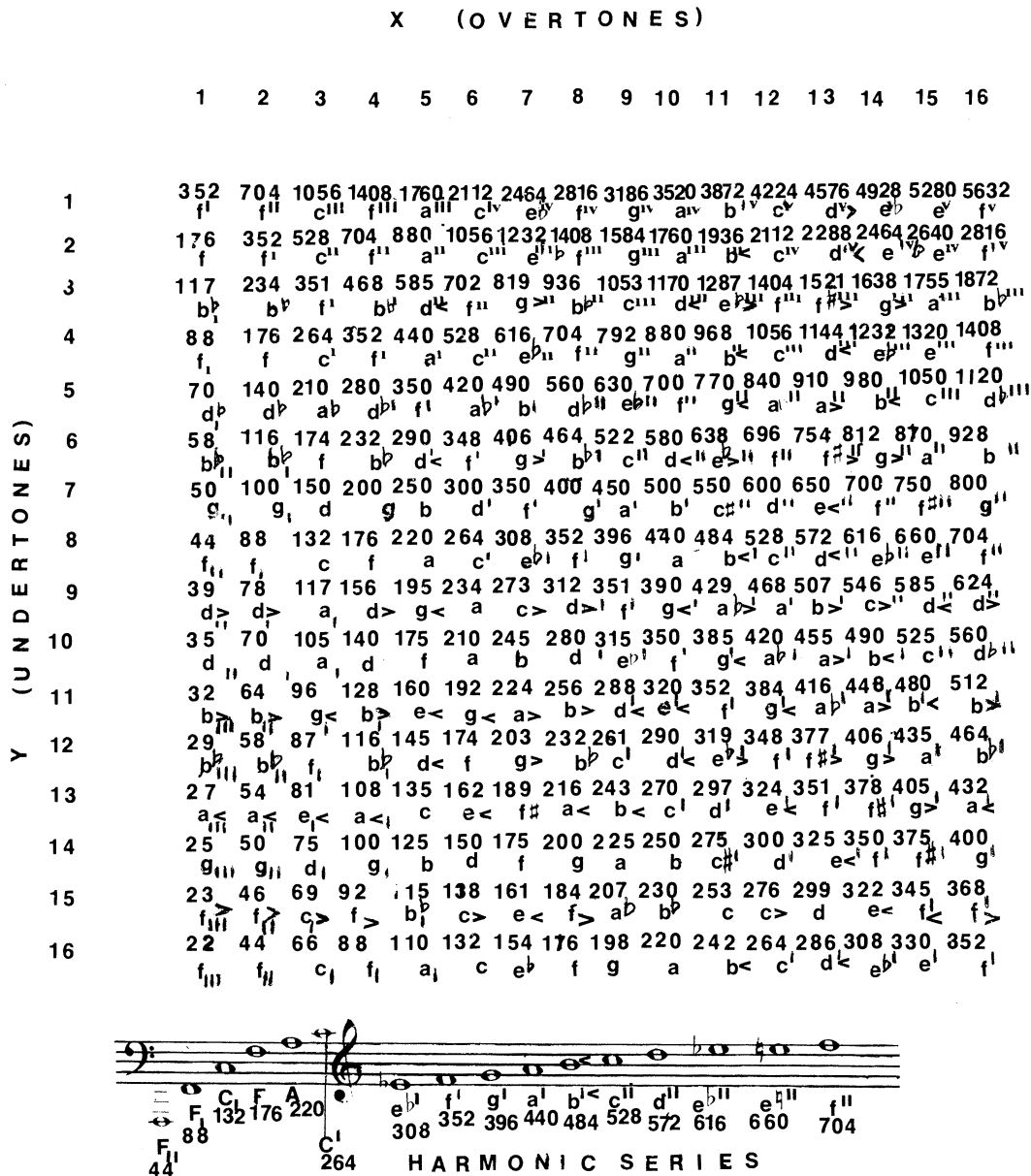
3.

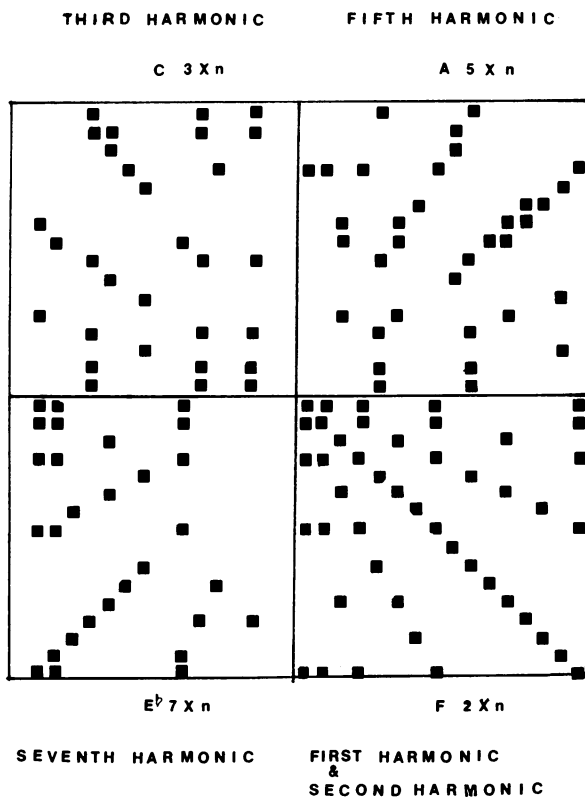
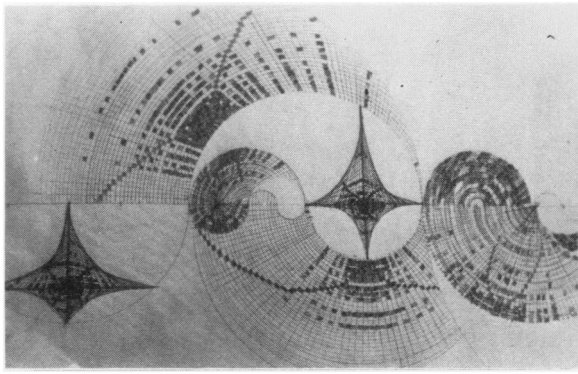
My aim is to produce Lissajous figures that are aesthetically pleasing as well as meaningful. It is desirable to minimize dissonances to obtain well delineated designs. The absence of dissonance is assured when only frequencies of the *harmonic series* are employed. The numerical values of the frequencies of the harmonic series are obtained by multiplying the frequency of the fundamental tone (which I have chosen to be 352 Hz) by the integers 1–16 and by dividing each of the products by the integers 1–16. This calculation, which is realistically restricted to integral multipliers and divisors below 17 to provide frequencies covering eight octaves and which roughly includes the frequency range of present-day pianos, follows the plan of the Lambdoma diagram [1]. The results of the calculation can be tabulated conveniently as an array of 256 numbers (Fig. 1). The notation for the harmonic series is shown below the array.

Figure 1 shows the tone notations corresponding to each of the frequencies in the array. To determine the frequency of a tone, one must read its coordinates *x* and *y*; then multiply 352 by *x* and divide the result by *y*. For example for *g*, read *x* = 4 and *y* = 7. The frequency is then calculated to be 201 Hz. In Fig. 1, each of the 16 horizontal rows represents one *overtone* of the harmonic series and each of the 16 vertical columns represents one *undertone* of the series. For convenience the first of the harmonic series begins with the fundamental f_{11} (44) and is followed by f_1 (88), an octave above it, then by the fifth *c* (132), the third octave *f* (176), the third *a* (220), another fifth c^1 (264), the seventh e^p (308), the octave f^1 (352), g^1 (396), a^1 (440), b^1 (484), c^{11} (528), d^{11} (572), e^{p11} (616), e^{11} (660) and f^{11} (704). The undertone series can be traced in the same way downwards for four octaves, starting at f^1 (352) or f^{11} (704) up to f^v (5632).

When a pure sine-wave tone is mixed with another, a sum and a difference are produced. For example, if f^1 (352 Hz) is combined with its third harmonic c^{111} (1056 Hz),

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pattern resembling a projection of the Möbius strip. A fifth combined with a fundamental tone can produce crown-like patterns. A low, barely audible tone, around 20 Hz, coupled with a harmonic tone produces well-defined figures.

The Lissajous figures serve me as a source of inspiration. Figure 2 shows a drawing containing shapes based on Lissajous figures and tone patterns, with bands of colored squares, suggesting the Lambdoma array.

Four patterns are shown in Fig. 3; these are derived from the array shown in Fig. 1, as indicated in Fig. 4. The pattern for the first harmonic (Fig. 3, bottom right), for example, was obtained as follows: I blackened all the squares in Fig. 1 occupied by the fundamental Γ^1 and its

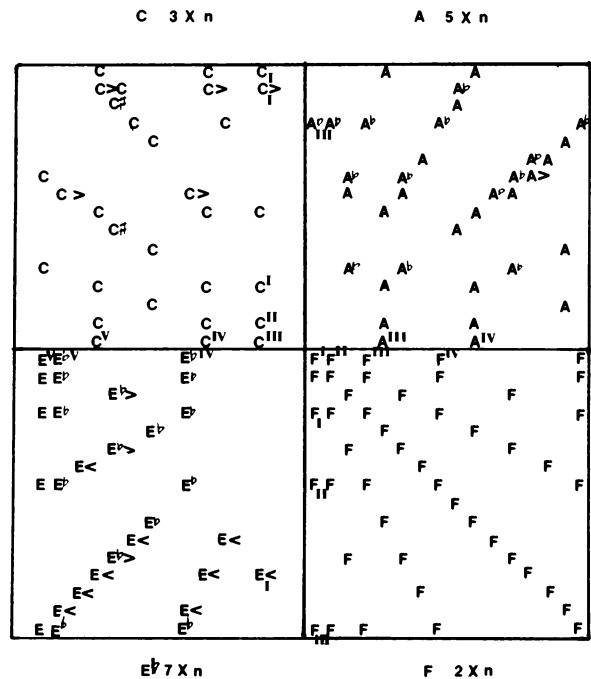


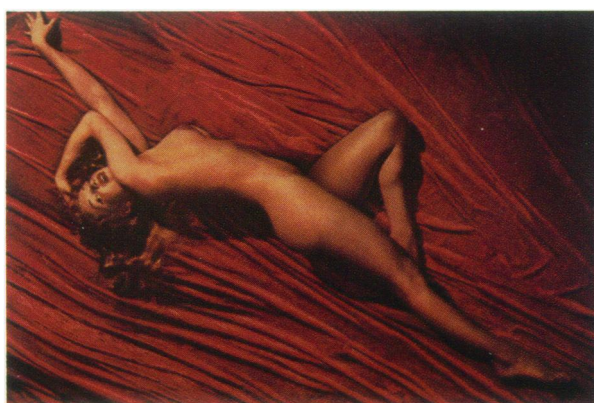
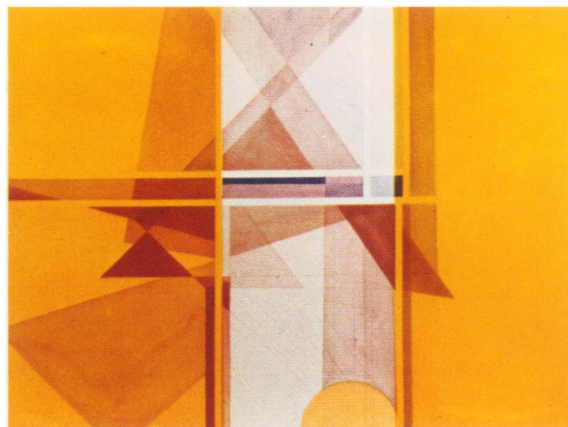
Fig. 4. Key for making the tone patterns shown on Fig. 3 (cf. Fig. 1).

overtone f^{11} , f^{111} , f^{1v} and f^v and its undertones f , f_1 , f_{11} and f_{111} . The resulting pattern of black squares I then use to generate a drawing consisting of four quadrants in which quadrant I of the drawing is the mirror image of the tone pattern shown in Fig. 3 (bottom right). Then the drawing is completed by producing in quadrants II and III the mirror image of the quadrant pair I and IV. One can make drawings in a similar way using the other three tone patterns in Fig. 3.

If the Lambdoma diagram in Fig. 1 were continued beyond the 16th harmonic series to higher and lower frequencies, it would be found that the black square patterns would be repeated. This repetition can be detected in the picture reproduced in Fig. 5 (cf. color plate), where I show the diagram extended to the 177th overtone and the 90th undertone of the harmonic series. The colors employed correspond to an arbitrary color code that I established for certain tones [1].

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Top left: *Barbara Hero. Untitled, felt pen on canvas, 90 × 140 cm, 1975. (Fig. 5, cf. page 303)*

Top right: *Naomi Boretz. 'Based on Yellow', watercolor on paper, cellulose acetate film, 42.5 × 54.0 cm, 1973. (Fig. 3, cf. page 294)*

Center left: *P. P. Konchalovsky. 'Portrait of a Fiddler', oil on canvas, 143 × 105 cm, 1918. (Fig. 6, cf. page 321)*

Center right: *Michèle Andal. Untitled, black ink and acrylic paint on paper, 91 × 56 cm, 1977. (Fig. 8, cf. page 272)*

Bottom left: *Tom Kelly. 'Marilyn Monroe', color photograph. (Copyright © Tom Kelly, 1978) (Fig. 6, cf. page 316)*

Bottom right: *Anaït A. Stephens. 'Eye', cylindrical white-light transmission hologram (120°), dia. 40 cm, height 26 cm, 1975. (Fig. 2, cf. page 306)*