A LIGHT EMITTING OBJECT

AND ITS ENVIRONMENT

by

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Submitted to the Department of Architecture
on February 8, 1983,
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ABSTRACT

The object that is intentionally produced with the inherent spirit of "Fine Art," will always be placed with a reverence for its setting.

"LIGHT GRID" is a light sculpture with flexibility to utilize the environment where it is placed as an element of its effect.

This thesis is the documentation of the development of "LIGHT GRID" and its temporary installation at the Center for Advanced Visual Studies, Massachusetts Institute of Technology, and a written perspective with artistic affinity.

Thesis Supervisor: Otto Piene
Title: Professor of Visual Design
and Director,
Center for Advanced Visual Studies

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At its best the urban lightscape is one of the grand sights of our age. A byproduct of utility, produced almost by accident, its splendor recalls the concentrated and ordered beauty of the great windows of thirteenth-century cathedrals. This accidental magnificence contains the promise of a great new art: the orchestration of light.

-- Gyorgy Kepes[1]

1. Introduction

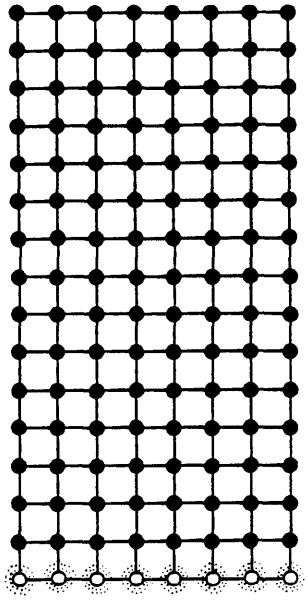
> A definition of sculpture: something you back into when looking at a painting.
>
> --Ad Reinhardt

This definition may apply to those large bronze objects that sit on the floors of most museums, but today the role of sculpture is not so easily defined. It no longer is required to sit quietly on its pedestal, it is now allowed to move freely, even outside the walls of the museum. Some sculpture has entered the domain of painting and theatre. Sculpture has become sound, light and movement, as well as being an object.

"A Light Emitting Object and its Environment," is my way of defining Light Grid, which is an environmental light sculpture. The documentation of the development of this system is discussed along with documentation of three installations. To offer some insight into the artistic climate that Light Grid will exist in, I have included some "Reflections on the Use of Light." This is a selected representation of artists working with various concepts of the medium of light. This selection is also representative of some of the historic and contemporary influences in my own work.

2. Technical Description

2.1 Model



The sculpture "light grid" is the product of an evolutionary development that has taken place during my course of studies while here at MIT. The very earliest form of this sculpture was a small box with a transparent top. This housed a 10x10 matrix of LEDs, which formed a very coarse resolution display screen for lissajoux patterns.

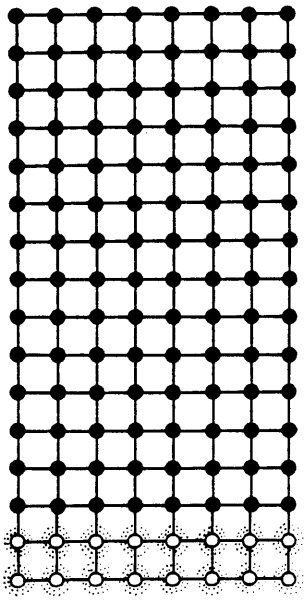
These patterns were generated by an electronic circuit which would repeat continuously until the viewer would move a joystick control lever, thereby changing the patterns. The positioning of the lever did not have an obvious direct relation to the change it would cause in the display.

This construction was made as a means of examining the light patterns, that the circuit would generate, within the 10x10 matrix. The LED box proved to be an interesting object in itself but it was actually a model for a much larger sculpture, which was to be the first version of "Light Grid."

2.2 Hardware

Upon examining my fascination with the LED matrix, I felt that it held my interest because of the sense of scale that it implied. I envisioned myself inside the grid with the light moving around and through the same space that I

occupied. In my mind's eye, the patterns produced by the light were not as important as the perception of scale and space that were being defined by the animated light.

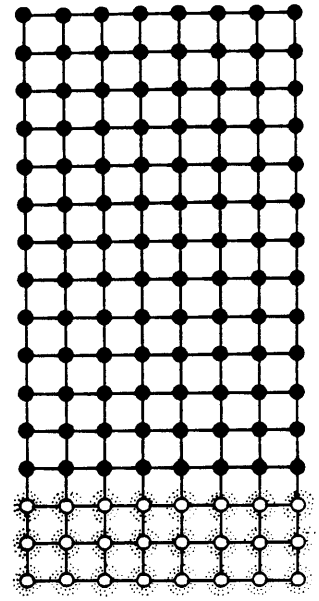


As a class project for Advanced Visual Design, taught by Otto Piene, I decided to build a grid system, like the LED grid but on an environmental scale. This system would be modular in design and would not have to rely on any one particular location for installation.

For the basic unit in the modular grid I used a standard base light bulb and socket. This has allowed me the flexibility to select from a wide range of commercially manufactured light sources. The socket does not require any mounting surface for support. The back of the socket screws down over the power supply lines, which also act as support. The most common use of this type of socket is in temporary installations such as construction sites or in strings of lights around automotive sales lots.

Using this modular unit I constructed a grid of one hundred lamps (10X10) approximately eight feet square. This was used for the class project installation, and more importantly a similar version was used for the thesis installation, "Light Grid."

2.3 Wiring



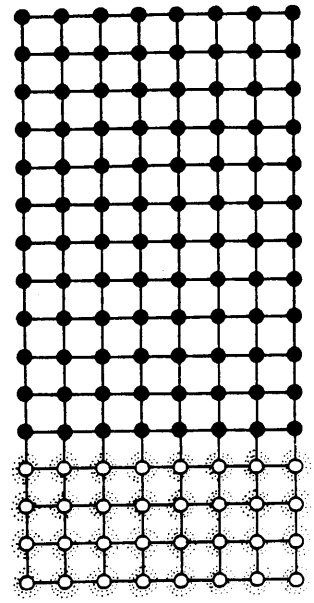
The grid is wired to provide maximum economy of function. The wires that form the rows and columns of the grid structure, also serve as the supply lines for the voltage (110 AC). In order to turn on one lamp it is necessary to turn on one row and one column; this supplies the positive and negative current to the light bulb which is at this juncture. To turn on one entire column of lights, that column is turned on and all rows are turned on (refer to Appendix A).

By wiring the grid in this way I have maximum control over the sequencing of the light patterns, while still maintaining esthetic control over what the grid will look like.

This design is not without compromise. Because of the row and column wiring the light patterns are limited to blocks, lines and points. It is not possible to turn on a diagonal line or an open shape like a circle, because all the rows and columns deleniating the boundaries of these shapes must be on (see Appendix F).

These shapes can be drawn by turning on one lamp at a time very rapidly and scanning through the shape repeatedly. The persistence of vision in the human eye will give the illusion of seeing the total shape instead of each of its elements.

The individual modules of the grid may be easily moved along their support wires, thereby changing the distance between the modules and the dimension of the grid itself Additional modules may be added by increasing the number of rows and columns in the matrix. This is what gives the system "Light Grid" its potential for environmental installations. The scale, shape, density, and light of the grid may be changed for each installation.

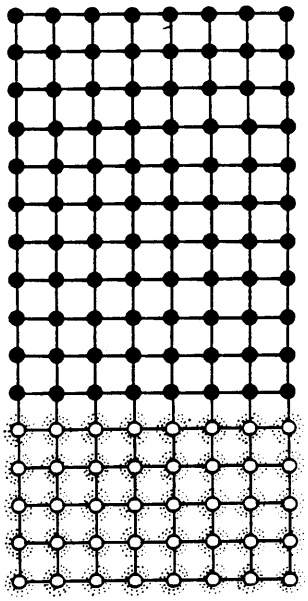


2.4 Control Flexibility

The early versions of "Light Grid" were controlled by analog sequencial circuits. By moving the joystick the viewer physically changed a value in the circuit that generated the patterns.

The thesis installations of "Light Grid" (see photos) were controlled by interfacing a personal computer to the grid system. This has allowed me to program patterns that are as unique for each installation, as the grid itself. The light movement, within the grid, now could have some direct function in relation to the environment defined by the grid.

2.5 Choice of Computer



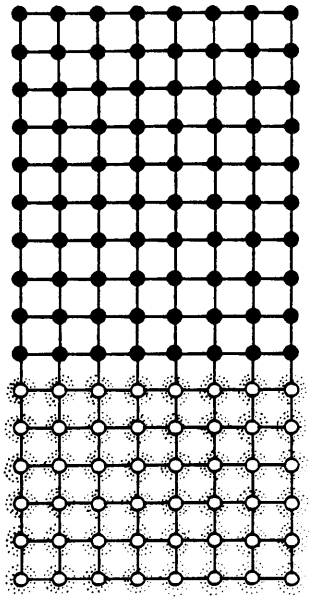
With the availability of relatively inexpensive personal computers it is now possible to use the computer for almost any control function. The electro-mechanical timers and sequencers that I have relied on in the past, to add movement, animation, and modulation to my sculptures, can now be replaced by a computer.

While here at MIT I have had access to very sophisticated state of the art computers which I could have made use of for my project, but I made the choice to start with a more basic commercially available machine which could change and expand as the need might arise. This decision also freed me of a dependence on any one machine requiring engineers for maintenance and programming.

The control required for "Light Grid" would be easily handled by almost any computer on the market, so my choice was ultimately determined by expense, weighed against expandability of the machine. The low cost also avoided the intimidation of opening up the computer to make any modifications or changes in the hardware.

The Boston Computer Society was most helpful in making my final choice. This Society is comprised of many subgroups which are user groups for each of the different personal computers on the market. This made it possible to

learn about these machines without having to deal with biased sales people.



My choice of computer was an OSI, CIP (Ohio Scientific Inc.). This computer has since been discontinued by the manufacturer. But, the Boston Computer Society user group for this machine is still very active and they meet here on the MIT campus once a month. This group is a valuable resource for both hardware and software.

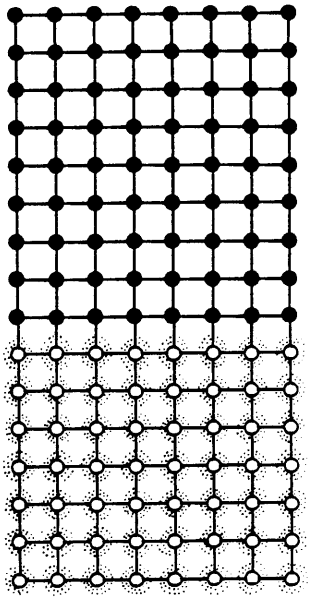
2.6 How It Works

The OSI, CIP is an 8-bit microprocessor. That means that it will process binary words that are eight bits long. In computer jargon an 8 bit word is one byte. A binary word is comprised of either ones or zeros. An example of an 8 bit binary word is 00011000.

The diagram in Appendix A shows the relationship of the 8 bit word to the control of the sculpture. The computer "sees" the grid as three memory locations, A, B and C. These locations are addressed at 63233 to 63235 on my machine, which has the capability of keeping track of 64,000 locations. This type of I/O (input-output) is called Memory Mapped I/O. The values in these memory locations are either read (input) or written (output) by the computer.

To simplify the programming of "Light Grid" I made the matrix eight rows by sixteen columns. Each row or column

is represented by one bit of the three bytes (words) stored in these locations. To turn on the twelve lights represented by "x" on the diagram, the program running in the computer has to store the values of 24, 3 and 240 (decimal) in the memory locations A, B and C. To turn these lights off the program changes these values to 0 (decimal).

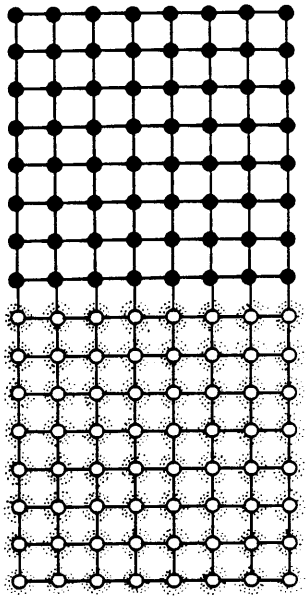


2.7 Interface

The interface between the computer and the grid is responsible for interpreting the data sent out by the computer. It does this by latching onto every new word and holding that value until it receives new data from the computer. Each of the bits of the 8 bit word is output as a TTL signal (transistor-transistor-logic), that is 0 = ground and 1 = 5 volts DC. These 8 TTL lines become control voltages for the triac switches. A high signal on the line (5 volts) will close the switch, a low signal (ground) will open it. The three I/O ports of the computer coming into the interface, leave it as 24 control lines going to the triac switches.

Finally, the 24 switches are divided into two groups. Eight switches are connected to one of the two AC power lines, these control all the rows of the matrix. The remaining 16 switches connect the other power line to the 16 columns.

2.8 Optocoupling



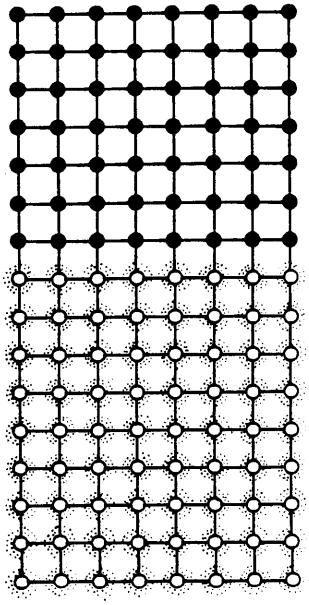
There is a potentially hazardous situation with this wiring arrangement. The computer operates at comparatively low voltage and current levels, compared to those required by the grid. If, as an example, there were a short circuit in the wiring of the grid, it would be possible for the AC line voltage to feedback into the computer. This would most certainly destroy the computer.

To avoid this possibly, optocouplers are used between the interface and the triac switches. Appendix B shows an example of how this optical isolation occurs. Within this device there is an LED placed next to a photo-transistor. The incoming TTL signal turns on the LED, the light from the LED activates the phototransistor which supplies a TTL output. The signal is transmitted optically, therefore there is no physical contact between the input and the output.

2.9 Programming

The computer does nothing until it receives an instruction. The program is a step by step list of instructions or commands that the computer can understand. In the section on "How It Works," I have mentioned that the computer

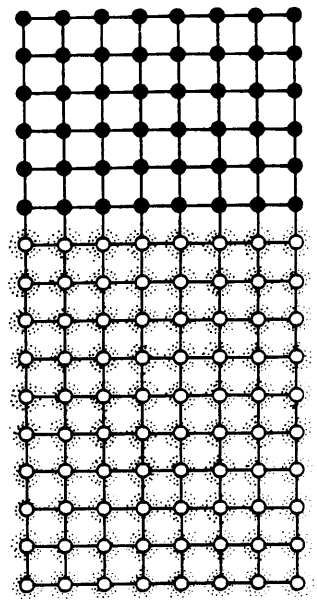
"sees" the grid as three memory locations. Any change in the grid pattern is controlled by the program manipulating the data stored in these locations.



The computer that I am using for "Light Grid" has the language BASIC stored in ROM (Read Only Memory). This means that the computer will understand the language BASIC.

During the installation of "Light Grid" the programs that were controlling the light patterns were stored on audiotape and loaded into the machine each day when it was turned on. These programs were often changed by myself depending upon how the grid was installed (see photos).

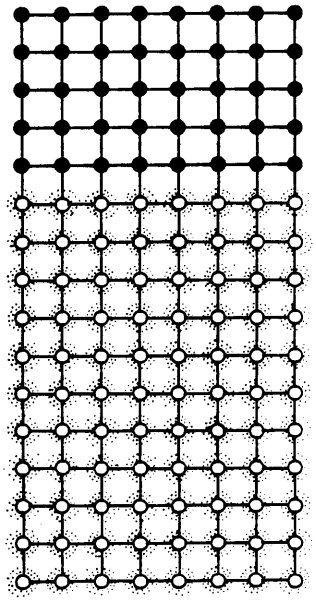
The programs were usually done as a number of subroutines, each of which would be a separate animation of the lights of the grid. These sub-routines were then called up one at a time by a random number generator. For instance, if there were ten subroutines numbered one through ten, the computer would select a number at random from one to ten, and that number would be the next subroutine to run through. The program would then loop back to the random number generator to select the next pattern. In this way the patterns would be strung together in an unpredictable fashion with no apparent end to the sequence.



An example of one of these BASIC subroutines is listed in Appendix C. Also shown is the random number generator. This subroutine turns on one column of lights and moves it from left of the matrix to the right. Here are two sections of a larger program that was running during the installa tion of "Light Grid." The first selection, lines 5 through 85, assign the three memory locations with the values A, B and C, and then randomly selects which subroutine to go to by line number. Line 25 randomly selects numbers between 1 and 10; then, lines 30 to 75 select which subroutine to go to, depending upon the choice of line 25. In particular, if the number 9 is selected the program will continue down until line seventy where it is told to skip ahead to line twelve hundred.

This subroutine contains the instruction that will turn on one column at a time until all sixteen columns are lit. It starts at the left and moves toward the right, creating a flow of light in this direction. The values for the grid are present in lines 1205 to 1215. The word POKE in lines 1230 to 1240 is the BASIC command to enter a value into a memory location, as in line 1230 the value x (255) is entered into memory location A (63233). Line 1250 is a delay loop which counts to 50 before continuing on

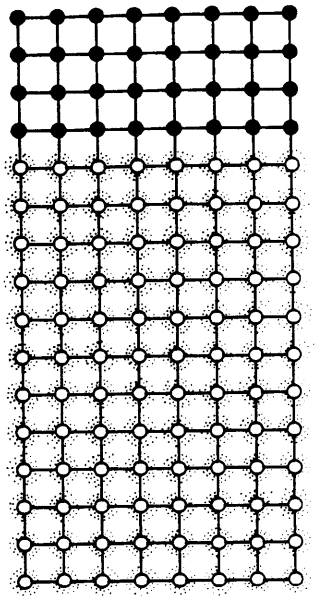
with the program. This becomes the length of time the lights are on before they are changed to the next step of the sequence. The next step is determined by lines 1260 and 1265 where the value Y is changed before the program loops back to 1230 where the values are again POKED. This loop continues, with Y being incrementel by W each time through, until Y = 255, the program then goes on to line 1300 (see Appendix D).



At this point all of the lights controlled by X and Y are on. The second half of the program continues the sequence until all of the lights of X and Z are also on. This condition is tested by line 1360, if it is true the program loops back to line 10, where the process of selection is repeated. The series of graphs in the upper right-hand corner of pages 6 through 21 are a representation of the steps of this subroutine (Appendix C).

The most efficient way for me to program "Light Grid" is to work on graph paper. The example in Appendix A shows how I lay out the grid with the X indicating the lights that I want to be on. The numbered lines of ports A, B and C indicate the eight bits of the binary word in those locations. Reading down these lines, if there is no X such as number 8 of port A, that line will have the value 0. If the line is occupied with an X, the value of that line

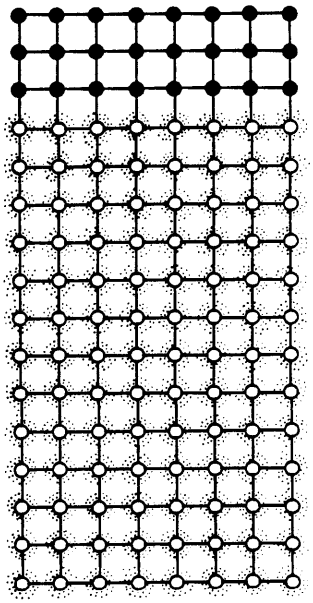
becomes a 1, as in number 5 of port A. The list, in the lower left of appendix A, shows the values for the three ports, A, B and C, in binary and decimal.



To give the appearance of animation, the program running in the computer must change the values stored in these locations. If I want the twelve lights of my example to move in a block to the top of the grid, I can leave the current values in B and C, but port A must change with each step. The following steps would be 00110000, then 01100000, then 11000000 and so on.

A useful programming tool is the program of appendix E. This program prompts the user for a binary character string and returns its decimal equivalent. The BASIC control program requires that the values be entered in decimal, as in the POKE commands of the BASIC program example (appendix C).

3. Documentation of Installations



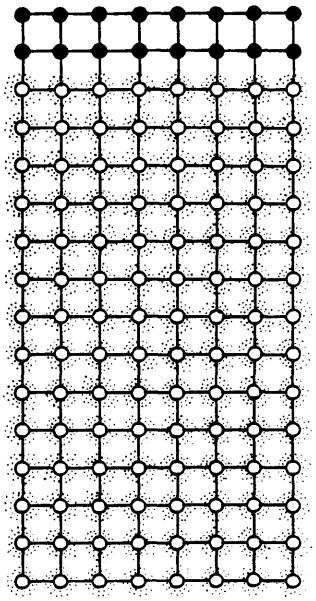
During discussions with my advisor, Otto Piene, I became aware of the fact that my plans for the presentation of "Light Grid" were not what he had hoped for. A transformation of the exhibition room into a total light environment was what he was expecting; while my plans were to do an installation, that would be a demonstration of a modular system which could be expanded into a total environment. This conflict was resolved by my decision to do three installations in the same space, thereby showing the flexibility of the system to accentuate smaller areas of architectural space, and to define implied space as well as total environment.

I decided to limit some of the modular aspects of the system by using the same configuraiton of the grid for all three installations. The photographs 1 through 9 show these three versions. In this configuration the lights are placed on twelve inch centers thereby giving a seven by fifteen foot dimention to the grid (8x16 matrix).

3.1 First Installation

My first installation was quite formal and visually rigid. The grid was held in place by aluminum wire which supported the outside boundaries of the matrix. Photograph

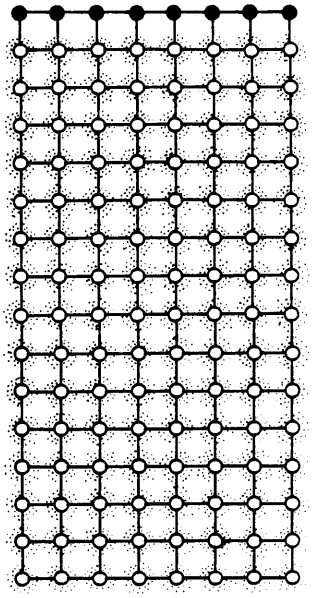
number 1 shows the view upon entering the room. Instead of trying to hide the post, or ignoring it, I decided to use it to emphasize an area of the room. This view of the grid shows all the lights in the foreground turned off and all the lights in the background on. The grid, being folded back on itslef in this manner, produced some interesting effects as the light patterns would run through it. The strong diagonal, or wedge, of the grid would move the viewer out into the room; this was emphasized by the programming of the piece which would move the lights toward the post.



Photograph number 2 shows the triangular area behind the grid. Many viewers were drawn into this space even though the lights were facing outward. Also in this view one can see the shadows that would play on the surrounding walls as the light patterns would change.

Photograph number 3 is effective in showing the sense of architectural scale that I was working with in this room. This post is the only one in the room. The other walls are all unobstructed. By wrapping the grid around the post I created an area of volume which helped to balance visually with the space above. The control lines run from the lower left of the grid to the computer, which is visible in photographs number 1 and 10.

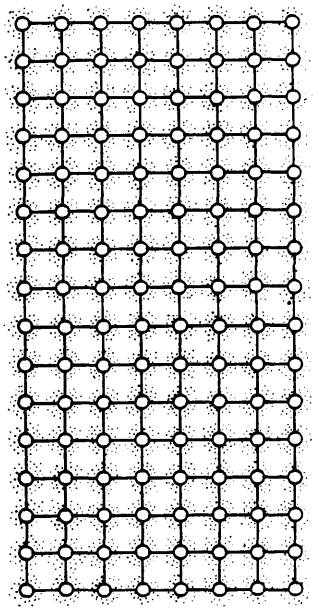
This first installation was also the first time that I had seen the full scale grid under computer control. As a result I spent a lot of time programming different light patterns to see their effect on this large scale display. Many of these animations would move from both the left and right edges toward the center simultaneously. The pattern of photo number 3 is one of a series that would start with all the lights on. The block of lights would get smaller by moving toward the center and at the same time moving up to disappear at the top.



In a way the development of this light sculpture is like reinventing paper. To program and animate images within the grid is like relearning the ability to draw. To begin with, I was pleased to be able to "draw" a line and make it move from here to there, but most of these first attempts did not have much meaning to the installation of the sculpture.

One program, that was a success with the formality of this arrangement, simply input random values into the computer thereby randomly turning on the lights. The length of time a light would be on was also randomly selected from a list of five delay loops. This random selection of delay was weighted toward selecting mostly short periods

with an occasional long delay. The result produced more of a visual rhythm than pattern. The lights would blink and shift around within the grid at a fairly constant rate and would occasionally slow down for what seemed a brief rest. This sporadic timing rate along with the unpredictable visual patterns, had the effect of defocusing the viewer's attention on the grid, thereby giving the illusion that the illumination was coming from a larger area of the room.



3.2 Second Installation

This installation (photos 4, 5 and 6) is an attempt at a more whimsical approach to the use of the grid. Here the grid is installed so as to make use of the flexible nature of the wire support. This is the opposite end of the room from where the first installation was placed. The wall at this end of the room did not have the overhang of the other three walls (see photo number 6). The placement of the sculpture here led the eye of the viewer from the floor up to the wall and beyond to the space above. The piece is hung approximately 7 feet high on the wall and 13 feet out into the room on the floor.

A different light bulb was used for this installation. Compare photos 2 and 6. In the first version the bulbs

were a clear 11 watt sign bulb. When these were on, the light source was the horseshoe shaped filament that glowed very brightly. In the second version the bulbs were also 11 watt sign bulbs but were yellow coated so the entire bulb would glow when on. This change made the grid seem visually more heavy because the point sources of light were much larger. The modulated yellow light of the sculpture made for an interesting contrast with the cold ambient daylight of the room.

The programming of this arrangement relied on the technique of accessing a number of subroutines randomly. Almost all of the patterns had an upward movement, reinforcing the implied gesture of the grid, from the floor to the space above. Upon explaining this random technique to a viewer, his comment was, ". . . oh it's like a mocking bird's song." Apparently the mocking bird sings a sequence of sounds that the bird randomly chooses from its surroundings. I like the poetry of this analogy.

It was possible for the viewer to stand inside the area of the grid that was on the floor. From this point of view, the light would pass under foot on its way through the grid. Photo number 5 shows a visually diminishing perspective seen from the front of the grid. An interesting alternative to the symmetry of this grid would be to gradually increase the spacing of the rows of lights, so that

the front row would extend to the full width of the room, emphasizing this distortion.

3.3 Third Installation

As seen in photo number 2, this installation is basically a reversal of the previous one. The grid is mounted on the side wall and extends up into the space of the skylight (photos 7-9). The gesture of the grid and its placement command much more physical space than the other installations. In this installation the grid seems to become soft and pliable where it comes in contact with the hard surface of the wall and as it moves away and out into space it becomes more rigid and flat. The grid is attached to the wall by only the two corners. This allows the grid to sag. The upper end of the grid extends up into the skylight where it is supported in free space by aluminum wire.

The programming of this installation was very similar to the second because of the upward gesture. The primary difference was that there were more subroutines, therefore, more visual variety. The same yellow lights were used, but because they were installed up high off the floor, the light produced was much brighter, and it seemed to charge the entire room with its movements. The programming example of appendix C was one of the subroutines used in this configuration of the grid. A graphic example of this subroutine is illustrated in the upper right hand corner of pages 6

through 21. By flipping through these pages an animation of the effect is achieved.

In all three installations the ambient light in the room was adjusted so that the grid was always visible. My personal approach to this work places more emphasis upon the selection of the hardware and how it is used, than on the light patterns that are produced. The manipulation and examination of environmental space is important in my work, but I chose to do it with physical sculptural objects instead of just illusion.

4. Reflections on the Use of Light

I remember, as a child, a time when I was afraid of the dark. It seemed to me at the time that my room, at the top of the stairs, was filled with an opaque gas that had choked the light. And if I were to enter this room the same would happen to me.

The experience is quite vivid. I can still recall my fear. Today looking back I can imagine what it must have been like for primitive man when he first discovered fire. His fear was of the light, mine of the dark. This is perhaps an interesting observation on the development of our civilized society. We have become so accustomed to our ability to push back the dark with artificial light, that it seems unnatural when we are forced into the dark. The blackout of 1965 in New York City is a good example of how helpless we can be.

The first cultural esthetic use of light was achieved by the Chinese. Their fireworks lit up the night sky in a way that must have been most impressive. Try to imagine what it must have looked like to the mind's eye of the average person at that time, whose only vision of light was fire.

The Chinese used fireworks for their psychological impact, whether for beautiful displays or to frighten their enemy during battle. Unfortunately it was their enemies who developed the destructive force of Black Powder

and then turned its power against the Chinese.

4.1 Color Organs/Synaesthesia

Light as art has its historic roots, coupled with the perception of music. As early as the 18th century there were instruments developed for the display of light to accompany music. These are today called color organs. The earliest record of such an instrument goes back to 1734. It was Father Louis-Bertrand Castel, Jesuit philosopher and mathemetician, who constructed the "Clevessin Oculaire," the first color organ. Castel writes:

> A clavessin . . . is a series of stretched cords which conform in their length and their thickness to certain harmonic proportions which . . . by moving the fingers as in an ordinary piano . . . makes the color combinations which correspond precisely to those of music.[2]

Along with Castel were several artists, inventors, scientists, all working toward what they believed was a universal relationship between musical and color intervals (synaesthesia). In theory this seems a logical pursuit. Just close your eyes while you listen to a passage of music, and the colors will soon appear. The result of most of this research led to the development of several keyboards resembling large organs. These were musical instruments which when played would produce visual light accompaniment.

The operas of Wagner influenced many artists and composers to develop what has become known as "total theater" or "multi-media events." These artists wanted to expand the emotional range of their medium just as Wagner had done with his epic approach to the opera. It was at this same time that new technologies were being developed for the projection of light. Many avant-garde theatrical concepts were developed on a parallel with the development of these light sources.

In 1915 Alexander Scriabin, a Russian composer, presented the first performance of Prometheus at Carnegie Hall in New York. Prometheus, the benefactor of mankind in Greek mythology, stole fire from heaven and gave it to the world. Scriabins' symphony is scored for large orchestra and piano, with organ, choirs and Clavier a Lumiere. This instrument in theory was a keyboard which could control the play of colored light in the form of beams, clouds, and so on, flooding the concert hall. Unfortunately the technology to produce these effects was not yet available. The instrument that was produced for the performance had to rely on a small screen placed behind the orchestra. The final effect was a disappointment to Scriabin.

The directions for the light effects consist of a single stave of notated music marked "Tastiera per Luce," light keyboard. Scriabin's friend Sabaneiev explains the notation and light sound concepts of Prometheus:

> Scriabin's musical color sensations could represent a theory for which the composers could gradually become aware. This is the chart:
>
> | | | |
> |---|---|---|
> | C Red | F-sharp | Blue, intense |
> | G Orange-pink | D-flat | Purple |
> | D Yellow | A-flat | Red-purple |
> | A Green | E-flat | Steely |
> | E Whitish-blue | B-flat | With a metallic shine |
> | B Similar to E | F | Red, dark |
>
> When arranging these tones on the circle of fifths, the regularity becomes obvious. The colors arrange themselves almost exactly according to the spectrum. Deviations depend only on the intensity of feeling (e.g., E-major - moon-colored). E-flat and B-flat are not to be found in the spectrum. According to Scriabin these tones have an indistinct color, but a very distinct metallic shine. This correspondence of colors was used by Scriabin in his Prometheus. Those who listened to the Prometheus with the corresponding light effects admitted that the musical impression was in fact absolutely equalled by the corresponding lighting. Its power was doubled and increased to the last degree. This happened despite a very primitive lighting, which produced only an approximation of the colors.[3]

Scriabin died at the early age of 43, just five weeks after the New York performance of Prometheus; leaving unrealized his most ambitious work, The Mystery, a total theatrical spectacle including music, dance, speech, smell, and light with a cast of two thousand.

In Munich in 1910 Wassily Kandinsky was painting the first totally abstract compositions. These paintings evolved directly from concepts that he was exploring with other artists working in other disciplines such as dance and music. The culmination of this work was his opera, Der Gelbe Klang (the yellow sound). Just as Kandinsky had abandoned imagery in his paintings, his opera also has discarded the use of realism. The primary elements in Der Gelbe Klang are color, movement and sound.

The first production of this opera was not realized until 1982 in conjunction with the exhibition, Kandinsky in Munich 1896-1914, at the Solomon R. Guggenheim Museum in New York. The producer director of Der Gelbe Klang, Ian Strasfogel, writes:

> Wagner and Scriabin used sight and sound in a harmonious, mutually reinforcing manner. Throughout the early years of the twentieth century, artists were fascinated by the concept of synaesthesia--the sound evoked by color, the color evoked by sound. Kandinsky, however, found synaesthesia limited and accused Wagner and Debussy of overusing it. To avoid such "overliteralism," the painter constructed The Yellow Sound, according to "the principle of contrasts." Thus we find in Scene 3 that as the stage is increasingly flooded with intense yellow light, the music gets lower and darker. Kandinsky felt that modern times could be expressed only through "storm and tempest . . . broken chains . . . antithesis and contradictions." Discontinuity, according to him, would produce "harmony" of the twentieth century.[4]

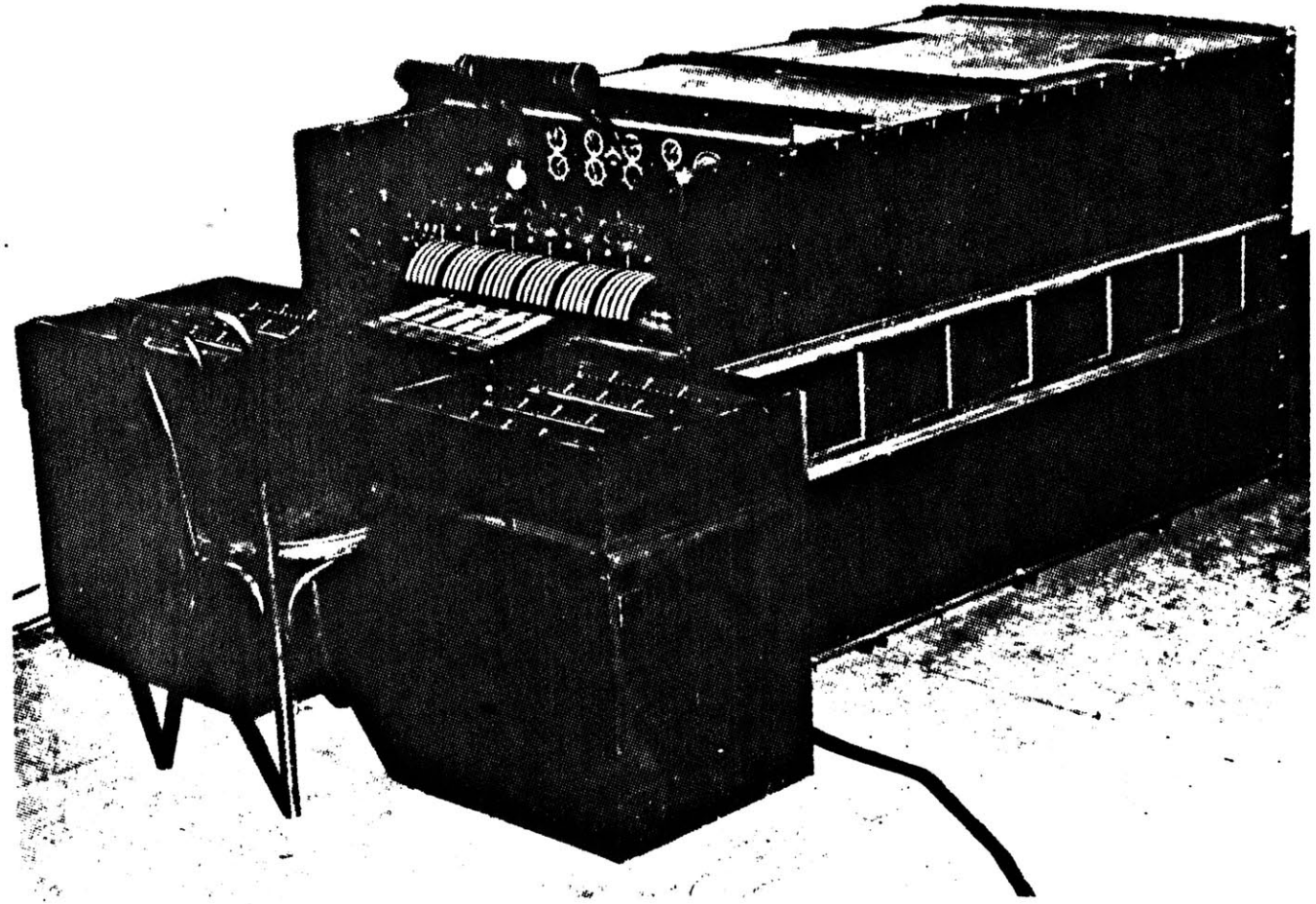
The opera of Arnold Schoenberg, Die glückliche Hand, was written at the same time as the work of Scriabin and Kandinsky. It too calls for the use of colored lighting effects in its staging.

These artists all have extremely divergent philosophies in the approach to their artistic statements, but they have in common the use of light as a visual and emotional catalyst.

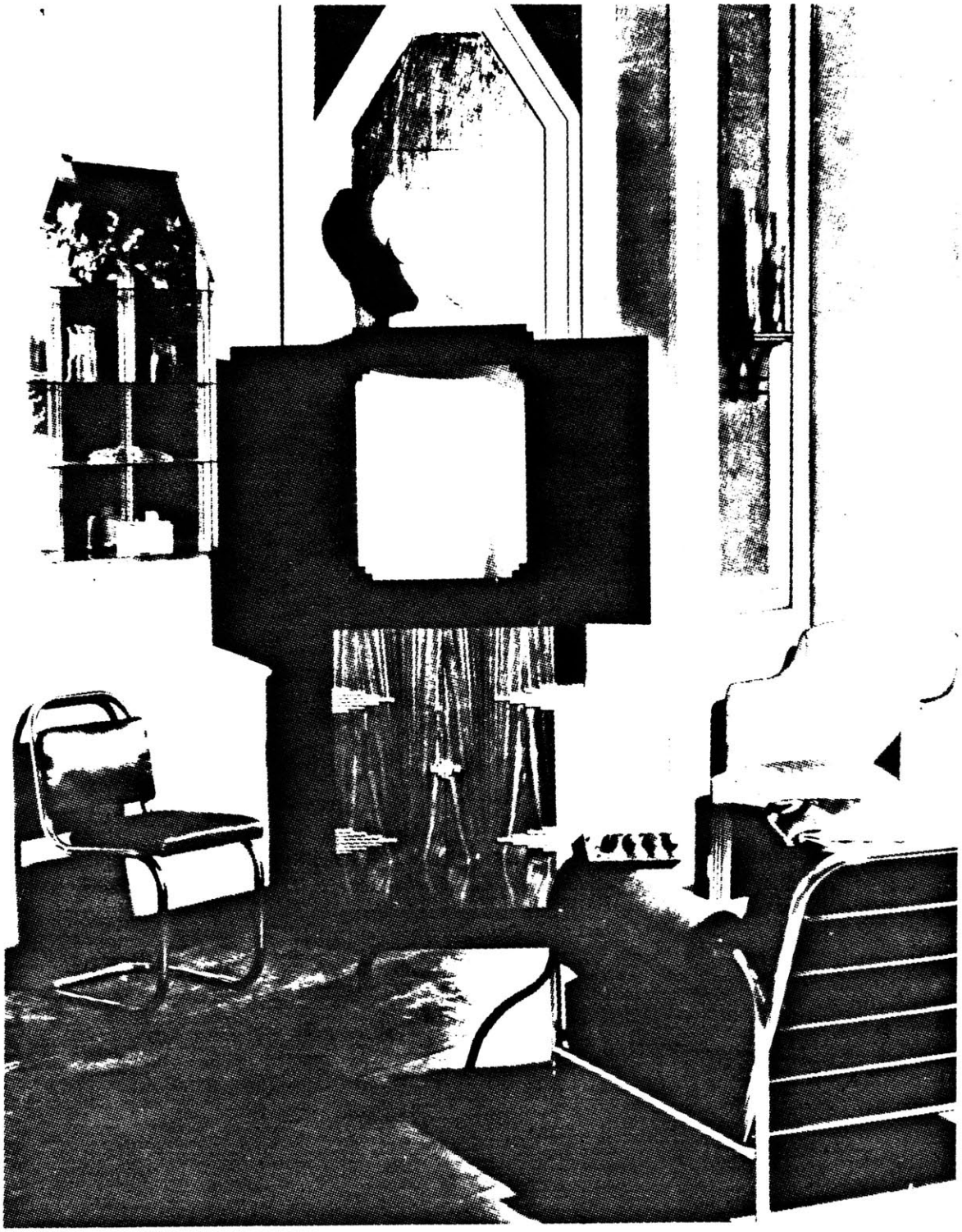
4.2 Thomas Wilfred/Lumia

In 1905 at the age of 16, Thomas Wilfred's interest in music led him to explore the theories of Isaac Newton, Father Louis-Bertrand Costel and others who at that time believed the colors of the spectrum had a direct relationship with the musical scale. By using a projector made from a cigar box he eventually came to the conclusion that there was no basis for the theory and that light could only be translated in terms of form, color and motion.

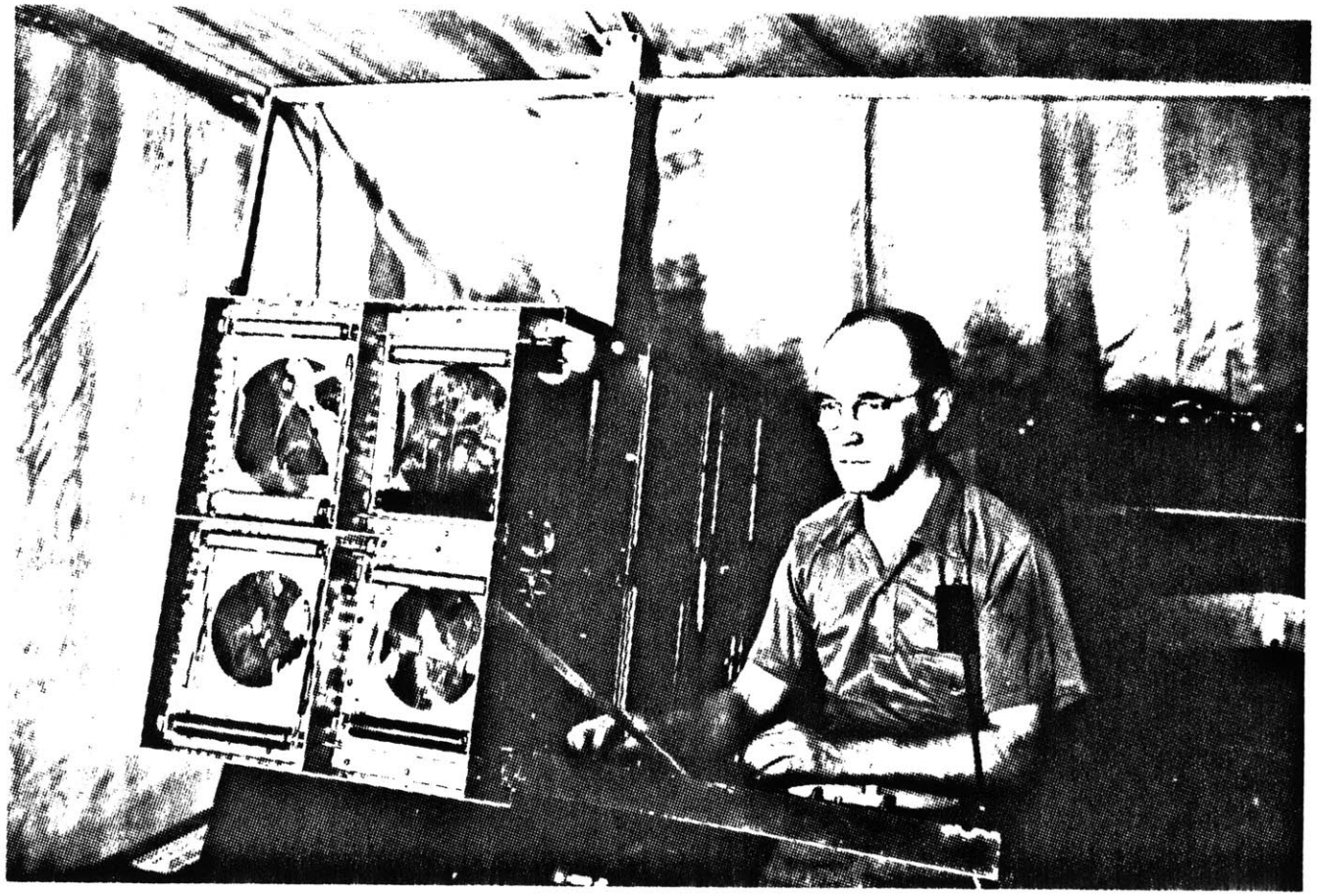
Wilfred spent the rest of his life developing an art of light which he called "Lumia." By 1919 he had completed his first instrument, the Clavilux, for playing his silent lumia compositions. The Clavilux was a keyboard instrument which when played would project abstract light forms onto a screen. From his first recital in 1922 the Clavilux developed into large scale permanent architectural installations, like the 210 foot-long projected Mobile mural (1922)



CLAVILUX



FIRST HOME CLAVILUX (Clavilux Junior), 1930



Thomas Wilfred with Clavilux Model G

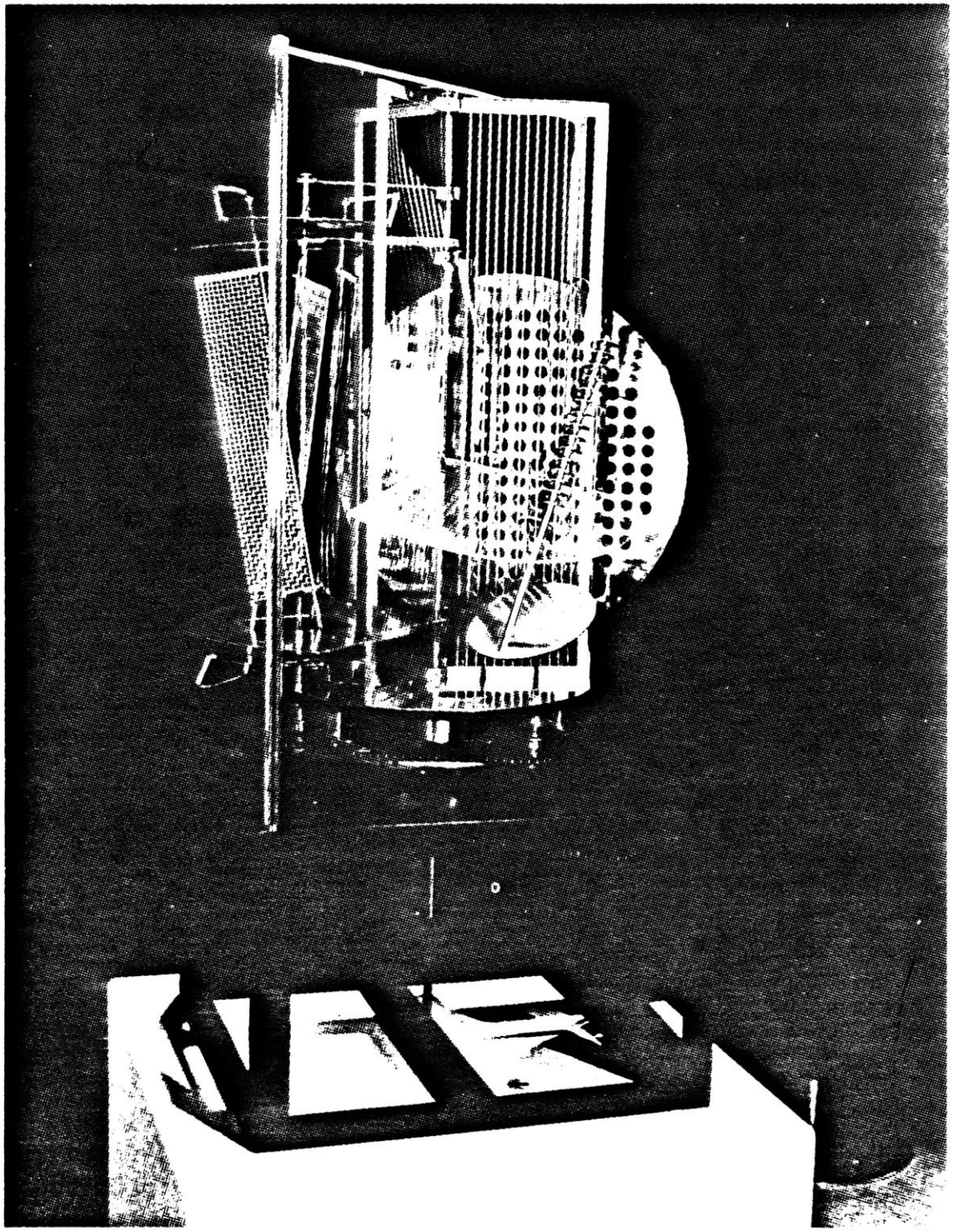
at the Hotel Sherman, Chicago, and Lumia Suit Op. 158 (1964) at the Museum of Modern Art, New York.

> Color is the factional manifestation of light, non-existant without light. A color is an optical phenomenon, not a pigment. Without light, a prism is just a block of clear glass, a pigment only a chemical preparation. Each is capable of breaking up the white light into its component colors--the prism by separating the different wavelengths from one another, the pigment by absorbing some of them and allowing the rest to reach your eye--yet neither prism nor pigment has more color than an untouched piano has sound.[5]

4.3 Moholy-Nagy

Any discussion of light in the visual arts would be incomplete without some aspect of the work of Laszlo Moholy-Nagy. As educator, artist, philosopher and designer he has made important contributions to almost every aspect of the use of light.

His Lichtrequisit, or Light-Space Modulator, was developed over a period from 1921 to 1930. This machine-sculpture is an articulated armature of polished metal surfaces and grids that, when set in motion by an electric motor, would act as a reflective modulator of light. The light sources, as many as 130, were placed around the room and sequentially selected by a rotary switch. The kinetic presence of the modulator would be extended by the play of light and shadows to fill the entire room.



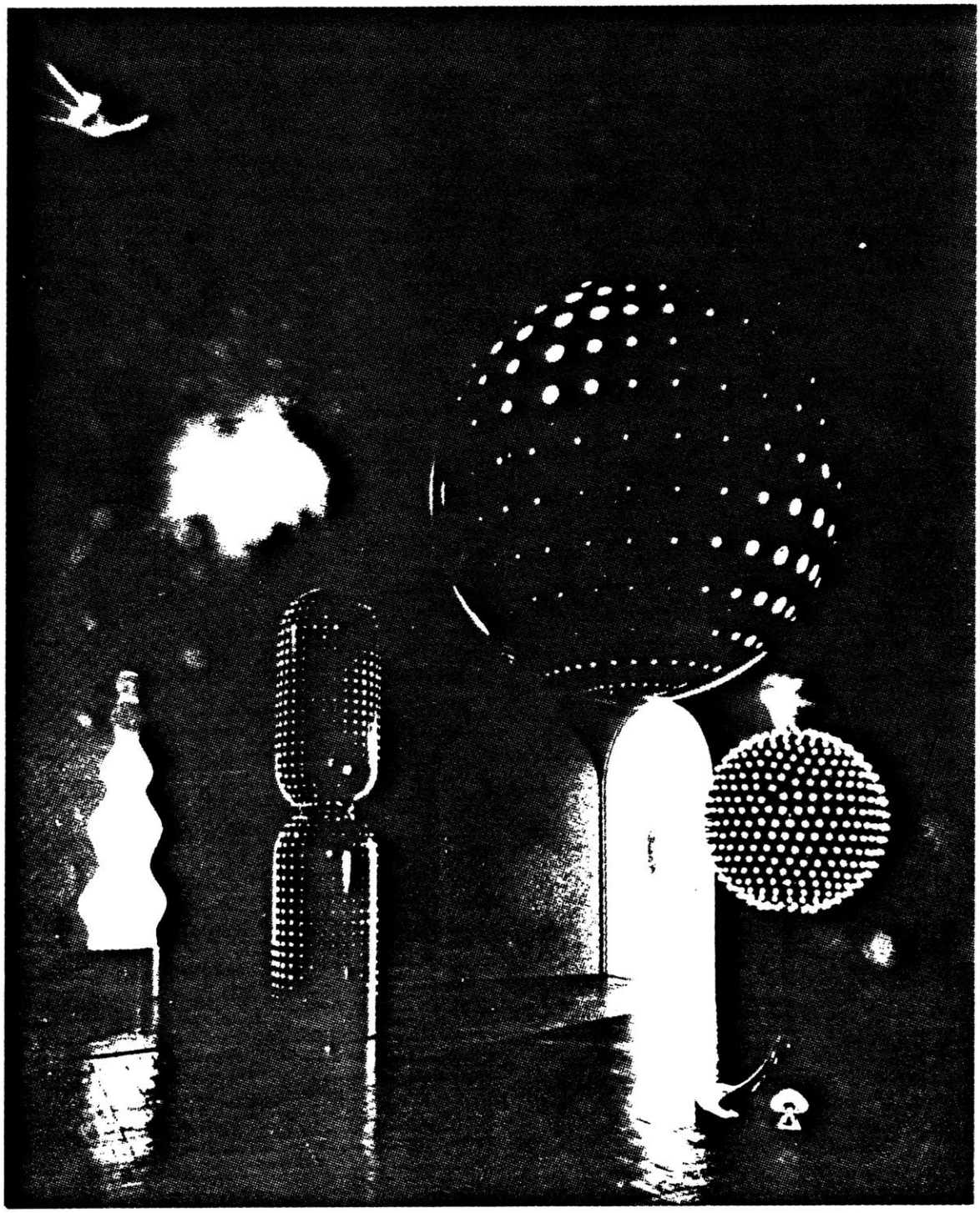
LIGHT-SPACE MODULATOR, Moholy-Nagy, 1921 to 1930

Moholy-Nagy did not consider this object as sculpture, even though it was successful on many levels: sculpture, environment and instrument. He felt it was more a bridge between sculpture and cinema. He used his Lichtrequisit for research into light perception and projection of visual phenomena. The Light Space Modulator is now in the collection of Harvard University's Busch-Reisinger Museum.

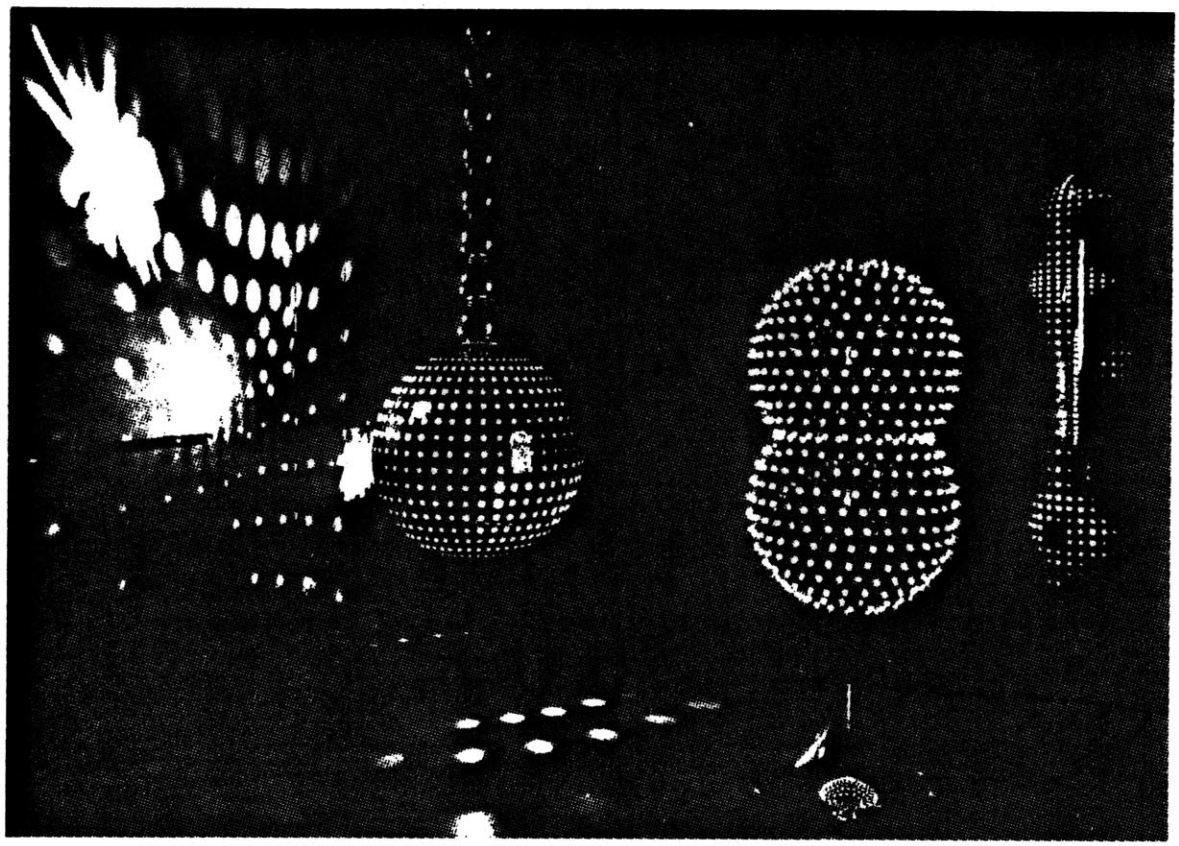
4.4 Otto Piene/Light Ballet

The etherial quality of light escapes the artist's attempts to define visually its emotional impact. Each statement made by the artist always opens new avenues of exploration no matter how successful the effect or installation may be. The Light Ballets of Otto Piene are just such an example. These light installations, performances, environments started in 1957 and have evolved and changed over the years. The one constant in these events is the use of light on an environmental scale. Otto Piene states by way of explanation:

> The important thing is the inclusive use of all the space, in contrast to the way space is used in the show business arts of theater and film. The light is not confined to a peep-hole stage or a flat screen at one end of a long room, where the observer sits in darkness. Instead it reaches everywhere in a given space. This is how the observer gets the impression that he is the center of the action: the light "passes all the way through." A dynamic sensitivity to the space is created,



Otto Piene: Light Ballet installed in the gallery Heseler 1972. Lichtsaule double 500, Lichtkugel 500 hangend, Single Neon, alle 1972.



Otto Piene, Light Sculptures 1972:
Projecting Light Sculpture (left)
Double neon (center)
Light Column (right)

> and thus the force of gravity loses its spell. The seemingly necessary plot conflicts which characterize traditional theater productions are used in the Light Ballet; instead there is a distribution of phases which is closer to a continuum. A strictly continuous light transformation, however, will only be possible when the Light Ballet has reached a greater degree of mechanization. Then the actor will step even futhre into the background.[6]

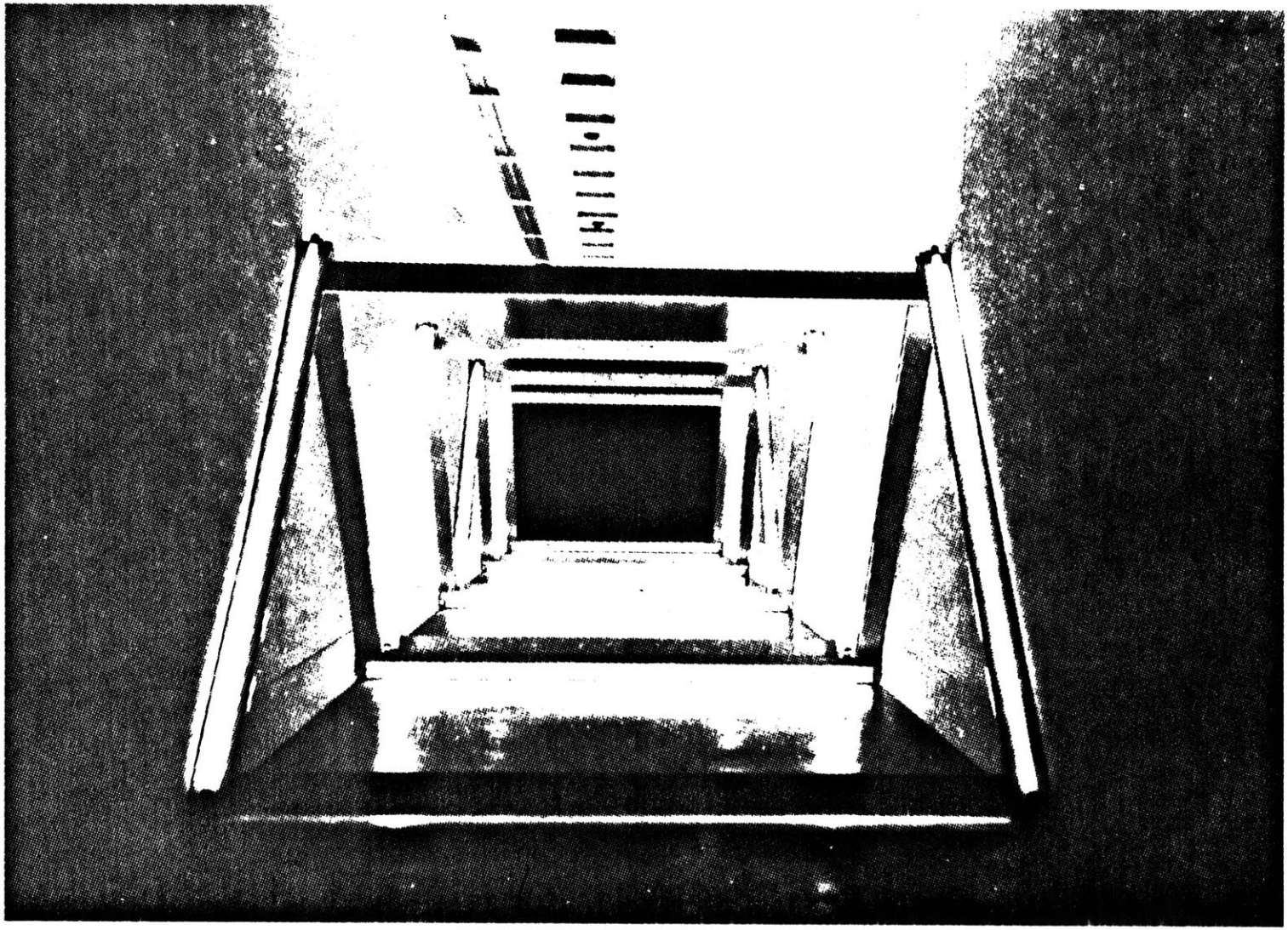
The environments for the Light Ballets are produced by a combination of light sculptures and various projection apparatus.

Piene's environments are similar to the effects produced by Moholy-Nagy's Light Space Modulator. Both of these environments are produced with active sculptural objects that have a presence and a kinetic life of their own, that can visually effect their immediate surroundings. The environments are populated by--and exist because of--the sculptures that create them.

4.5 Dan Flavin

It is the interaction of light that colors our feelings about space. Dan Flavin's placement of fluorescent tubes could be defined as environmental. The placement of any light source in an interior space will effect the ambience of the room. Gregorie Muller defines Flavin's approach:

> There is no place in this strict research for the old flirtation between art and handicraft. The fluorescent tubes are industrial products; they are put on the



Dan Flavin, Light Installation

> walls by electricians while the artist remains in the background. Flavin's role, however, is not merely to choose a ready-made object and to transform it into a work of art through his decision that it be one. His role is to place the tubes in a situation and to give them a function in space. What he creates is not so much an art object as it is the phenomenon of the piece's existence in a particular location, at a particular moment in time.[7]

Flavin defines his approach in relation to his earlier more traditional methods of producing art:

> I sense no sytlistic or structural development of any significance within my proposal, only shifts in partitive emphasis modifying and addable without intrinsic change. The system does not proceed, it is simply applied. All my diagrams, even the oldest, seem applicable again and continually. It is as though my system synonymizes its past, present and future states without incurring a loss of relevance. This differs greatly from the former sense of development, piece by piece.[8]

4.6 James Turrell/Illusion

The environments that have been discussed so far have primarily been spaces modified by the use of light. James Turrell is an artist whose work produces unique built environments to generate a quality of pure light, a light you want to touch.

> . . . the decision to work with light in space, not light going through plexiglas or scrim, but actually just light inhabiting space and how to deal with that, was a little bit difficult for me, because it's a medium that you can't get your

> hands on--it's not like clay. It's very difficult to form . . . "[9]

Turrell's effects are exceedingly subtle. In his most recent show, at the Hayden Gallery, M.I.T. (January 1983), he has constructed a large room which is completely empty. The very low light level in the room is produced by only four flood lights illuminating the side walls. At the far end of the room there is what seems like a large gray rectangle painted on the wall. This seems a first to be a flat minimal, colorfield painting but, upon closer examination, the surface becomes a velvety gray fog. It is not until you try to touch the surface of this painting that you realize it is only an illusion. The rectangle is an opening in the wall, behind which is another large room painted light blue. The illusion is created by careful attention to the scale of the space in relation to the placement of lights.

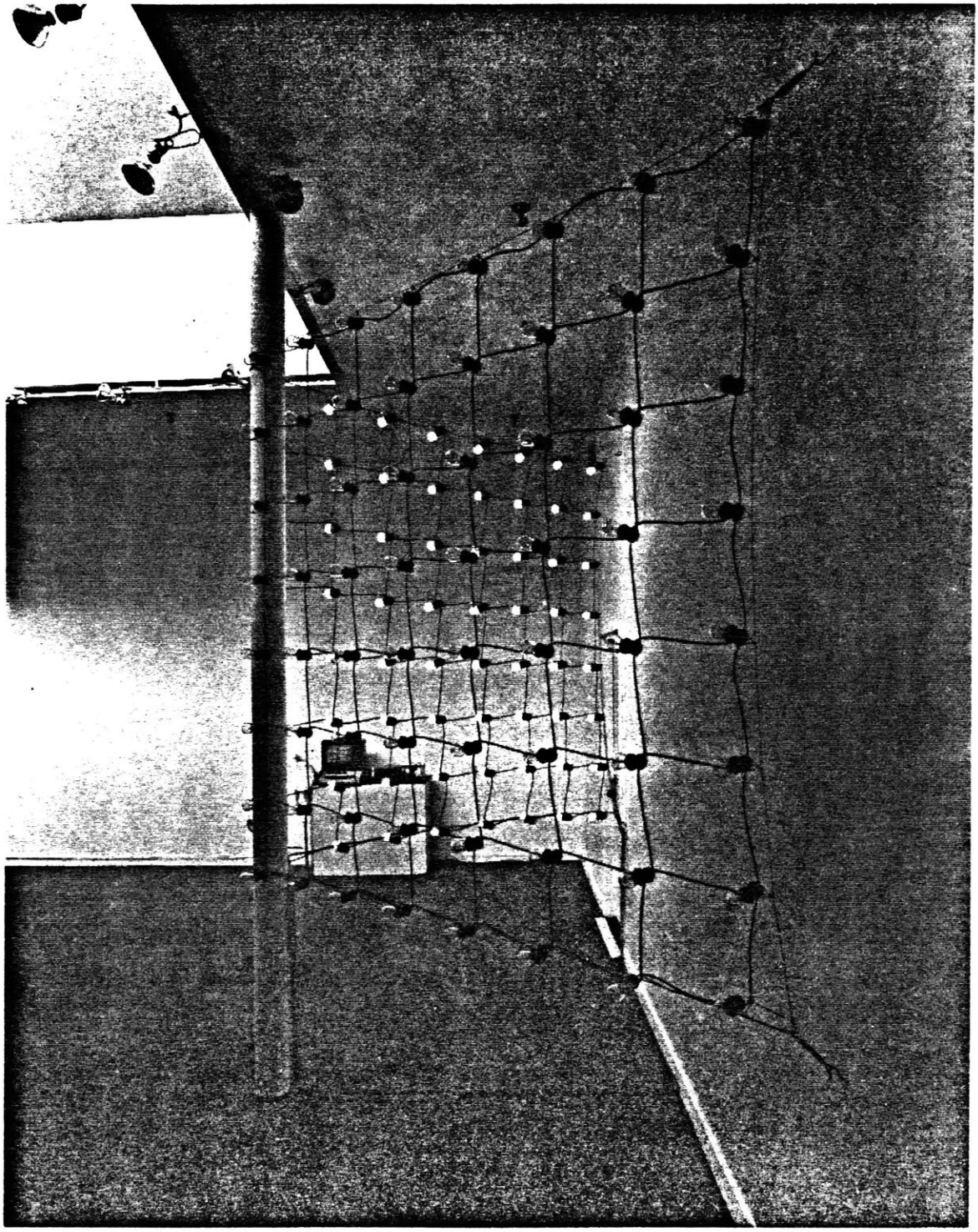
The eye sees surface by reflected light, the mind's eye sees illusions, often created by reflected light.

5. Conclusion

The system Light Grid is a sculpture with no defined limitations for its use; in this respect, it follows the historic precedence set by Moholy-Nagy's Light-Space Modulator, that of an instrument for the examination of light phenomena. The three installations of Light Grid were done to support the thesis that the sculpture can also be used to define and accentuate the physical space where it is placed.

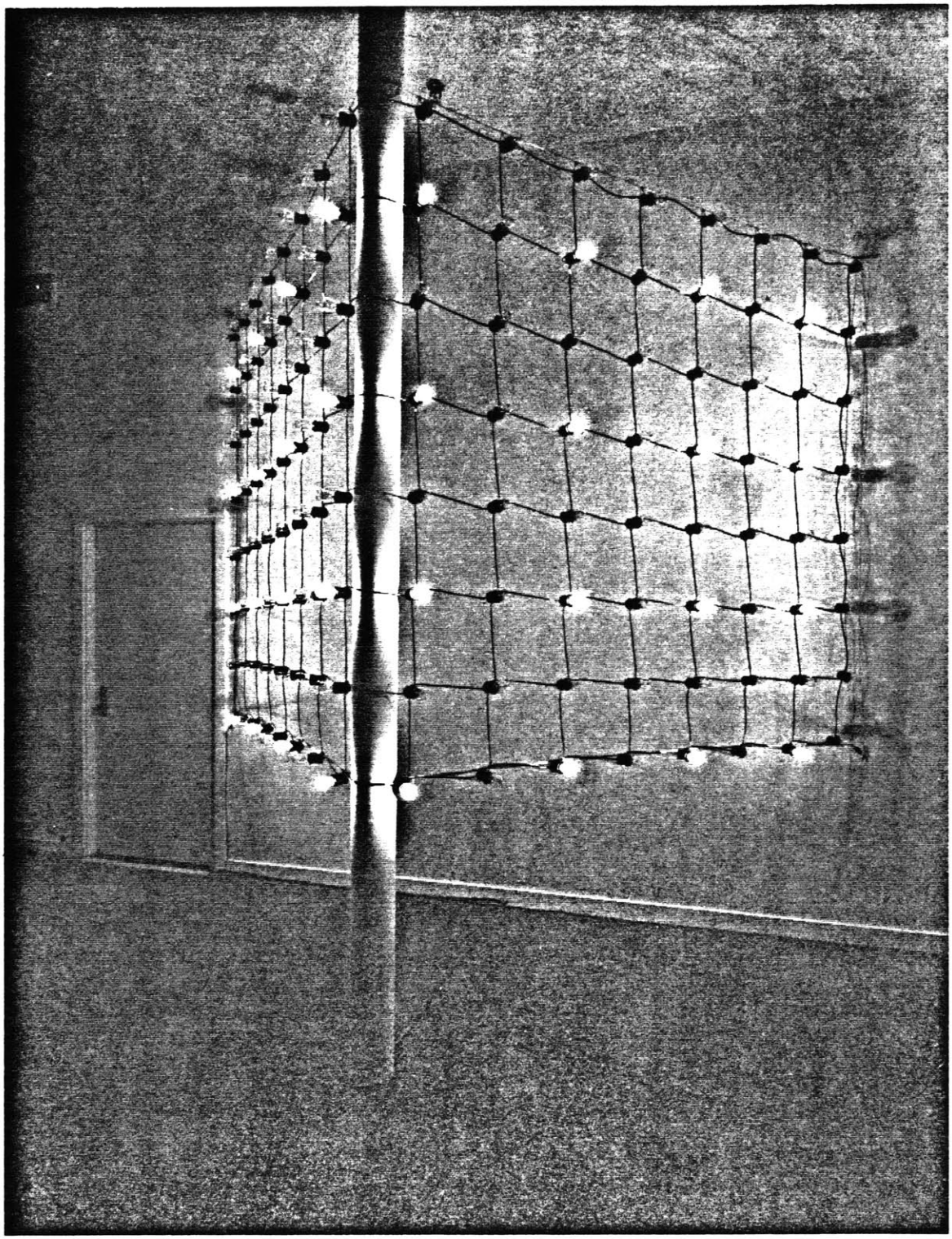
The process of installation is one of environmental examination and conscious magnification or modification of architectural space. This process is further defined by the choice of light and the programming of its modulation. Once the system is installed it becomes a sculpture that exists in its own environment. This process is the activity of generating art. Dan Flavin's "placement" is done with a diagram which others follow. Light Grid could be installed in just such a way, although the building of the piece is personally rewarding to me.

> Painting with light is an old chapter of human activity. We have documents about antique illumination for theatrical performances in which colored glass, prisms, etc., were used. Centuries later the magic lantern appeared--fireworks, the light effects of the baroque opera; and later still, different projects for a color organ. Today, in light, from photography to television, we have more sources for a new art form than at any other period of human history. But unless we learn to clear our minds of the old, traditional ideas of painting, not even the work of talented painters will reach the level of a genuine artistic creation.
>
> -- Laszlo Moholy-Nagy[10]



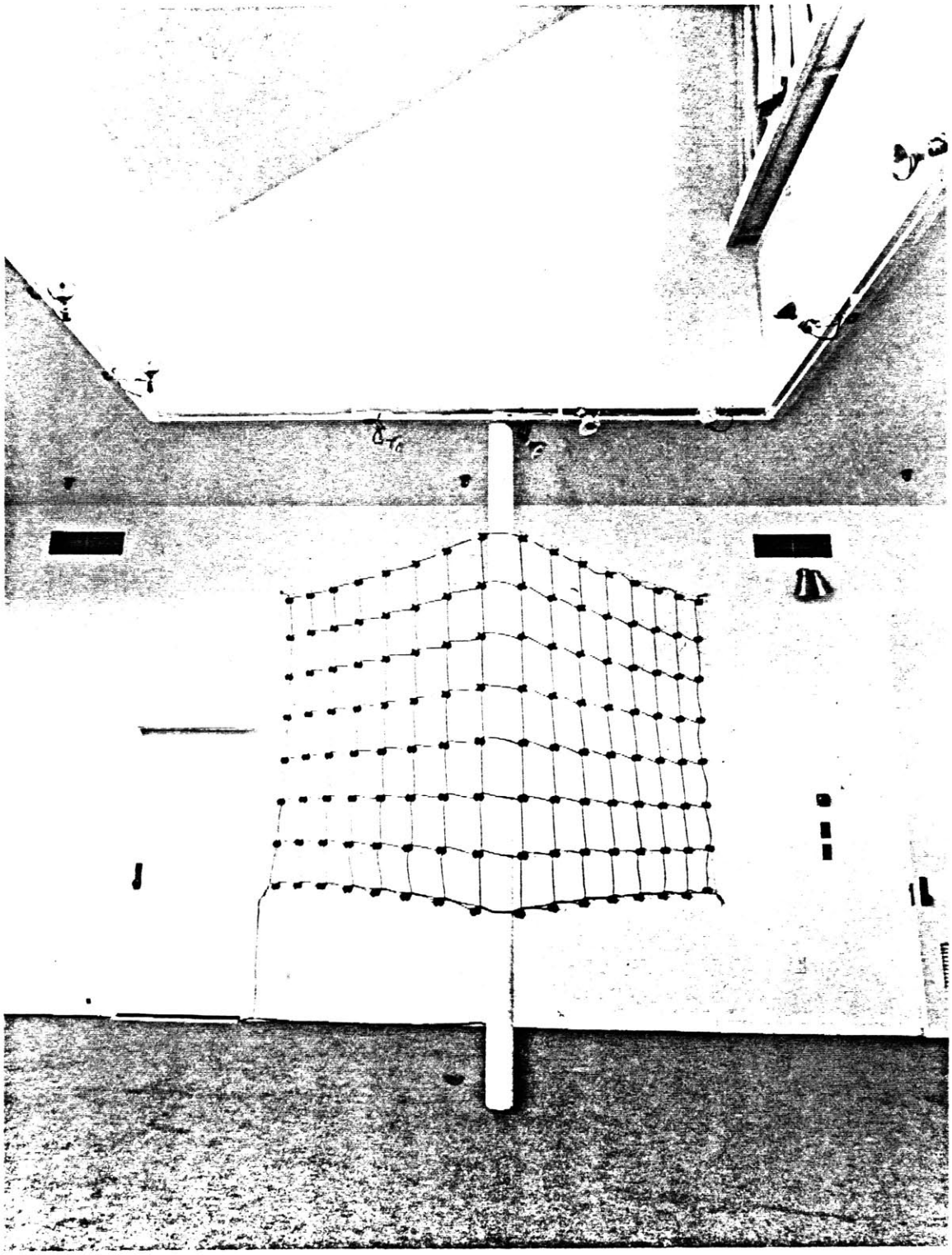
LIGHT GRID, installation number one photo #1

photo by Mark Strand



LIGHT GRID, installation number one photo #2

photo by Mark Strand



LIGHT GRID, installation number one photo #3

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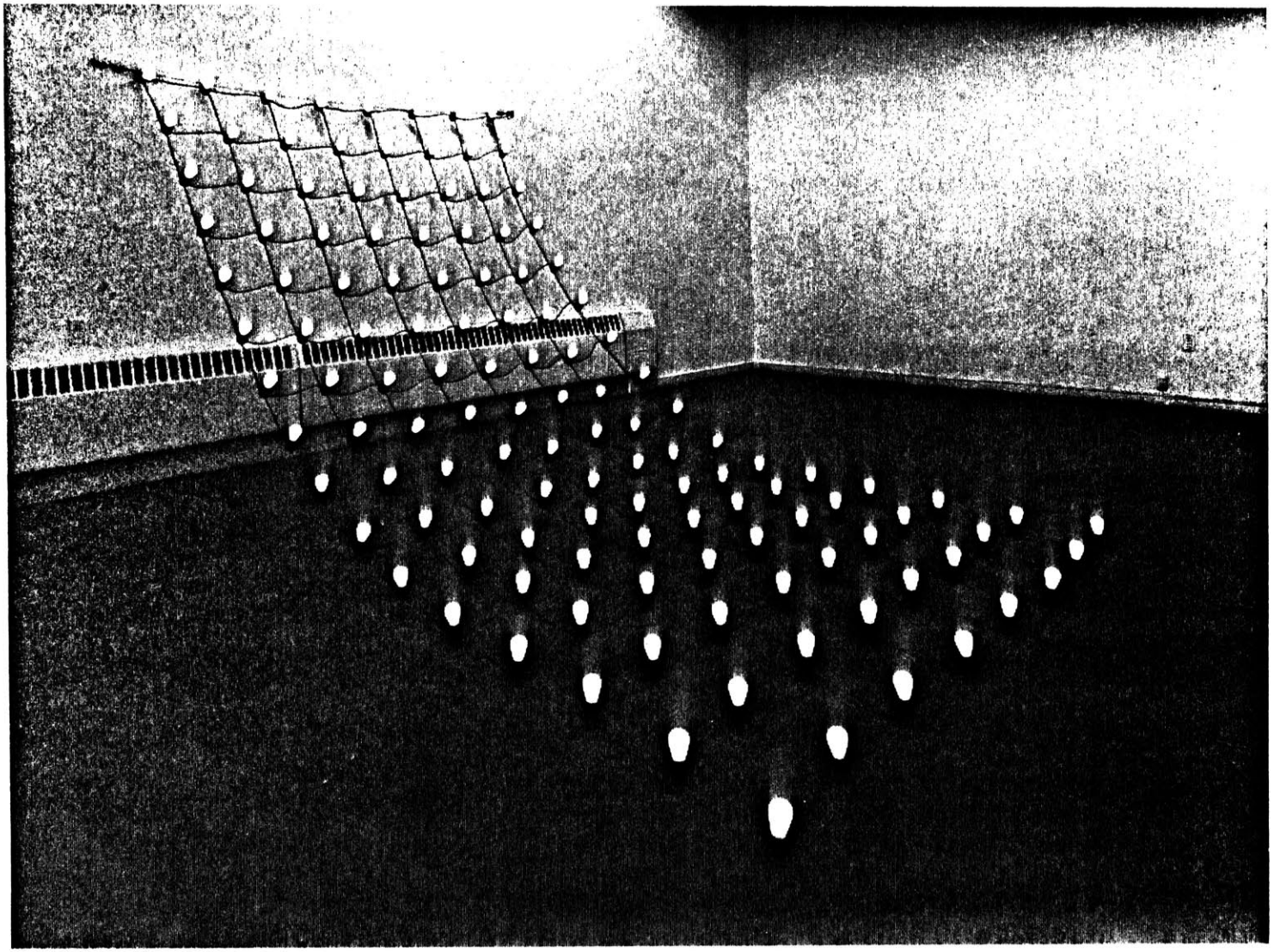

photo #4

LIGHT GRID, installation number two

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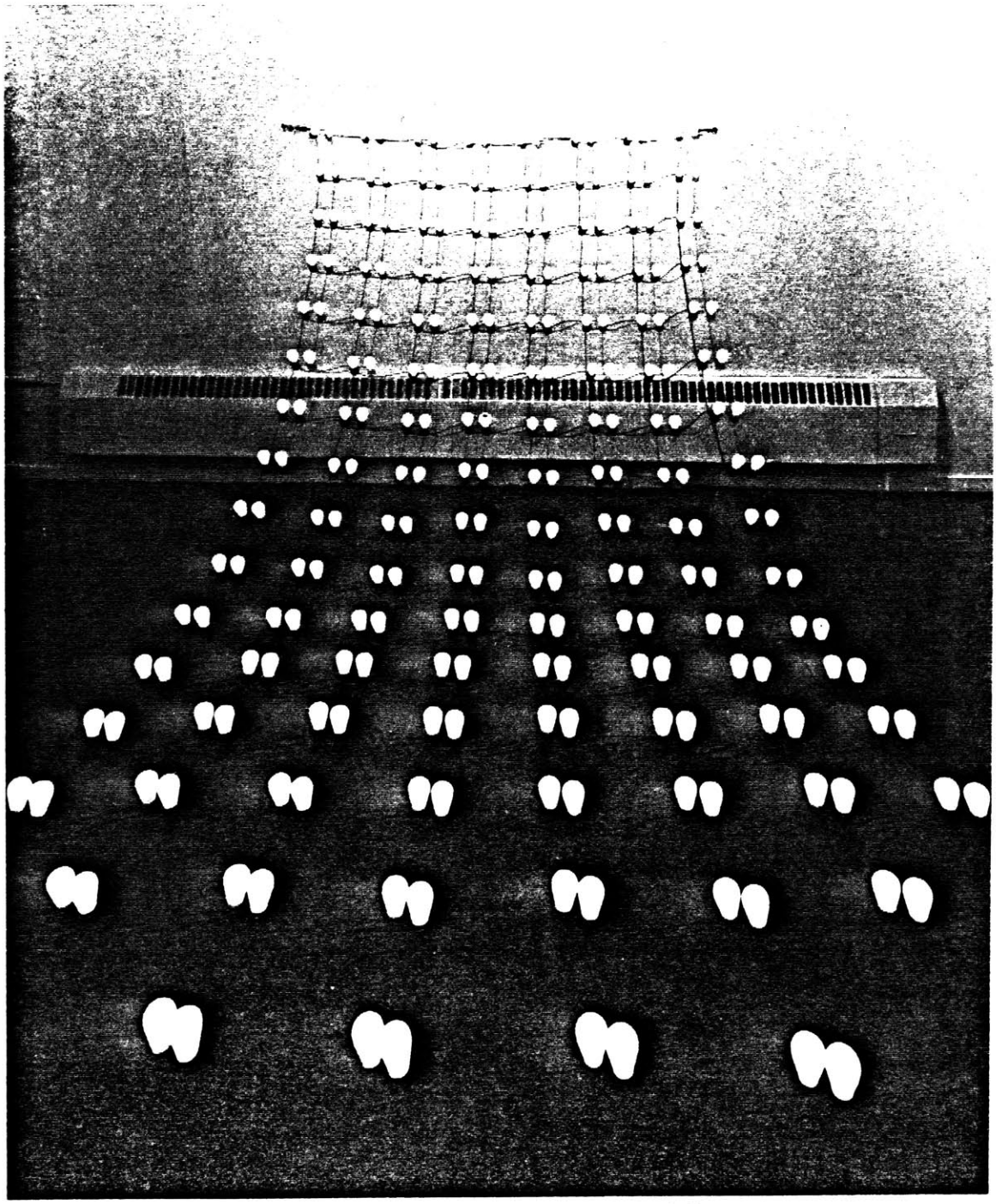
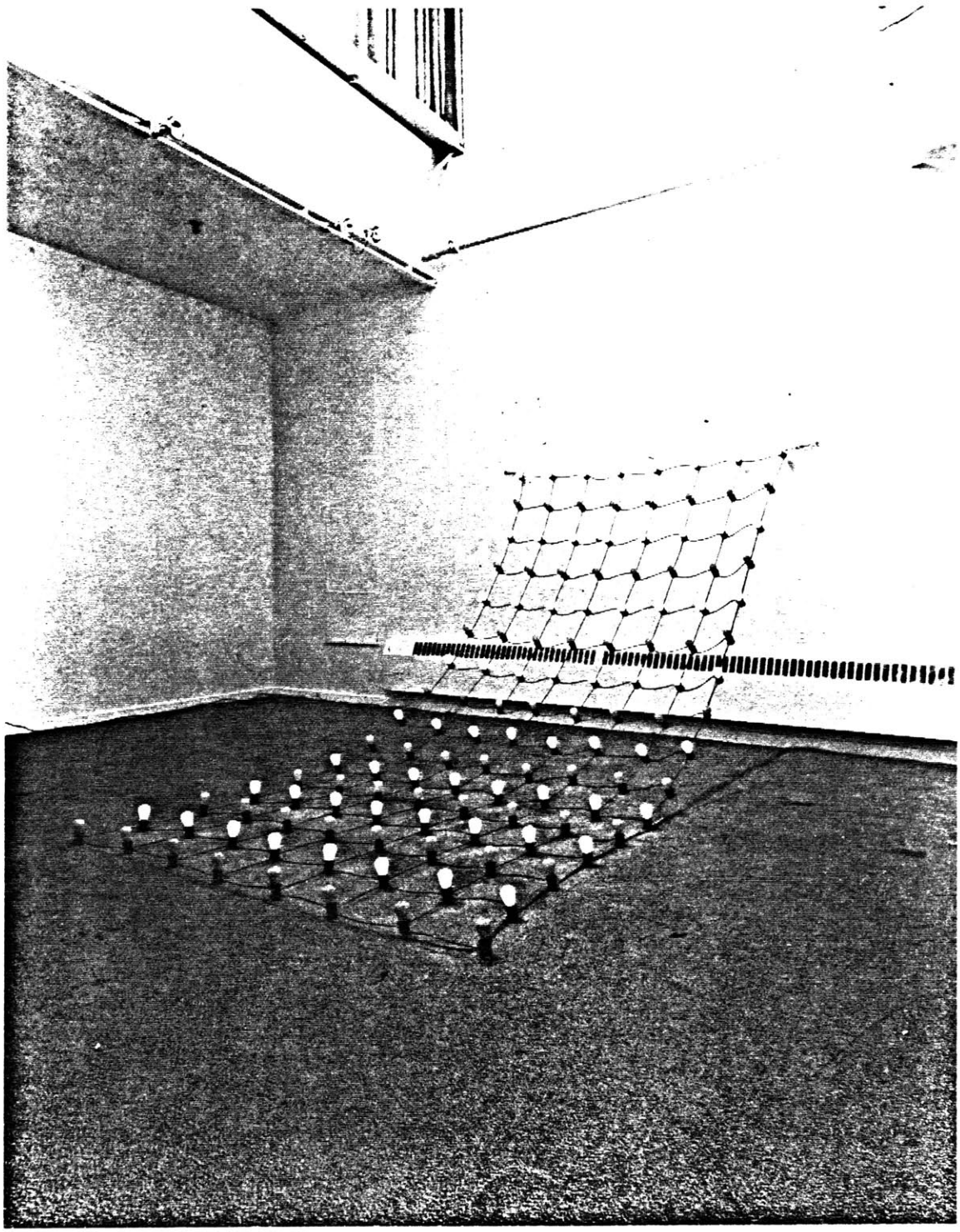


LIGHT GRID, installation number two, double exposure
photo by Mark Strand photo #5



LIGHT GRID, installation number two photo #6

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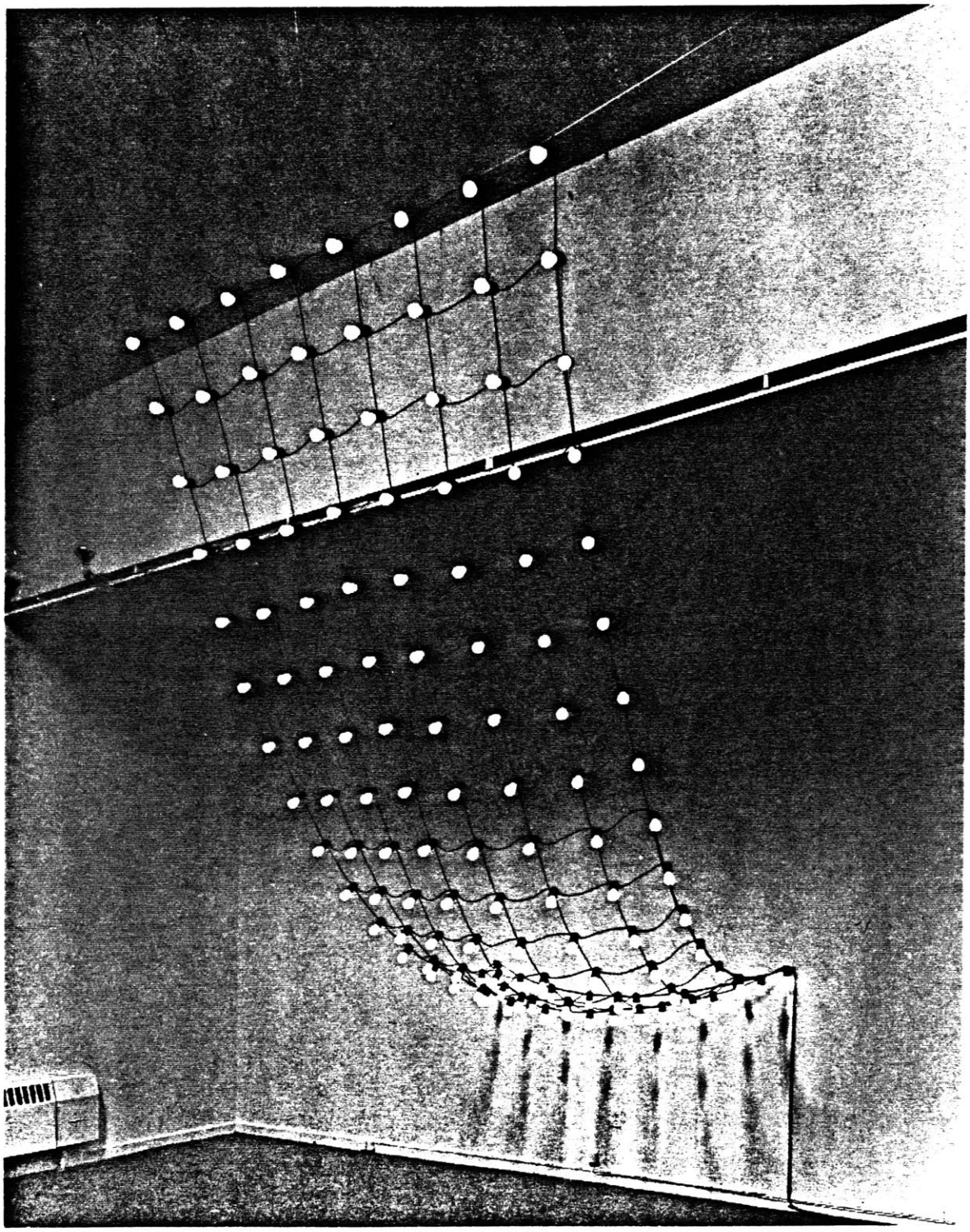
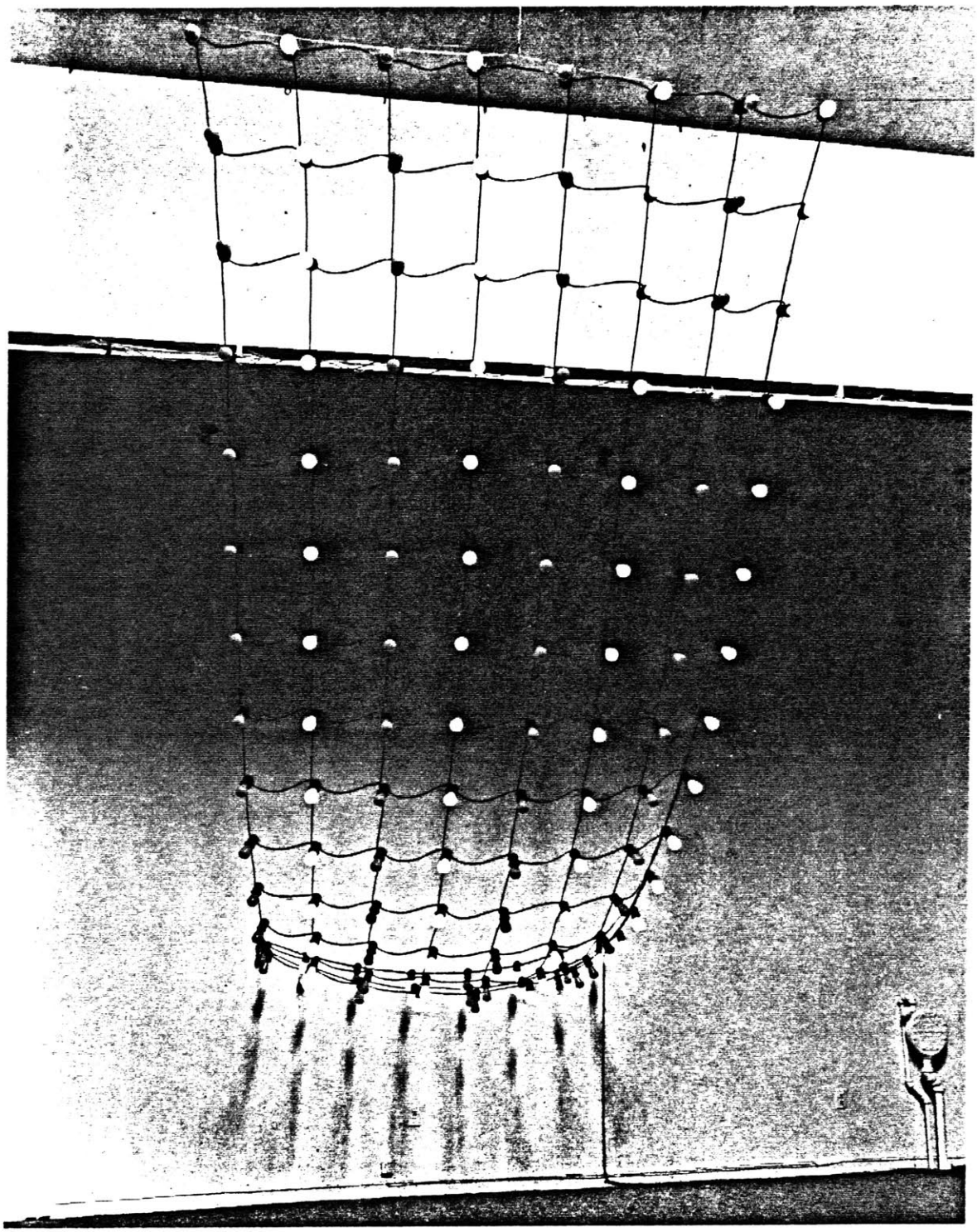


LIGHT GRID, installation number three photo #7

photo by Mark Strand



LIGHT GRID, installation number three photo #8

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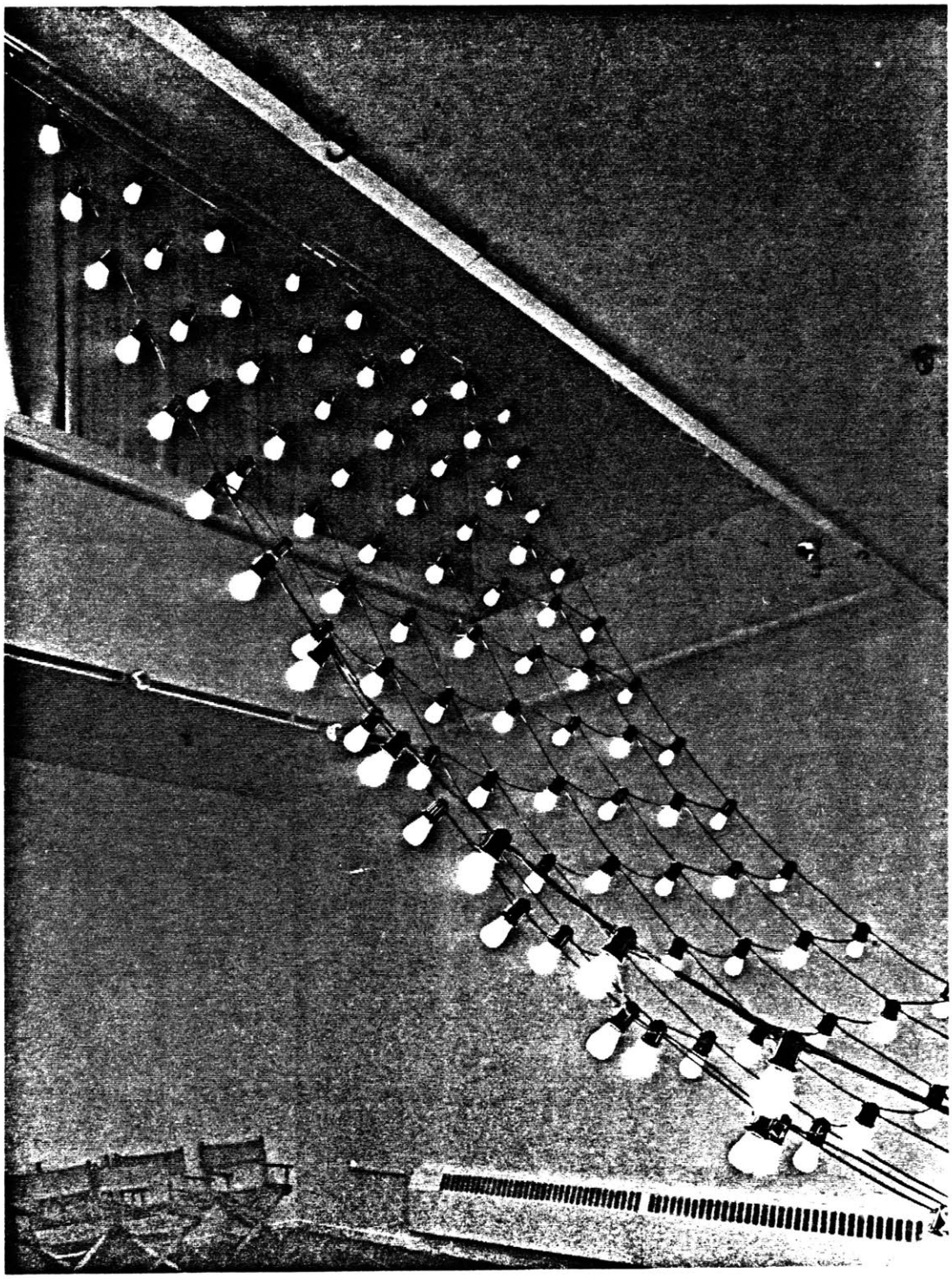

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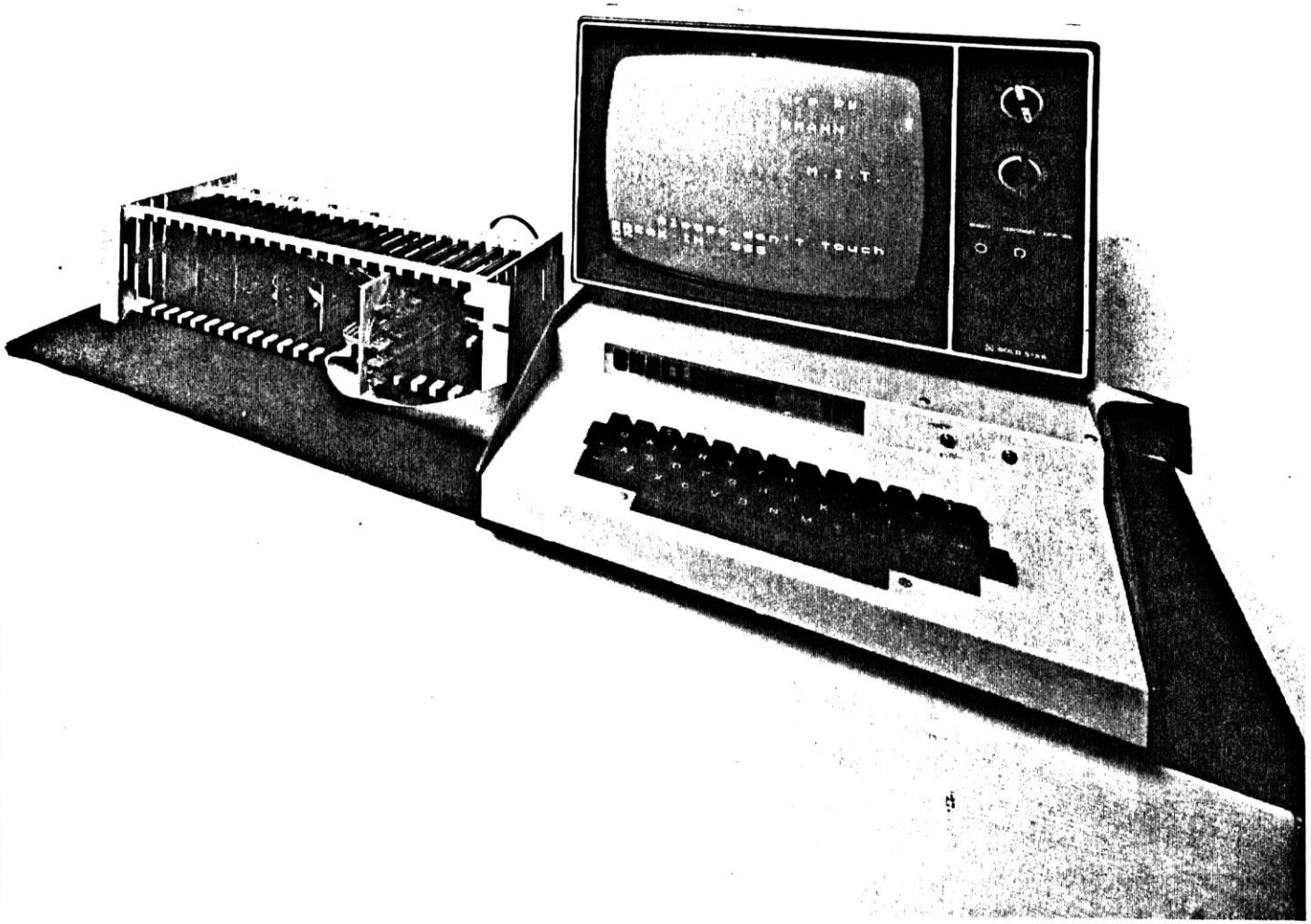
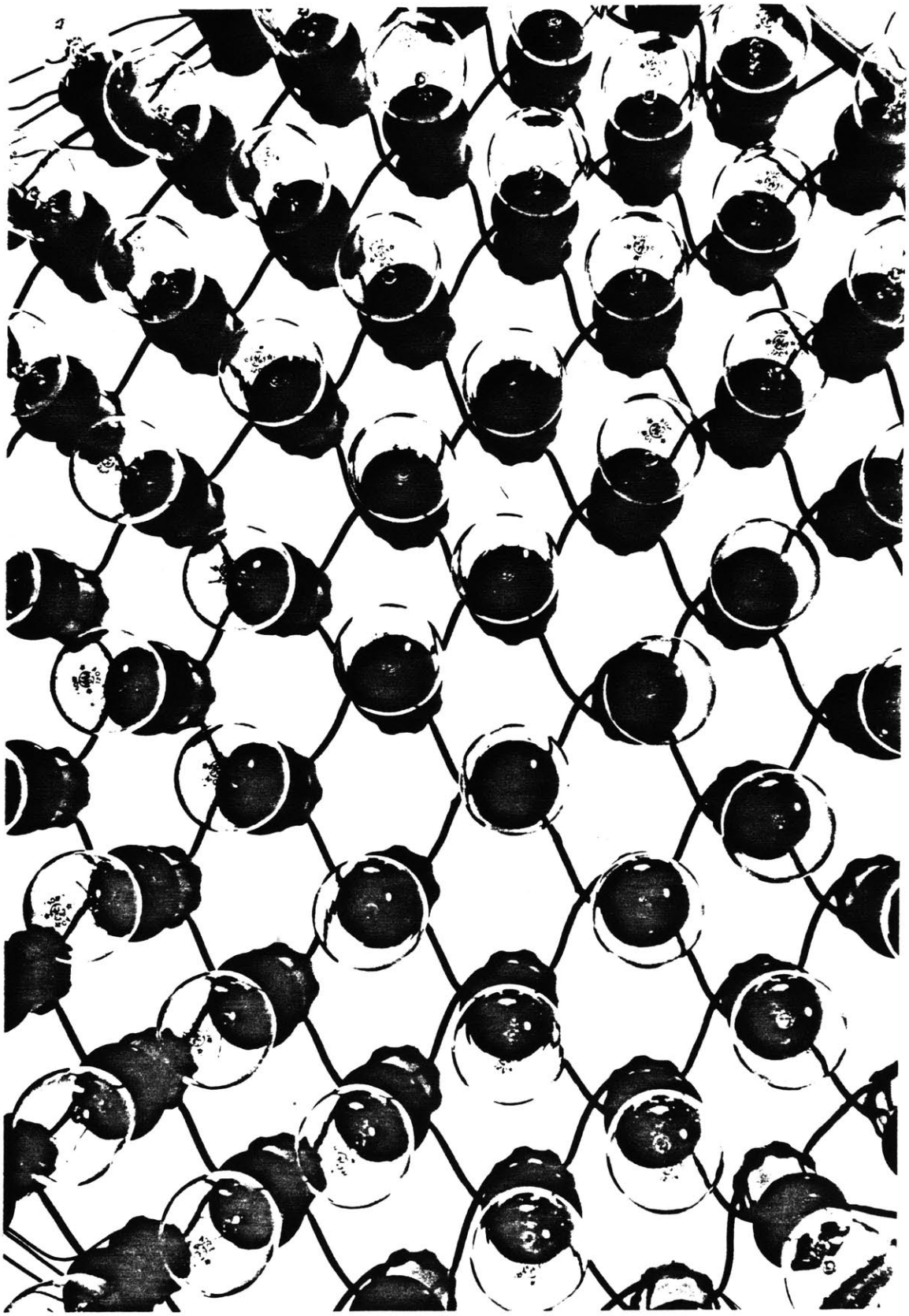


photo #10

the computer and interface for LIGHT GRID

photo by Mark Strand



FOOTNOTES

1. Kepes, Gyorgy, Catalog produced for opening of Center for Advanced Visual Studies, p. 27.

2. Sharp, Willoughby, "Luminism," Light/Motion/Space, (catalog), Howard Wise Gallery, New York, 1967, p. 4.

3. Lankeit, Klaus, (New Documentary Edition), The Blaue Reiter Almanac, edited by Wassily Kandinsky and Franz Mark, The Viking Press, New York, 1974, p. 131.

4. Strasfogel, Ian, "A Radical Vision," Opera News, January 1982, pp. 10-11.

5. Stein, Donna M., Thomas Wilfred: Lumia (catalog), A Retrospective Exhibition, The Corcoran Gallery of Art, Washington, D.C. 1971, p. 63.

6. Piene, Otto, Otto Piene (catalog), Retrospective Show in Kolnischen Kunstvereir, from 9.12.73 to 27.1.74, produced by Dr. Wulf Herzogenrath, Annette Piene, and Joseph Keller, Germany, 1973, p. 40.

7. Muller, Gregorie and Gorgoni, Gianfranco, The New Avant-Garde, Praeger, New York, 1972, p. 10.

8. Flavin, Dan, Dan Flavin Pink and Gold (catalog), The Museum of Contemporary Art, Chicago, Illinois, 1968, pp. 5-6.

9. Millin, Laura J., editor, Jim Turrell Four Light Installations (catalog), Center for Contemporary Art, Seattle, The Real Comet Press, Seattle, 1982, p. 11.

10. Kostelanetz, Richard, Moholy-Nagy, Praeger, New York, 1970, p. 151.

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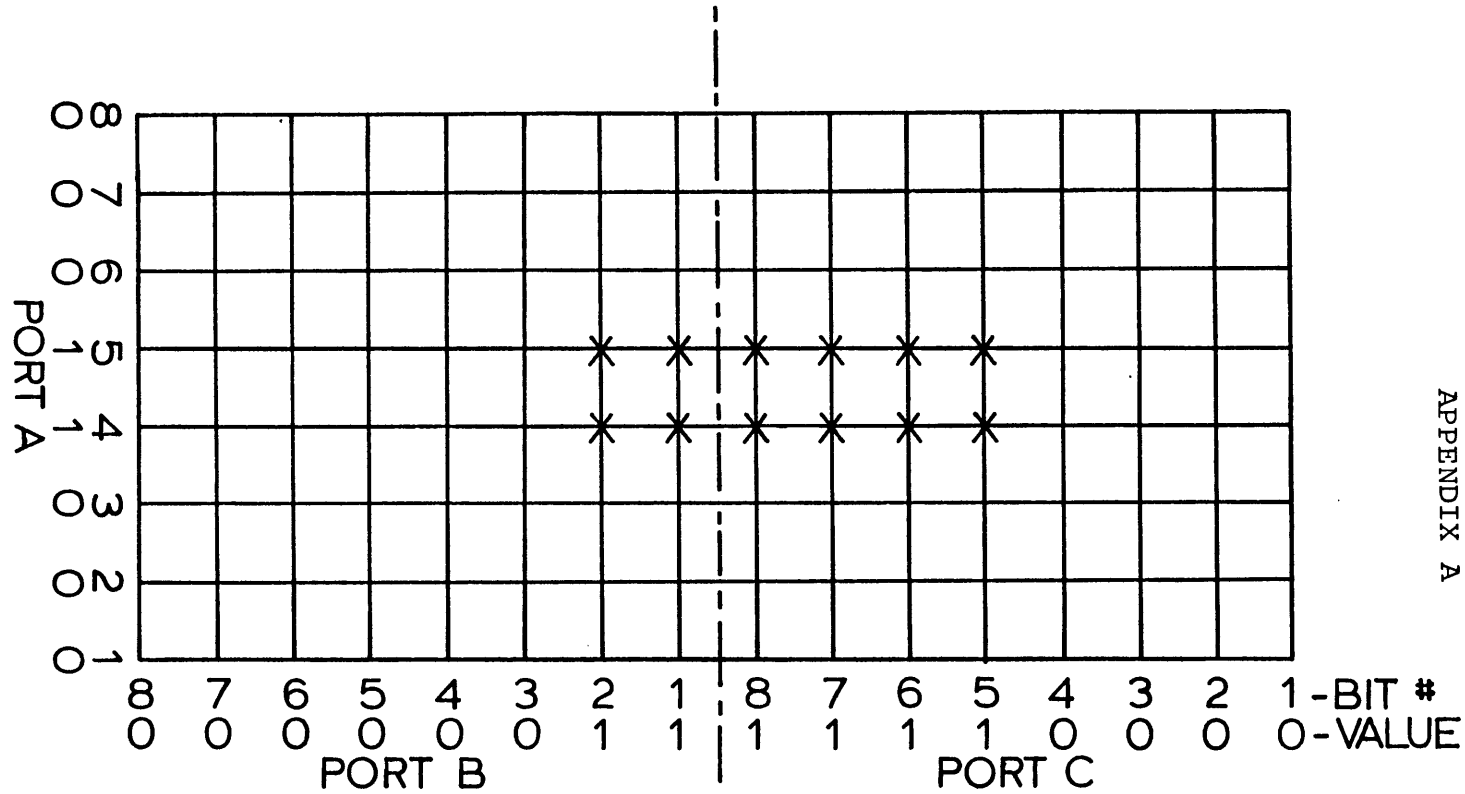
LIGHT GRID 8x16 MATRIX



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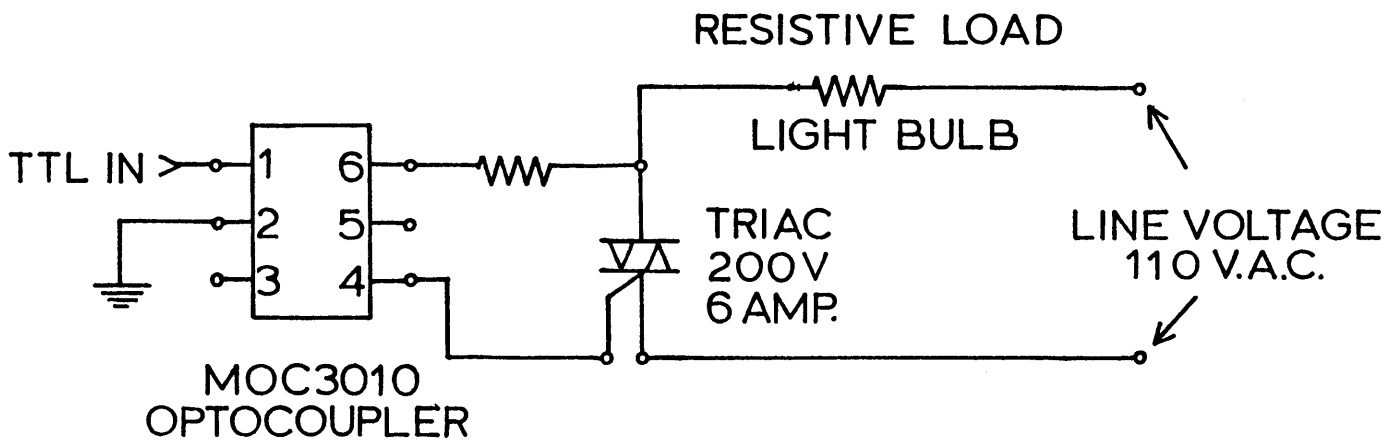
		00000000	=	0
		11111111	=	255

8 ROWS (A)
16 COLUMNS (B & C)



The optocoupler of this circuit protects the computer from the high voltage that is used to drive the grid. The Triac is a solid state switch which turns on the voltage to the rows or columns of the grid.

APPENDIX C

```
   5  REM THESIS INSTALLATION
  10  A=63233
  15  B=63234
  20  C=63235
  25  Q=INT(RND(1)*10)+1
  30  IF Q=1  THEN 100
  35  IF Q=2  THEN 200
  40  IF Q=3  THEN 300
  45  IF Q=4  THEN 400
  50  IF Q=5  THEN 700
  55  IF Q=6  THEN 800
  60  IF Q=7  THEN 900
  65  IF Q=8  THEN 1000
  70  IF Q=9  THEN 1200
  75  IF Q=10 THEN 1400
  80  IF Q>10 THEN 10
  85  :

1200  :
1205  X=255
1210  Y=128
1215  Z=0
1220  W=128
1225  :
1230  POKE A,X
1235  POKE B,Y
1240  POKE C,Z
1245  :
1250  FOR D=1 TO 50 : NEXT D
1255  :
1260  W=W/2
1265  Y=Y+W
1270  :
1275  IF Y>255 THEN 1300
1280  GOTO 1230
1285  :
1300  Y=255
1305  W=128
1310  Z=128
1315  :
1320  POKE A,X
1325  POKE B,Y
1330  POKE C,Z
1335  :
1340  FOR D=1 TO 50 : NEXT D
1345  :
1350  W=W/2
1355  Z=Z+W
1360  IF Z>255 THEN 10
1365  GOTO 1320
1370  :
```

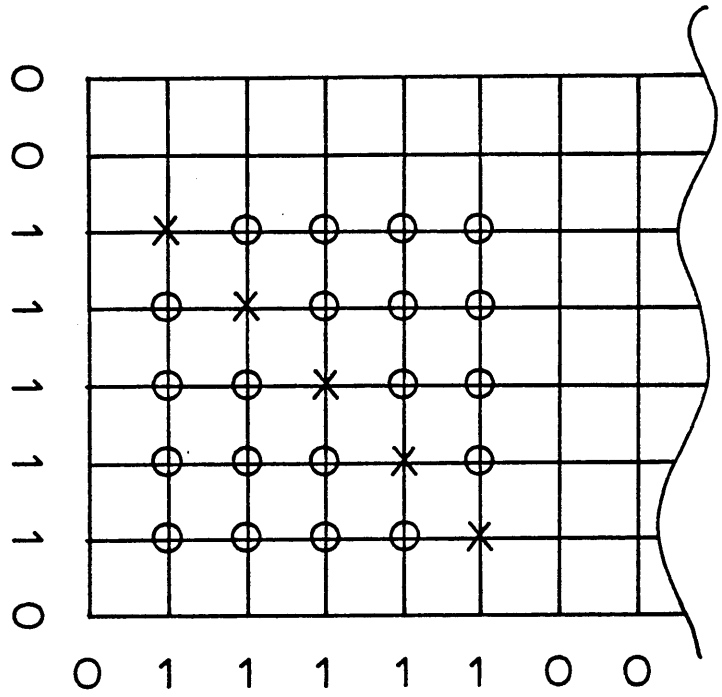
W	Y		DECIMAL		BINARY
			128	=	10000000
64 + 128		=	192	=	11000000
32 + 192		=	224	=	11100000
16 + 224		=	240	=	11110000
8 + 240		=	248	=	11111000
4 + 248		=	252	=	11111100
2 + 252		=	254	=	11111110
1 + 254		=	255	=	11111111
(Y + Y)			1	=	00000001
			2	=	00000010
			4	=	00000100
			8	=	00001000
			16	=	00010000
			32	=	00100000
			64	=	01000000
			128	=	10000000
(Y x 4)			192	=	11000000
			48	=	00110000
			12	=	00001100
			3	=	00000011

APPENDIX E

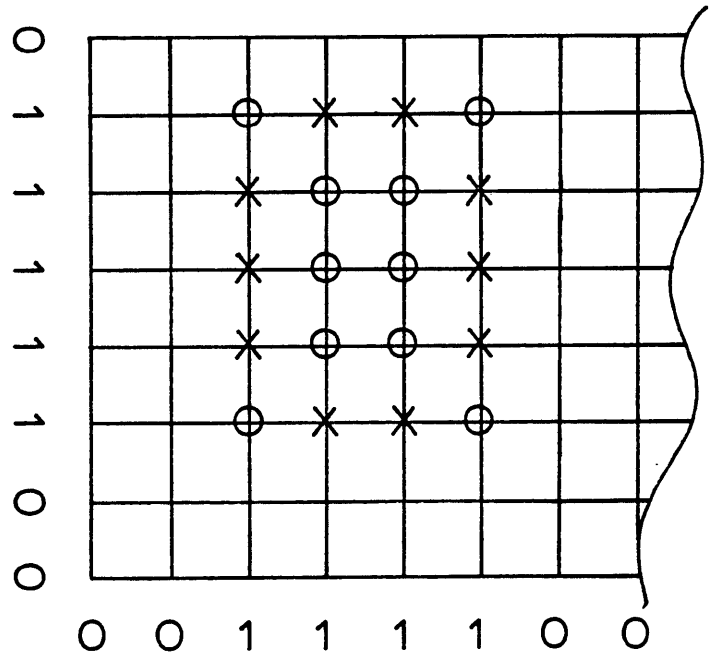
Program to convert binary character string to a decimal number and display it (BIN-DEC).

```
   90 REM DISPLAY DECIMAL VALUE
  100 PRINT"ENTER BINARY NO."
  105 INPUT N$
  110 T1$=N$
  120 GOSUB1100
  130 IFT<OTHEN100
  140 PRINTN$;"BINARI IS"
  145 PRINT T; "DECIMAL"
  150 GOTO100
  430 R$=""
  440 GOSUB2000
  500 PRINT"DECIMAL";R;"IS"
  510 PRINT "BINARY ";R&
  520 PRINT
  530 GOTO100
 1100 REM CONVERT BIN. CHAR. STRING TO DEC. NO.
 1105 T=0
 1110 L1=LEN(T1$)
 1120 FORI1=1TOL1
 1125 T=T*2
 1130 IFMID$(T1$,I1,1)="1"THENT=T+1:GOTO1150
 1140 IFMID$(TI$,I1,1)<>"0"THENT=-1:RETURN
 1150 NEXTI1
 1160 RETURN
 2000 REM CONVERT NO. TO BINARY CHARACTER STRING
 2010 C$(0)="0":C$(1)="1"
 2020 R2=R
 2030 T2=INT(R2/2)
 2040 S=R2-T2*2
 2050 R$=C$(S)+R$
 2060 R2=T2
 2065 IF LEN(R$)>16THENR$=RIGHT$(R$,LEN(N$)):RETURN
 2070 IFT2<>0THEN2030
 2080 RETURN
```

APPENDIX F



DIAGONAL LINE



CIRCLE or
OPEN SHAPE