Newton Harrison has taught since 1965 in the art department at the University of California, San Diego. In the fall of 1967 he described to his painting class a notion he had been pursuing of rendering colored light as form, in a way not possible with ordinary neon tubing or incandescent lights. One member of his class, Keith Carter, a former physics student, responded by showing Harrison a glow discharge display in a bell jar in one of the physics laboratories. A glow discharge is the ionization or breakdown of gas (helium, neon, argon, etc.) into a diffuse arc by means of a plasma or fluid which conducts electricity. A simple form of a glow discharge is neon light, but because the ionization activity takes place within the constricted, narrow area of a tube, the various types of phenomena which occur during ionization are not visible. Glow discharge is a commonly known physical phenomenon, used by scientists for years in various kinds of research and experimentation, for example as a method of converting thermal energy into electricity.

Harrison was intrigued by the possibilities of artistic expression inherent in this phenomenon. The colors that can be made to appear range from subdued pinks to bright orange to blues and greens. Under varying conditions one can observe that the light takes on numerous distinct shapes: arcs, lightning streaks, platelets, bubbles, or shafts of color. The colors and forms depend on three variables: amount of vacuum in the chamber; type and amount of gas used (primarily helium, neon, argon, carbon dioxide and nitrogen); amount and type of electricity (either AC or DC). Harrison set up a display in his studio with a primitive piece of equipment and experimented with it for some time, attempting to determine the capability of a glow discharge as a workable art medium.

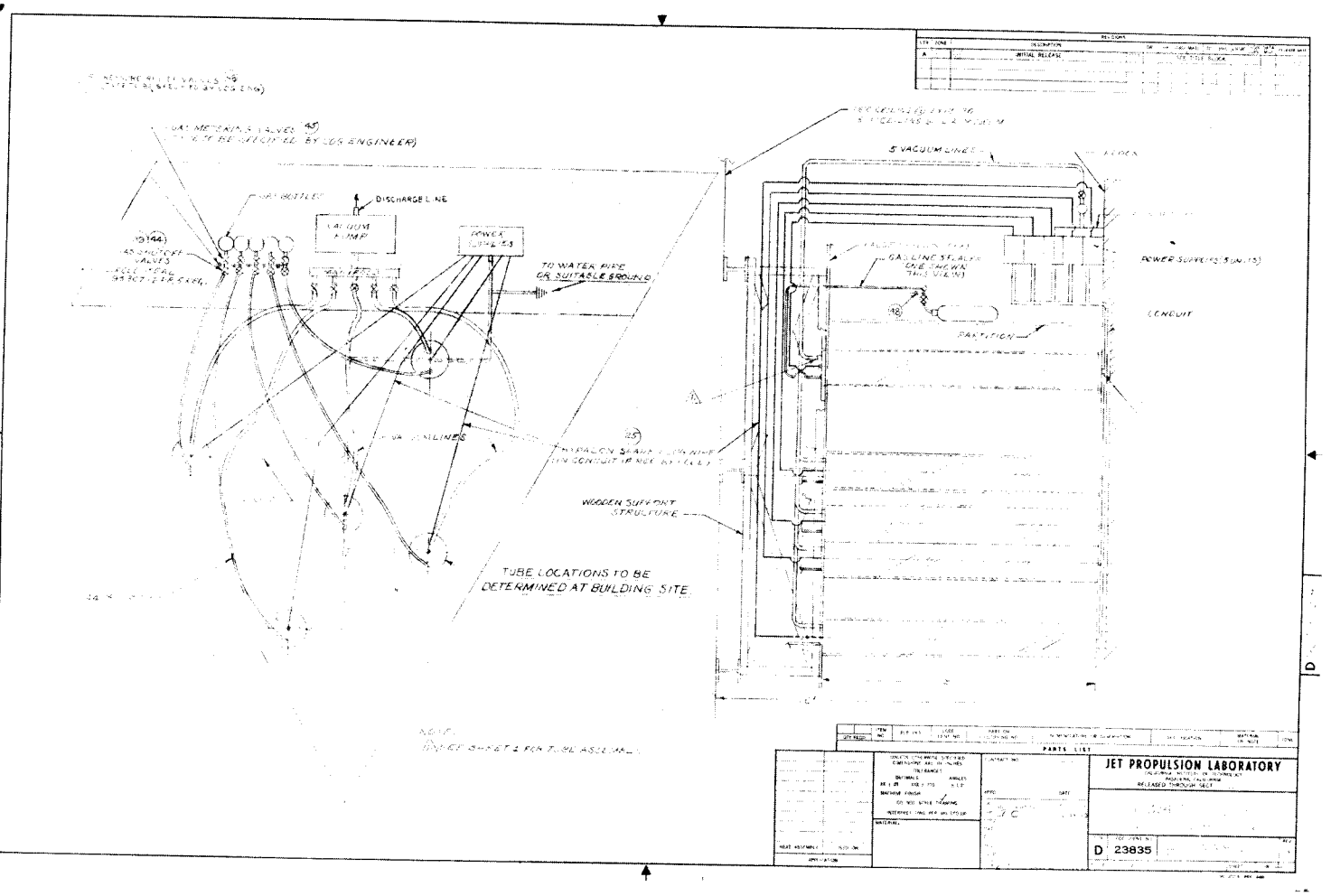
At about this time we learned of Harrison's interest in A & T from his colleague David Antin at UCSD, and in April, 1969, Hal Glicksman visited his studio and saw the experimental set-up of a glow discharge in the three foot bell jar. With Antin's encouragement, Harrison submitted to us a project proposal titled "Light as color in space," which states in part,

> Our normal associations with light are that it defines or illuminates a pre-existing form by its presence or absence. This is true of conventional sculpture. It is also true of every light work I have ever seen. Even searchlight sculpture in defining giant space volumes must be considered as drawing on a grand scale. In this work that I propose light as color is the form. It defines itself. It needs no object. A plasma is light unadulterated.

After studying the proposal and checking through our roster of contracted corporations, we decided to send a copy of Newton's proposal to Dr. Robert Meghreblian, Deputy Assistant Director of Jet Propulsion Laboratory. (We had toured JPL with James Byars, Richard Serra, Mark di Suvero and Michael Asher but had been unsuccessful in placing any of them at this extraordinary research facility.) In July, we visited JPL to discuss further the feasibility of a collaboration between the company and Harrison. The artist met first with Dr. Meghreblian, who was impressed by the amount of research Newton had already accomplished and by his ability to converse intelligently about the scientific aspects of the problems involved. Meghreblian assigned Donald Bartz, Manager of Propulsion Research and Advanced Concepts Section, to work with Harrison. That same afternoon Harrison had a lengthy discussion with Bartz, Ray Goldstein and several other plasma experts. This meeting evolved into a productive problem solving situation, establishing a rapport between Newton and the JPL staff which existed throughout the collaboration. At that preliminary session they talked of revising the shape of the gas container from Newton's original concept of a six by nine foot cube to a cylindrical shape, thereby eliminating the necessity for several glued seams and strengthening the vacuum chamber. The size of the cylinder remained flexible, to be determined at a later date along with other esthetic and technical considerations. In addition they discussed the problem of removing or disguising the electrical wire running from top to bottom of the chamber. Various tentative solutions emerged but nothing definite was decided. Bartz suggested that a JPL design team be assigned to investigate these structural and technical problems and to project a cost estimate.

In the next few weeks Newton met with Bartz and the engineering team on several occasions from which eventually emerged the final design for the gas containers: they decided to make five identical columns, each of one inch thick plexiglass, eighteen inches in diameter and twelve feet high, or from floor to ceiling. This solution eiliminated the need for visible exterior wiring since the electrodes would be housed in end-plates at top and bottom and all support mechanisms would reside in floor and ceiling. The cost estimates for building the five units were so high that JPL, because of its connection with NASA as a non-profit space research organization, decided it would not completely finance their construction. JPL agreed to supply technician time to run all necessary tests on the tubes, to furnish additional engineering designs [1], and to make available on a loan basis any miscellaneous equipment they could spare, but they would not fabricate the plexiglass units or cover the cost of the electrical fixtures.

The project at this point became more than a one-to-one collaboration, and in accordance with this special situation, Newton agreed to apply some grant money he had acquired from UCSD to design and construct the power



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supplies (transformers and variacs) and gas injection system. For this part of the project he pressed into service Keith Carter who, from his previous experience with the glow discharge, had the knowledge to carry it through, using the metal and electrical shop facilities at UCSD. Fabrication of five plexiglass tubes was done by a local plastics firm and paid for by the Museum's A & T "materials" budget.

By August work had begun on all three of these fronts, and by this time we were considering Harrison's sculptures as likely for the Expo show. For a time, the design of the installation became a collaborative effort involving all of us. In several meetings with Newton we discussed various possibilities, including that of a total environment using liquid crystals in some kind of configuration with the tubes. An idea Newton had had in mind for the São Paulo Bienale was to make a liquid crystal pathway which would change colors under heat and pressure from the passing crowds. He now proposed using liquid crystals in conjunction with the tubes, perhaps as a path leading to the cluster of five light columns. We encouraged him to extend this notion further, suggesting an arrangement of liquid crystals in a stepped formation, ending at the columns. An alternative solution was to

design a corridor with the wall surfaces covered by the crystals and heat lamps spaced along the floor with an electric-eye device triggered by the passing crowds who, by their movement, would control the color modulations in the liquid crystals.

However after considering all of these notions, Harrison decided that the tubes would have greater impact if they were displayed by themselves, dispersed in a carefully worked out configuration in a room devoid of ambient light. The spectators would pass through the grouping of columns, actually coming into contact with them and possibly altering the glow discharge by interfering with the electrical field.

In October, after delays in fabrication, testing began on the tubes at JPL. Several technicians, primarily Ray Goldstein [2], first ran tests designed to examine various kinds of stress on the structural strength of the tubes, and the results showed a safety factor of 7.0 above the expected loads. (Safety factors of 4.0 and 5.0 are typical in engineering design.) Harrison and Carter began experimenting with the phenomenon itself, manipulating its three elements—the gases, electricity (in the form of a heavy duty neon sign transformer) and a vacuum pump. One of the first things they discovered was that the range of visible effects in a twelve foot column was, as could be expected, much greater than in a three foot bell jar. Harrison gradually became able to control a wide range of color-shapes and configurations which became his formal vocabulary.

His initial conception had included certain key prerequisites which he later outlined in an interview:

> I wanted this piece to have a participatory quality. I found that by touching the tube, a human being could alter what was going on in there because inside those chambers are electro-magnetic fields and a human being is a resistor, I guess, and so his field interferes with what goes on there or affects it. So now I had at least one element that I could call participatory about it.
>
> The next thing I wanted was a certain kind of configuration. If you have just a beautiful glowing tube, the metaphorical possibilities are limited, but the minute lightning arcs start occuring, you have a frankly frightening object.

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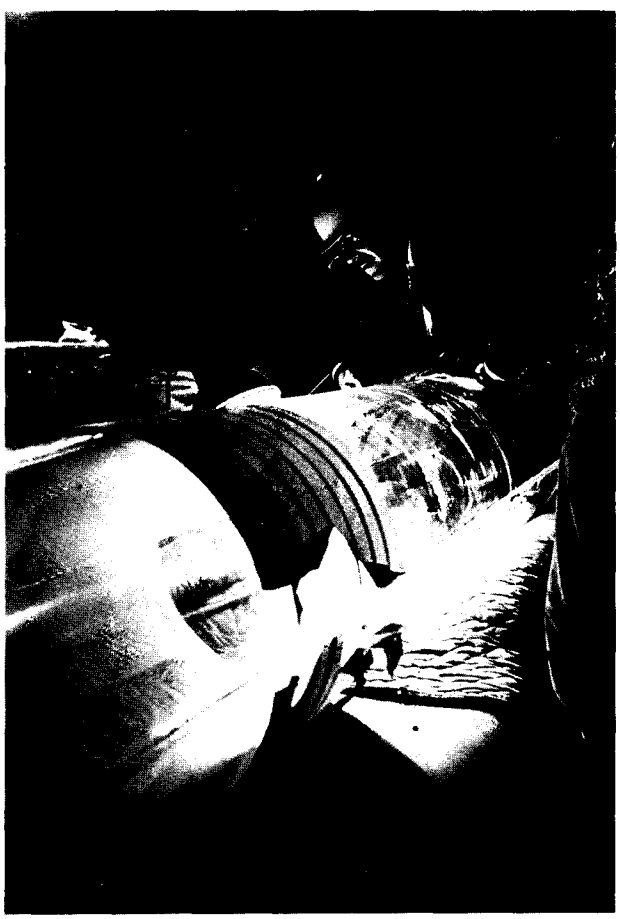
> I wanted them to be simultaneously beautiful and scary and eerie and contemplative . . . .

After the tubes had been running constantly for about fifty hours, the plastic surfaces began to cloud over, obscuring the configurations and movement of light. Because the glow discharge is used only intermittently for scientific purposes, such chambers in the past rarely developed this defect, and the technicians were not prepared for this contingency. A spectralanalysis of the clouding indicated that the ion bombardment was cracking the surface of the plexiglass. Keith Carter discovered, quite by accident, a possible solution. Applying a silicone grease to the interior surface of the cylinder would, he found, protect against ion bombardment and the consequent obscuring effect.

In December the plexiglass columns and all miscellaneous equipment were shipped to Osaka. Before the tubes were en unpacked, the Japanese Safety Commission for the World's Fair refused to allow them to be installed, fearing that the vacuum chamber and gas injection might implode or that crowds touching the tubes might receive an electrical shock. MT made emergency calls to us at the Museum, and we in turn contacted Bartz and Meghreblian requesting a letter explaining the extensive safety precautions taken by the JPL staff. Bartz wrote a statement describing the electrical design of the tubes, concluding with the statement that "touching the surface of these tubes is no more dangerous than touching the surface of an ordinary fluorescent lamp." The Japanese authorities were persuaded to allow the installation to proceed.

At this point another problem arose. On one of the tubes, which had undergone the most experimentation and testing at JPL, a solution had been applied which cleaned the interior surface, but it also caused small fissures and cracks in the plexiglass which did not appear until after transit to Japan, where Harrison discovered them. [3, 4] With the opening deadline rapidly approaching, this tube was sent to a local Japnaese plastics firm in a last minute attempt to polish out these imperfections.

Before coming to Japan, Newton had spent several weeks working out a placement scheme for the tubes. His intention was to avoid a geometric configuration and



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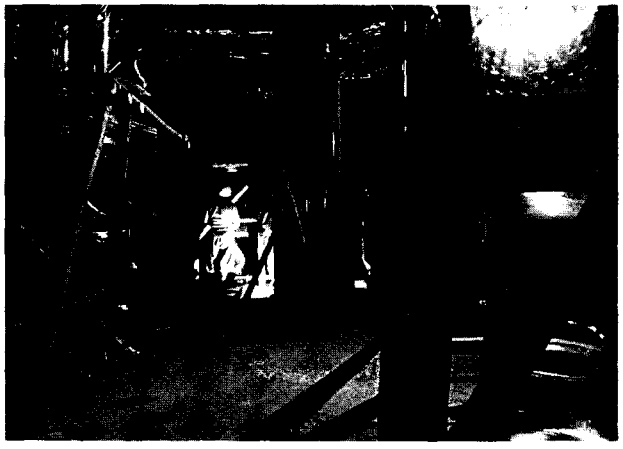
to arrive at random appearing arrangement. With the programming assistance of Jeff Raskin at the UCSD computer center, he had attempted to achieve a random disposition but abandoned this method because, in his own words, "every time I obeyed the computer and placed tubes randomly the results looked calculated." He then used full-scale cardboard models and experimented with them in the UCSD art gallery, marking off the size and shape of his area in the Pavilion. He went on to say.

> I ended up choosing an array that had two columns very far apart. By having two as far apart as possible, I was able to make one column brighter and one column slightly dimmer, and so when you stood at one end, the space expanded or compressed, depending upon which end you were looking at, by virtue of light constancy. I felt it was very important that the columns, exclusive of the light, energize the space. I also put two columns very close to one another so that a sense of surround could happen, with one uncomfortably close to the wall so that a little pressure to the wall would tie the whole array to the room. [5]

Once the tubes and vacuum pumps were in place, the ceiling to support the vacuum pumps completed, and the scaffolding removed, Harrison was finally ready to determine the composition of each chamber. Months of research, design and testing were merely preparatory steps to the process of actually creating the piece. Throughout the preceding eighteen months, both with the bell jar display in his studio and with the actual tubes at JPL, Newton had familiarized himself with virtually every relationship of color, shape, and movement of which the system was capable. He had purposely avoided deciding beforehand which gases would go in



each tube, so that he could manipulate the numerous possibilities in the space itself. Newton later described how these final choices came about:

> . . . in the first tube I put an arc that was a mixture of helium and argon. The helium helped the arc path; the argon guaranteed that it would be a shocking pink-violet arc. We set it up so that the gas was injected in such a way that it started out as lightning, stayed lightning for about two minutes; became an arc; stayed the arc for about three minutes; became a glow—a total glow in the tube; . . . the glow started to break down into platelets and then I shot more gas in so it would be an arc again. This was a ten minute cycle. I found out strange things. I had originally

wanted to make it just lightning for five minutes. But lightning for five minutes was a bore. Lightning for four minutes was a bore. Lightning for a minute and a half to two minutes was exciting and lightning flipping into an arc every six minutes say, had a right sense to me. That flip was very important, and if I lengthened the time between the flips, it became less frightening. One of the things that is frightening is sudden and unexpected change, so I used sudden change as a time frame system.

We took the far tube and put nitrogen in it, and started to run it from arc, to mass, to space. Through the color changes that are involved in that, I started to play with timing. I found out that if two tubes arced at once, they gave each other away. But if they would arc at different times, we quadrupled the sudden change that was going on as well as strengthened the dialogue. So I programmed the nitrogen at the far end to go into an arc state only when the first piece was in lightning form or in mass form. If you

make a painting out of day-glow colors exclusively, they cancel each other out. They have an acidity in common that makes you tire of them quickly. I found out that all the gas colors also have a certain acidity, a low-key brilliance in common. The difficulty was to cancel that sense of commonality in the gas. Keith, with great delicacy, resolved the critical timing problem. I chose in one tube to use neon

which is orange-red and in another helium which is green and white. Then I had one tube left and after playing with it, introduced CO_2 to it. It was bluish-white, and as a color it talked a bit to the lightning, and argued a bit with the rest of them, but it made strange platelets that were very narrow and then turned into bubbles. I found out that when you touched those bubbles, they were responsive to you too; you could actually raise or lower a bubble of light . . . .

I was involved in creating a friction. The cylinders look very organized; they are very contained; they are very sedate. I wanted to create a friction between the neatness and the elegance of the cylinders and the sensation of the sudden release of more power than you had ever seen before in one place. When that floppy arc happens, you cope with that. The eye tells you everything is contained and safe; your experience says I doubt it. It's the friction between those two responses that I was interested in, rather than either response. The whole piece has that kind of an attitude in it.

When Newton had finished programming the cycle, the group of sculptures suddenly came together as an esthetic entity. It was an exciting moment. The element of timing is the critical factor, as Harrison said:

> The cycles run from ten minutes to forty-five minutes, and to really see how the thing works, you have to spend about ten hours with it, but nonetheless, you could know it in a non-rational way, feel it, in about two or three minutes, and that was a very tough problem which conditioned how fast I made the spaces grow. For instance, if the spaces grow too fast, then they look tricky, but if they grow slowly, it's too slow to see but it's suddenly there anyway. I like the idea of playing with slow and fast changes and transformations. There is a much slower than heartbeat change, and then there are abrupt changes; the work becomes a study of small differences and changes.

He also described some of the specific intentions he had. An interesting example was a color configuration, in one of the tubes—a rose-white hue—which hovers on the top and bottom with an empty space in the middle. Newton explained this as,

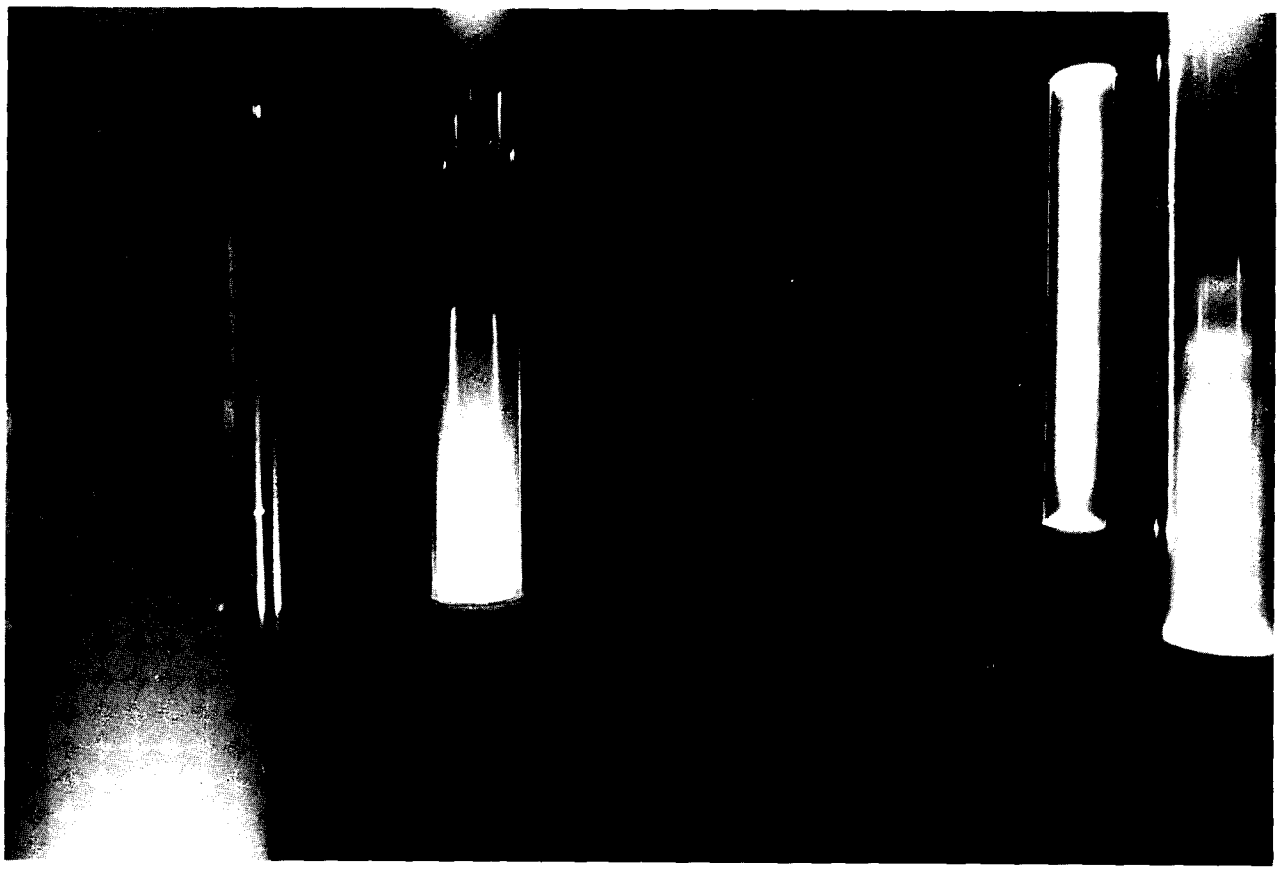
> . . . just what Rothko was dreaming about. I knew what he was doing . . . . He was trying to make paint do what paint could never do, although he got his work to cast a light. The far tube to the right I really made a sort of private homage to Rothko. I made a very specific reference to him. If you looked at the shape on the top, it was a Rothko type shape, a Rothko color shape, a Rothko intensity shape and it was surrounded by a dark field. This was my way of acknowledging a man whom I thought was involved in a kind of magnificent and very lonely vision.

Newton also described a further fantasy about the work:

> . . . The variables in it were sufficiently simple so that we could use one of the brainwave converters and once a person had played it with a control panel, he could undergo further transformation and work the thing by alpha waves alone. At that point, you could call in storms by your own mental activity. I would like the work to be such that a person could be so familiar with the keyboard that he could then put the cap on and experience a whole other kind of control and activity. This kind of experience might be interesting scientifically. Until now we've been working with state-of-the-art technology, and one shouldn't see these works as 'science.' It's really engineering.

In retrospect it was the opinion both of Newton and of the JPL staff that although the project was perfectly suited to the laboratory's capability, the collaboration

itself—interaction between the artist and the scientists—was not as extensive as it might have been. Dr. Meghreblian commented that one of JPL's reasons for participating in A & T was to establish a staff interaction with an artist, but that this objective was only partially realized because executing the project involved so few personnel. Those individuals, however, did make a significant contribution, specifically in the design and testing of the chambers. But because of JPL's financial limitations, Newton had to rely on sources outside the host company and consequently the real collaboration took place between him and Keith Carter. Carter made a major innovative contribution in the design of the gas injection system and in working out the final timing sequence of the tubes.



Nevertheless, Newton's A & T experience was valuable in provoking changes in his attitude toward his work:

> My whole sense of priority has changed. Normally, artists have a fierce, one-pointed preoccupation with making a form of art, and end up censoring and cancelling anything that appears irrelevant. I find that attitude personally destructive. My own growth came as I tended to give up the designation of artist, giving permission to myself to be as diffuse as I choose or as focused as I choose. As a result I abandoned my studio about a year ago and have only been in it to assemble things. I no longer think in my studio. To be in a studio was to do painting and sculpture. As I abandoned the concept of myself as an artist, I began to think of myself as a problem solver instead. This was very much enhanced by my experiences at JPL . . . .
>
> What I've reached is something else; I'm now almost uninterested in offering single pieces of art. What I do comes out of interaction of all kinds. It might be interaction with something I have seen, but I find it's more productive to interact with human beings: they can talk back . . . . I have ceased making art by myself. As an activity I find it uninteresting, and I am appalled by the isolation that surrounds the artist's approach to his work. So many people find it natural and inevitable. I surely don't.
>
> The real learning experience in this multiplex collaboration was my own development of a way to admit people into my process immediately past intuition rather than at the much later point when formalization takes place. I am now experimenting with executing works with people during the intuitive state or even in advance of it and in search of it.

A tangible extension of this conclusion has been developing in the months since the Expo show. While watching Newton operate the chambers in Japan, John Fork-

ner (the engineer on Whitman's environment) commented that the glow discharge phenomenon works in much the same way as the aurora borealis. Intrigued by this way of looking at the glow discharge piece, Newton conceived of making an artificial aurora borealis and has since been pursuing the problem, trying to resolve the logistics of its execution. It would involve projecting a rocket into the ionosphere which, when fired, would activate the ions in much the same way that a plasma functions in a glow discharge, creating a similar effect on a grandoise scale. Newton met with Dr. Feynman, who agreed to attempt to procure small rockets and permission to use a launching site through his contacts at NASA. It remains to be seen if these efforts will be realized.

Gail R. Scott

Erich Hartmann
Born Munich, 1927
Resident New York City

The photographer Erich Hartmann saw MT in New York in December, 1968, and wrote to us later that month:

> Since I saw you I have speculated and daydreamed pleasantly and repeatedly on which corporation would interest me and what sort of work within it I would propose. But although this is fun, it is finally self-defeating. It cannot help but sound like a sales talk for myself and even worse, it attempts to make predictable what should not be predictable if it is truly to fulfill the purposes of the project. Ergo, no concrete proposals from me.
>
> Instead, I want to give you the state of mind, the attitude, with which I would approach this project regardless of the industry, the products, the people, the underlying ideas involved. I would first of all attempt to *sense* who and what they are, what they make and how they make it, their underlying principles of concept and design and manufacture. I would want to do this with all my senses, without preconception of knowledge or experience, but using instinct and intuition. I would want to soak up the place and the people and the environment until I were full like a sponge, hearing conversations reverberate in the mind's ear and seeing previously seen sights in the mind's eye long afterwards. Only then would I begin to ask of myself and of others the questions which signal the entry of intellect and of the desire and the need to organize experience into something meaningful and expressible and understandable.
>
> Most important of all, during all of such a project, I would intend to address myself on every level of perception possible to the meaning of the project itself, Art and Technology, to the attempt and the effort to fuse the two entities into an expression of their relatedness. My belief is best expressed in a sonnet by Francis Thompson: 'All things, Near or Far, Hiddenly, to each other linked are . . . '
>
> What this frame of mind together with experience and skills, plus the stimulation of the host environment, would yield for the 1970 exhibition I don't know and cannot possibly foretell. Perhaps it would be photographic or in some ways related to photography, perhaps not. From my core as a photographer I have ventured into other fields, not always related to photography, such as graphic and conceptual design, a personal blending of words and images, into the design of three-dimensional structures and objects to convey the feeling and sometimes even the meaning of complex technological ideas like programming for computers.