# REFERENCES
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Millay, J. "Education and Music, an Interview with Ali Akbar Khan." In *Association for Humanistic Psychology Newsletter.*) San Francisco, CA: May 1979; 22-23. Guion, C. & Millay, J. (Eds.)

## DVD

**Solar Max** an Imax film with actual NASA images of the Sun, solar winds, Aurora, etc. www.Amazon.com, or Discovery Channel.

## Biofeedback Instruments and Information Companies

Biofeedback Research Inst. -- (Stephen Wall) bri@7hz.com

Buryl Payne -- www.buryl.com -- buryl@buryl.com

HeartMath ® and the Freeze Framer ™. www.heartmath.com

The Biofeedback Center -- (George H. Green). www.stresslesslife.com

Thought Technology Ltd. www.thoughttechnology.com

Michael Mahon www.biofeedbckeducation.com -- (information only)

The Journey to Wild Divine. www.wilddivine.com (adventure game for GSR / Heart rate)

## Biofeedback Companies Advertising new Brain Toys --- (not tried by author)

Biofeedback Resources International, Corp. www.mindfitness.com

www.futurehealth.org/biofeedback_overview.htm

www.NeuroSky.com

www.EmotivSystems.com

www.CyberLearning.com

# APPENDIX A

## ACKNOWLEDGEMENTS

### To Those Heroic Pioneers Who Believed in and Developed Educational Biofeedback and Left this Important Legacy for All of Us

(Only a few are listed in this brief and extremely condensed history. However, all those who contributed are appreciated.)

**1778 -- Luigi Galvani** discovered that muscles are controlled by electrical signals.
**1879 -- Romain Vigouroux** began making crude measurements of skin resistance.
**1920 -- Hans Berger.** His work led to the development of ways to measure and to study human electrical activity.
**1950 --** GSR, EMG and Skin Temperature began to be studied in relationship to physical and mental activity by many researchers.
**1960 --** Applying this research to biofeedback was not studied until major pioneers independently began to realize that it might hold a key to rapid learning of voluntary control of physiological processes. Among the most prominent of these pioneers are: **Elmer Green, Ed Taub, John Basmajian, Tom Budzynski, Johann Stoyva, Charles Adler** and **Buryl Payne.**
(In those days a computer was so huge it filled a whole room. For example, the PDP 15 cost $100,000 with a whopping **16k memory**, and only government agencies, universities or large foundations could afford - or get grants - to research this type of biofeedback.)

**1966 -- Buryl Payne** developed the **first portable hand-held GSR** with sound feedback with a booklet of simple instructions for its use at a cost of around $60. This small design allowed the general public to research the fascinating new world of biofeedback. We could explore our own emotional responses, and expand our own ability to focus attention. Most important of all, we could bring the GSR into the classroom for students to explore.

**1958 -- Joe Kamiya, Ph.D.,** was the first person to discover that people could identify their own alpha brainwaves when a gentle sound was provided to indicate alpha was present in the EEG signal. With this feedback, subjects could also learn to increase the alpha signal voluntarily. His early journal publications about this discovery initiated a worldwide study into the potential health and psychological benefits of EEG biofeedback. **Kamiya** began his research by studying EEG and dream states before he discovered that EEG biofeedback could be useful. He was a professor of medical psychology at the University of California at San Francisco for many years, and was Project Director of the Psychophysiology of Consciousness at UCSF's Langley Porter Neuropsychiatric Institute. Though he is now retired, he is still very active in the various national societies devoted to Biofeedback-Neurofeedback and the study of consciousness. His many years of research created a major shift in the study of psychology worldwide.

**Elmer & Alyce Green, Ph.D.** (First Director of the Psychophysiology Lab in the Research Department of the Menninger Foundation) His book: *Biofeedback* was widely read.

**1968 -- Barbara Brown, Ph.D.** (Chief of Experiential Physiology at the Veterans Admin. Hospital, Sepulveda, California). She published numerous scientific articles and books. (See References.) She was co-founder and first president of the Biofeedback Research Society, 1969 - 1970. In 1968, **Millay** volunteered for **Brown's** EEG Biofeedback study, and so did **Scully**. This experience was life changing for both of them. (References.)

**1967 - 2007 -- Stanley Krippner, Ph.D.,** was the Director of the Dream Lab at Maimonides Medical Center in Brooklyn, NY. There he used EEG to study psychic activity in dreams from 1967 to 1973. He also trained volunteers in alpha brainwave biofeedback in an attempt to improve their telepathic accuracy. He later published this prediction:

> *"Through these types of programs, individuals could be taught, in a relatively efficient manner, to cultivate aspects of their potential that are usually neglected and often wasted. Hopefully, with the current revolution in electronics, we can extend this promising technique to new areas of human life and help humanity evolve into a more integrated, creative and actualized species."*

Since 1973, **Krippner** has been professor of Psychology and Saybrook Graduate School and Research Center. He has guiding hundreds of students and teachers around the world in Humanistic Studies. He has been highly honored in many countries, such as Brazil, Russia, and Costa Rica. Among his early publications are: *Song of the Siren – 1975,* "Telepathy and dreams: A controlled experiment with electro-encephalogram-electro-oculogram monitoring." *Journal of Nervous and Mental Disease 151 (1970): 394-403* (with Ullman). "Dream ESP experiments and geomagnetic activity." *Journal of the American Society for Psychical Research 83 (1989): 101-116*. (with Persinger). *(More in References)*

**1970 – EEG used for therapy –** Following these early EEG results, several researchers began to develop a therapeutic program using EEG biofeedback for ADD, ADHD, intractable epilepsy, and alcoholism. Among them were: **Max Cade, Barry Sterman, Joel Lubar and Gene Penniston.**

**1970 - Dean Brown, Ph.D.** and **Robert Kantor, Ph.D.** This is quoted from a report on their study about the potential for educational biofeedback:

> *"The possibilities of using the machine as a manipulable mirror for the ineffable processes of the mind are perhaps the most significant areas for research… machine augmentation of self-education in the inner states will help us to know and develop new dimensions of the self."*

**Kantor** was a psychiatrist and researcher. **Brown** was a physicist, metaphysicist, and Sanskrit scholar. He pioneered the development of computer education in several countries through the U N. This was years before desktop computers were developed. He founded and was president of Picodyne, Corp., and was a board member of DynEd International, Inc. His books include: "*Learning and Teaching,"* (student response to computer education) *"The Upanishads"* (his Sanskrit translations), and "*Cosmic Law*" (web site: www.fmbr.org.)

**1970 - R. Timothy Scully, Ph.D.,** designed the **first portable EEG**, so all of us could use it for our own personal research. Over the years Scully improved the technology and in **1971** he developed the Aquarius Electronics Brainwave Analyzer**.** By **1972** he added the isolation switch boxes, so that brainwaves could be used to turn on electrical signals.

**1972 - Jean Millay, Ph.D.,** collaborated with **Scully** to design the *First Stereo Brainwave Biofeedback Light Sculpture*, which she demonstrated to teachers and young students at the Jr. Center of the Metropolitan Museum of Art in NYC, at the De Jung Museum in S.F., at conferences in Europe and South America and around the U.S. Millay used this large display to try to interest educators in the idea that children could be trained to increase their abilities to sustain a focus of attention. They could also learn to become centered and calm, at will, to increase creative thinking. (See Appendix D.)

**1974 - Scully** developed The Phase Comparator that produced a mellow OHM tone when both signals from the two analyzers were in the same frequency category, and a harmonic tone to that when both signals were in phase-coherence. Learning to synchronize both

hemispheres led to a better understanding of meditation, since the tone turned off instantly as soon as the mind wandered. The Phase Comparator made possible Millay's research project in training EEG Synchronization between two people. (See References.)

**Scully & Millay** create patterns for biofeedback of GSR & Skin Temperature on an Atari.

**1986 – Brown, Scully & Millay** created a GSR biofeedback game for an IBM computer. Since Harish Johari had recently translated an ancient Sanskrit game *"Leela"* into English, we used that as an inspiration for our design to encourage Stress Management. We called our game "*Integration."* By 1986, the IBM had evolved to the expanded memory size of **256k**. It had several background colors and Millay had a choice of two different sets of three colors each to create images that would respond to the GSR (neither set of colors was very aesthetic). The large pixels made the edges of images to look like stair steps.

**1972 - Bob Beck, D.E.,** developed a portable EEG with tones very different than those of the **Scully** machines. The different types of feedback from these different machines provided **Millay** with additional information about her own EEG, and helped her understand trance states. Beck's interest, however, was not in elementary education, but in advancing consciousness with adults. He also developed magnetic field detectors. **Beck** and **Millay** explored the effect changes those had on the EEG directly.

**1972-1979** -- **Marge B. King, M.S.,** developed the **"Self-Discovery Model"** of using biofeedback as a **science lesson** for her high school students. Once the inexpensive GSR was developed by **Buryl Payne, Ph.D**., and the **Scully** portable biofeedback machines (including the EEG) were available, it was possible for **classroom use** for students. Many of the innovative biofeedback lessons included here are from King.

**1973 – Millay** began using *The Stereo Brainwave Biofeedback Light Sculpture* to illustrate the concept of the mind as an energy of light. She gave workshops in EEG biofeedback at various campuses in the University of California system to promote the potential of biofeedback as a profoundly fundamental educational tool.

**1973 – 2007-- Eleanor Criswell, Ph.D.,** is a Professor of Humanistic Psychology at CSUS (California State University at Sonoma), a former president of the CA Biofeedback Society, Director of the Somatic Inst., one of the Founders of Humanistic Psychology inst. (now Saybrook Graduate School and Research Institute). Criswell introduced biofeedback along with **Scully's** portable EEG machines to her college students for their personal study.

**1974-80 -** Millay began teaching parapsychology at Santa Rosa Junior College. She was able to bring **Scully's** portable biofeedback machines into her classes. She had begun her research to train bonded couples to synchronize their EEG (See References for her book). Years later, a few students returned to tell her that learning to focus attention with biofeedback was continuously useful in their lives, even without the machines.

**1976 -- Elmer Green, Ph.D**., studied the EEG of spiritual leaders in India, finding strong Theta rhythms while they were in deep meditation. Later he declared:
*"We expect that, within a few years, every high school in the nation, every biology class in the nation, will have a feedback machine ... merely as a device to demonstrate the fact that the body responds so easily to the mind."*

**1976- 2007** -- **George Green, Ph.D., F.A.B.M.P.,** began his longstanding career at *The Biofeedback Center* in Reno working with a wide range of stress related disorders, including the Attention Deficit Disorder. (See References for a list of some of his books.)

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**1977-1979** -- **Joanne Kamiya, M.A.**, introduced biofeedback to elementary and junior high children in a private school in San Francisco. Children eagerly learned to focus attention, as the energy of that focus would make a toy train go around the track. While computers now dominate the way biofeedback is used, it is the three-dimensional toys that grab the interest of very young children. It would be a great step forward if the newer, high tech tools for biofeedback were again supplied to hook up to trains, bumper cars, and other (as yet unimagined) remote -control toys for elementary education.

**1980-2003** -- Through these years, personal computers evolved through rapid improvements that were also applied to biofeedback. During this period, the technology was dominated by clinical use, rather than classroom use. However, it is the clinical studies with many subjects participating that proved biofeedback training could alleviate ADHD. Since this has become a growing problem among students, classrooms could also benefit.

**1991 -- Doc Childre, Ph.D., & Howard Martin, Ph.D**., developed the **HeartMath program** In Boulder Creek, CA. At first it was introduced to administrators and employees in large corporations to help manage stress. Then it was used to learn to sustain a higher level of emotional intelligence. Gradually, teachers began to take an interest, as well, since biofeedback of heart rhythms has the potential of alleviating the strong negative emotions that often develop in classrooms. (Selections from the FreezeFramer™ is quoted on pg.41)

**1992 – Steve Wall, Ph.D.,** developed the **Bio Integrator™ system**; a complete EEG and physiological measuring instrument combined with artistic high-resolution graphics and soothing sound feedback. (His report on biofeedback in education begins on page 56.)

**1997** -- **Phyllis Gagnier, M.A.,** is one of the teachers who began using the **HeartMath** program in her project at San Simon School in Arizona with elementary and junior high students. One of her 3rd grade students wrote, *"We give heart to each other."* (Her report is included on page 45.)

**2001 -- Mara Mayo, M.F.M.C., C.S.A.C**., was a high school therapist who began using the **HeartMath** program in her office to help students take control of their emotions. She found that it is very useful for herself, as well. Stress management became easier for the high -tension type of interaction among the widely diverse cultures at Pahoa High in Hawaii. Gradually, students began to take personal responsibility for their own behavior by learning to bring entrainment to their heart rhythms. (Her report is included on page 43.)

## Education for the Twenty-First Century

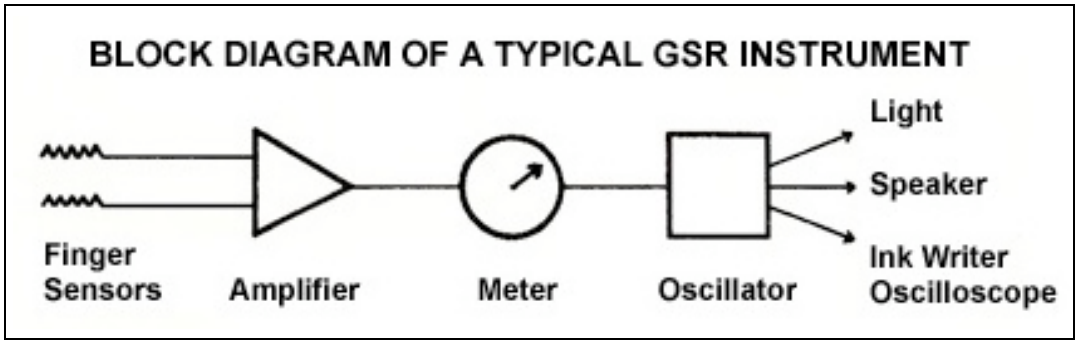
In this 21st Century, let us take advantage of this legacy our heroes have provided for us. Unfortunately school boards with budget problems have been very slow to consider this evolutionary technology. The enormous capacities of computers to advance the possibilities of biofeedback instrumentation can provide all of us with these fundamental tools for self-discovery. Let children discover their own health issues so the cost of health care as they age can be greatly reduced (along with the cost of legal and illegal drugs abuse). Bring Biofeedback into every classroom to educate the whole child. (That idea was lost in multiple choice testing and the competition SAT scores.) I am firmly convinced that biofeedback is the most important educational process that has ever been developed. Introduce biofeedback in every public school across these United States, and we can raise academic performance, and we can discover the innate power of our own multidimensional minds, which can produce a quantum leap in **intellectual efficiency and emotional equilibrium**.
( from "Seeds of the 60's" by Tim Leary )

# APPENDIX B

**HOW GSR INSTRUMENTS WORK**
**By Buryl Payne, Ph.D. ***

## All instruments consist of four basic parts:

1) **Sensors** -- connect to the body, usually the palms or fingers,
2) **Amplifier** -- allows the minute changes in the skin response to become strong enough to activate the oscillator.
3) **Oscillator** - vibrates in the audible frequency range
4) **Signal readout** – might be a light, a meter, a speaker, and/or an ink writer oscilloscope




The **GSR** (Galvanic Skin Response) is the most useful biofeedback instrument. It is also the least costly to manufacture and the simplest to operate. The use of audible output is probably the best kind of feedback mode because it allows people to close their eyes and thus be free of visual distractions while they are working with the instrument. Some electrical supply catalogs offer a GSR kit that could be assembled by students.

The sensors most commonly used consist of a strip of Velcro cloth that has been coated with silver by a vacuum depositing process. These sensors are wrapped around the tips of the fingers and connected to the amplifier. A tiny current-about one hundred-thousandth of that needed for a flashlight bulb-flows thru the fingers. Changes in the current are amplified and used to change a meter reading, vary the pitch of an oscillator, or vary the intensity of a light. The more expensive units have extra controls, output jacks and other features, but do not differ basically from the simplest, least expensive units.

When the resistance of the subject changes due to some emotional or physical stimulus, that allows a different number of electrons to flow into or from the first stage transistor. This change is amplified by the transistors and ends up as a change in audible frequency. Smaller input resistance increases the output frequency; larger resistance decreases it. The frequency of the instrument can drop down to less than one cycle per second. The output of this circuit is not a smooth sine wave; rather it is a sharp spike. While this spike is not so pleasant to hear as a traditional sine wave, it can be heard over a larger range, especially in the region of the lower frequencies. In actual use, while relaxing or meditating one can actually drive the frequency down to zero. The length of the conductive path between the sensors is not significant. It makes practically no difference whether a sensor is hooked to two adjacent fingers, to one finger on one hand and one finger on another hand, or to one finger and one toe. Generally the dominant hand shows more activity.

## GROUP EXPERIMENTS

One instrument can be connected to a whole group of people if they hold hands or touch each other on the skin. (If you notice a buzzing or rasping sound when two or more people are connected to the instrument, one person may touch a water pipe or ground connection to eliminate this. If that noise occurs, it probably comes from 60-cycle pick-up in the human body, which is generated by ordinary house wiring and fluorescent lamps.)

We have connected more than 100 persons to one instrument. The two who are connected to the finger sensors, however, must not touch each other, because the circuit will only pass between those two instead of through the whole group. The tone will stop when any two anywhere in the group stop touching. This breaks the electrical connection in the same way that turning off a flashlight does. While everyone else is still connected, ask one pair to tap their hands in a rhythm. The same rhythm will be heard in the beeps from the GSR. Laughing, deep breathing, chanting, or any of the exercises and experiments that have been done with the GSR individually can be done with an entire group. Ask each participant to take a deep breath until the tone increases. Then ask the group to relax to bring the tone down together. We are all connected through our energy all the time. This helps us experience that connection directly.

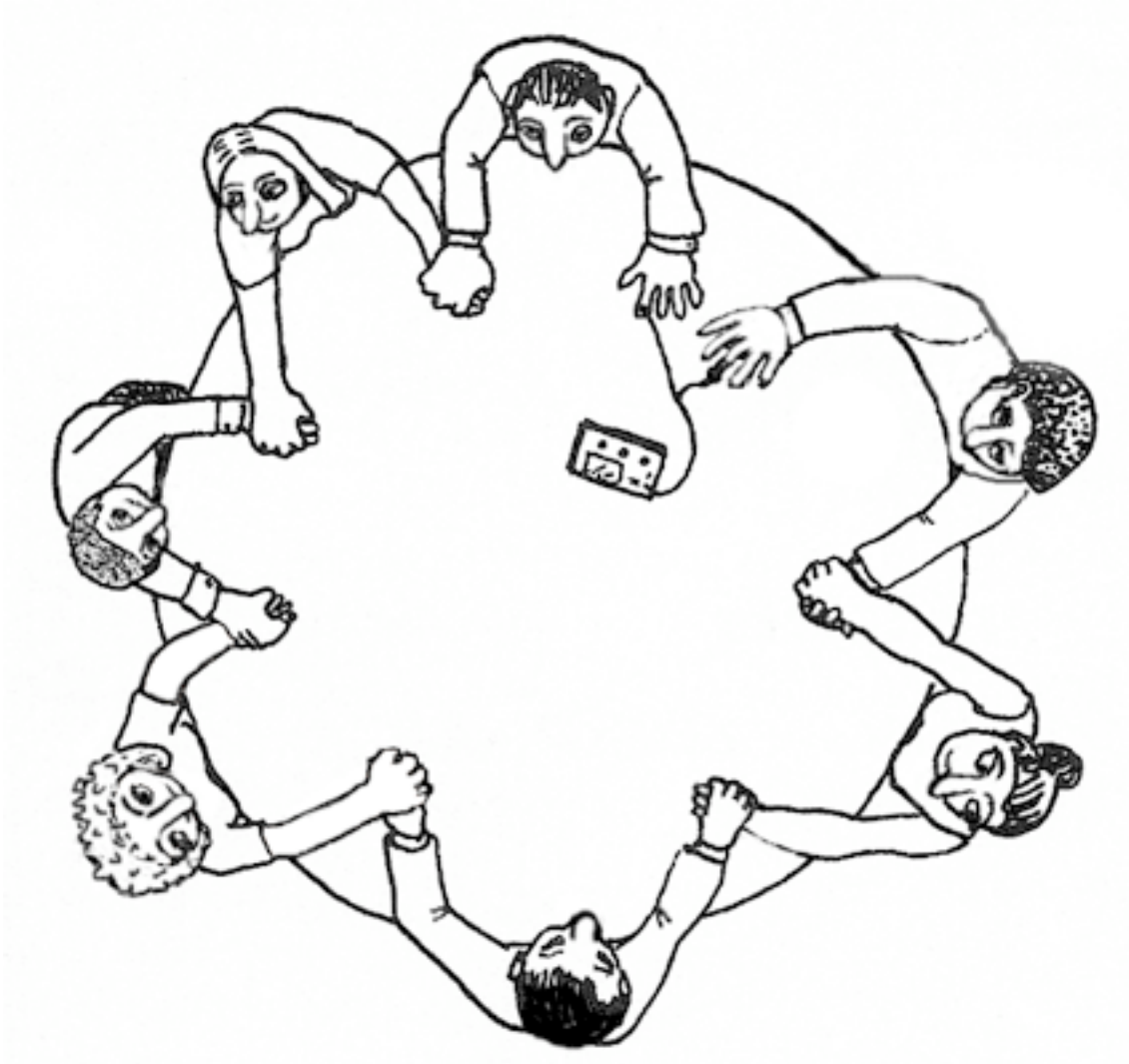


**Illustration from BioMeditation by Payne and Reitano**

# APPENDIX C

The unparalleled abilities of the human mind arise not from neurons but from the coherence of brainwaves.

--- R. Douglas Fields, Ph.D.
"Beyond the Neuron Doctrine,"
Scientific American Mind.
June / July 2006

# APPENDIX D

## TWO EXAMPLES OF HOW THREE PRIMARY COLORS OF LIGHT CAN CREATE SEVEN SHADOWS FOR PEOPLE OR FLOWERS

# Short History of the first Stereo Brainwave Biofeedback Light Sculpture

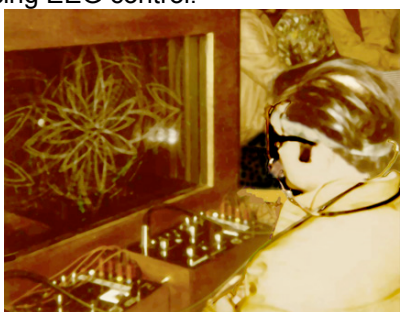
The design for the first Brainwave Biofeedback Light Sculptures (seen below) grew out of Jean Millay's & Timothy Scully's 1968 experiences as volunteers for Dr. Barbara Brown's early experiments in biofeedback. Dr. Brown was the Chief of Experiential Physiology at the Veterans Administration Hospital in Sepulveda, CA at the time. The following year Millay volunteered for Dr. Stanley Krippner's biofeedback and dream telepathy experiments at the Maimonides Medical Center Dream Lab in Brooklyn, NY. That same year, Scully designed the first portable brainwave biofeedback machine. By 1971, Scully had expanded the capabilities of his instrumentation to include the Aquarius Electronics brainwave analyzer. With that and with Dr. Krippner's help and encouragement, Millay and Scully built their first 4-channel light sculpture as seen below, left. By 1972, they were able to build the 8-channel model as seen below, right. Once they played with it, they could see relationships between right and left hemisphere that were not yet in the literature. In 1974, Saybrook Graduate School and Research Center (then H.P.I.) gave Millay a scholarship to begin her own Ph.D. research. At the same time she began teaching parapsychology at Santa Rosa Jr. College, where she trained individuals and bonded couples to bring phase-coherence to their brainwaves. Scully continued to designed and build more advanced equipment. Millay was privileged to use several of his instruments -- two BW analyzers, two isolation-switching boxes, and the all important phase comparator. This showed the EEG signals from both hemispheres at the same time in mondalas of color, instead of sign waves on a graph. The analyzers provided one tone when both signals were in the same frequency range and another tone (harmonic to the first one) when both signals were phase-coherent. The results of these studies indicated that the couples with the highest scores in paired brainwave phase-coherence, also had the best telepathy scores ($p < .001$). * Below are two photos of students practicing focus of attention with the earliest two designs by Millay and Scully.

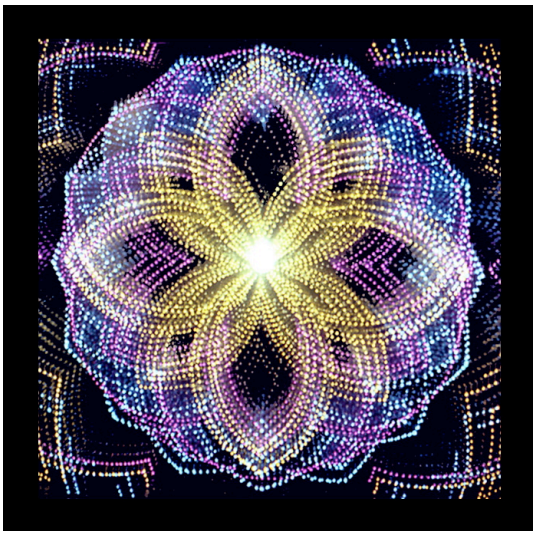
This one has only 4-channels from one set of electrodes. These channels activate the lights so that the 4 Plexiglas panels can be displayed in the different colored Mondalas that represent three of the brainwave frequency categories (beta, alpha, theta). The 4th panel flashes white only when eye movements interfere with EEG.

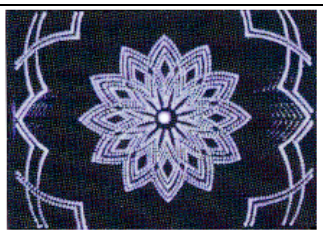
In May 1972, the Met. Museum of Art in NYC invited Millay to demonstrate this BBLS at their Jr. Center. Subsequently other museums in Europe & South America also invited her to show it. In 1976, Millay designed a new Light Sculpture (below right) to be more compact for the eyes. The design represents the aura as dots of light in motion that change as they accompany changes of thought. Millay does not see the aura as these "daisy" patterns, but the mondalas are important so the eyes can stay focused while practicing EEG control.

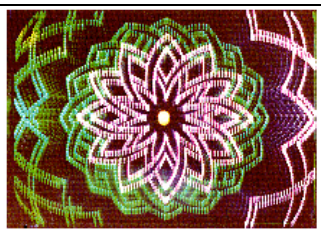
Millay carved each dot on the 8 sheets of Plexiglas to form all of the mondalas.

**"How I think is what I see. Focus defines my Reality."**









Above: When the brainwave signals from both analyzers are in the alpha range, the blue patterns light up on both sides. When the BW signal on the left is in beta, the green panel shows. The right side is alpha (even though the film exposure here is pink, you see the blue pattern). Each of the 2 BW analyzers activate only one panel each at a time for the current dominant frequency.

Left: All the 8 Plexiglas panels have been turned on to show the pattern as a whole. The colors have been changed to be bright enough to get a total exposure.