Article: Maintaining high relative humidity with active and passive systems in large exhibition cases
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Source: *Objects Specialty Group Postprints, Volume One, 1991*
Pages: 92-101
Compiler: Pamela Hatchfield

MAINTAINING HIGH RELATIVE HUMIDITY WITH ACTIVE AND PASSIVE SYSTEMS IN LARGE EXHIBITION CASES

Arthur Beale

Like many older museums in the United States built at the beginning of this century, the Museum of Fine Arts, Boston has had a difficult time retrofitting its buildings with climate control that meets with current standards for collections care. Even in its West Wing special exhibition galleries designed by I. M. Pei and built in 1981, HVAC mechanicals and control are now out of date and have trouble coping with block buster shows with big crowds at certain seasons of the year. While experience and studies done at the MFA, Boston and elsewhere have clearly shown that new construction with state-of-the-art climate control is often considerably cheaper than renovation of many existing structures and systems, other factors, such as location, often dictate the more costly solution. Because of the astronomical costs associated with these conversions, only about 40% of MFA spaces are truly climate controlled with perhaps another 20% served by some form of air-conditioning.

As a result of this situation, MFA conservators starting with William Young as early as the 1930's have developed both active and passive microclimate systems for both large and small exhibition cases in the museum. Recently in the process of building a new case for a particularly humidity sensitive Egyptian limestone sculpture, we discovered the old case contained a formerly active device built by Young in 1939 to lower relative humidity in a confined space. This "artificial atmosphere" was designed to keep humidity steady and low, at or below 30% RH, by pulling air with a small electric pump through a box full of moisture absorbing calcium chloride. A cylindrical drum in the system served as a miniature "gasometer" designed to equalize atmospheric pressure in the airtight case.[1]

The new system designed for this same Egyptian sculpture in 1991 is "passive" in nature as it has no moving parts driven by electricity. The old system was "active" by this definition, but manual in the sense that the electric air pump was not connected to a sensor. Someone had to look at a hygrometer gauge inside the case and flip a switch when the humidity began to get above 30% RH.

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[1] An interesting paper given at the 1988 IIC Congress in Kyoto, Japan, The Conservation of Far Eastern Art, entitled "Conservation and Exhibition of Cultural Property in the Natural Environment in the Far East" by Kenzo Toishi and Masako Koyano, pp 90-94 describes the use of an airbag as a "pressure dissipating" unit to help extend the life of conditioned silica gel in a tightly closed space.

The new system represents the type now widely used throughout the MFA. It also requires monitoring a small hygrometer dial to read relative humidity and then removing and reconditioning the silica gel used inside the case when the relative humidity climbs unacceptably above or below the desired level. Since the main topic of this paper centers on systems for large exhibition cases, I will not go into too much detail about our smaller cases except where the materials and hardware used have applicability to most any size case.

The first design criterion we have for all these cases is that we have access to the silica gel or machinery used to control relative humidity without having to move or disturb the objects housed in the cases. The design assumes that we are aiming to control relative humidity while allowing some temperature variations. The Museum is heated in the winter, but none of the areas where microclimate cases exist are air-conditioned (cooled) in the summer. I mention this because it has become clear to us through our research and experience that while air-cooling for visitor comfort often leads to drastic unacceptable shifts in relative humidity for the collections, active systems such as the Kennedy-Trimnel Relative Humidity Control Module, function more effectively within fairly stable temperature ranges. This will be discussed in greater detail later on in this paper.

Because these are closed spaces, another criterion used in case design is that all construction materials must be as inert as possible or sealed to mitigate against the outgassing of organic acids, formaldehyde and other aldehydes. The seals, achieved with gaskets in passive systems, must be as tight as possible to minimize the frequency of adjustments needed to keep silica gels at the desired performance level. To achieve this degree of tightness in case construction requires careful manufacture, augmented with glued joints and caulking compounds. For cost, speed, and ease of construction, our museum, like most, uses wooden case construction. Although some decorative elements may be constructed of other woods, the basic and interior elements of the majority of our cases are made of M.D.O. (Medium Density Overlay) sign board. This is a fir plywood bonded with type 1 exterior adhesive, phenol-formaldehyde, and faced with kraft paper to form a smooth surface.[2] The case sections are generally nailed and glued together, preferably with an acrylic emulsion adhesive, and sealed with three coats of Camger moisture-borne polyurethane Polyglaze 1-146 or with Sancure 878. These products

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[2] Although our "Oddy test" experiments have shown this plywood to be one of the safest of the ones we have tested from the point of view of volatile acid emissions, the laboratory at the Walters Art Gallery has not reported good results with this product in their experiments (see "Fixtures at an Exhibition Part I. Wood Product and Sealant Testing" by Donna Strahan in this publication). We plan to conduct more refined experiments in the near future to test the safety of this product. A recent review of our test samples suggests that different results are obtained from both M.D.O. and Medex™ depending on the age of the sample tested. In short, newly manufactured samples of either material seem to outgas products that resulting lead corrosion.

are often cut with water.[3] Often latex paints are then used on exterior surfaces as a final finish. Joint sealing or caulking in interior surfaces is done with Dow Corning No. 3145, RTV adhesive/sealant.[4] This product was chosen because it does not emit acetic acid while curing. A minimum drying time of two to four weeks is allowed for these sealing and caulking products. Where plexiglass vitrines fit into wooden grooves on bases or on the back of silica gel compartment access doors, we generally make our own gaskets out of 1/8" pcf2A black polyethylene foam (Volara™ Type A)[5] cut into strips and adhered with 3M 1/2" wide, double sided, self-adhesive tape No. 413 (Part No. 03764).

Other materials that may outgas harmful vapors are fabrics or decorative paint that may be used inside a case. These materials are, therefore, also tested before use, and fabric routinely washed in warm water to remove any excess finish that may emit formaldehyde.

In developing individual case designs, additional criteria applied are to minimize the internal space to be controlled, especially by passive means, and to maximize the areas of air exchange between the silica gel compartment and the enclosed exhibit space. In general our silica gel compartments are made no larger than is necessary to contain and easily remove 3" diameter module canisters or 2" high aluminum trays. The rule of thumb used in our calculations for the amount of silica gel necessary, dependant upon the efficiency of the silica gel, is 5 to 10 kilograms (10 to 20 pounds) per cubic meter of air being conditioned. Alternatively, 150 grams per cubic foot translates into 5.35 kilograms per cubic meter.

In general, we allow air exchange between the silica gel compartment and the exhibit part of the case in one of three ways; 1 1/2" to 2" holes spaced every 6" to 9" on center drilled in decks and covered with fabric, three visible 1/2" wide parallel

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[3] Camger Polyglaze 1-146 is available from Camger Chemical Co., 364 Main Street, Norfolk, MA 02056, tel. 508/528-5287. This product was produced for us using Sancure number 878 as a base material as a result of research conducted by Pamela Hatchfield in 1989. In discussions with the Museum's painters, as they report their experiences and conversations with the manufacturer, Camger Polyglaze 1-146 has been designed for spray application. Polyglaze 1-146-10 is a flat finish and 1-146-50 is a satin finish. It is normally cut with water, two parts polyglaze 1-146 to one part water. In a brush application on a large surface it is very hard to use, because of the speed with which it dries. Our painters' preference currently is to use the basic resin in Polyglaze 1-146, Sancure number 878. They report that even when diluted ten parts Sancure to nine parts water, as is normally done, its drying time is slow enough to get both good saturation and reasonable leveling. Sancure, which is manufactured by Sanncor Industries, Inc., 300 Whitney Street, P.O. Box 703 Leominster, MA 01453, tel. 508/537-4748, seems to be available through some local paint suppliers. We buy it from Dexter Brothers, Co., 86 Los Angeles Street, Newton, MA 02158, tel. 617/332-3434.

[4] Information available from Dow Corning Corporation, Midland, MI 48686-0994, tel. 517/496-6000.

[5] Available from Voltek, 100 Shepard Street, Lawrence, MA 01843, tel. 508/685-2557.

slots cut in the front of plywood decks, or by "floating" or raising a plywood deck with blocks 3/8" to 5/8" above the compartment for air exchange around all edges.[6]

The internal silica gel compartments are generally accessible through a series of two doors. In a free-standing pedestal, this door is hinged as part of a side panel and opened with a spring catch. Inside, one finds an open lower space for weighing or attaching the pedestal to a gallery floor and the upper silica gel compartment that is accessed by its own hinged or screw fastened door (Figure 1). Much larger wall cases, which sit on the floor have, snap-on panels in the bottom front of the cases with similar secondary compartment doors inside (Figure 2).

In cases which hang on a wall above the floor or free standing cases that have legs, the silica gel compartments are accessed directly from the bottom of the case by a hinged door. In some instances high performance "Arten Gel Modules"[7] (10" x 3" 100 micron porosity polyethylene canisters) have been successfully attached to the inside of these doors with electrical tiewraps made of plastic and stapled in place (Figure 3).

The system just described was developed for both large and smaller cases especially designed and built for the Museum's exhibit Ten Centuries of Courtly Splendor: Art Treasures from Japan. Although these objects were shown in climate controlled special exhibition galleries, the Japanese lenders required that all objects made of organic materials in the show be encased and maintained at 60% RH $\pm$2% while bronze and other metals be kept at a much lower relative humidity. Because these fragile polychrome wooden sculptures, lacquer ware, hanging scrolls and screens were being shown in our galleries during late fall in New England, and the show's visitorship was unpredictable, the Museum's engineers felt that they could not meet the tight environmental requirements of the lenders with the gallery HVAC system alone. The challenge then became to tightly control relative humidity inside some very large cases. The largest of these cases was constructed mostly of plywood modules approximately 3' deep, 6' wide and up to 10' tall. The modules were splined together to form up to 24' of unbroken interior width. This volume of exhibit space plus the volume of the silica gel compartments underneath totaled 800 cubic feet to control in the largest case. Each case module required 40 one pound Arten Relative Humidity Control Modules for a total of 160 for the entire 24' case. To give the reader an idea of the scope of this project, one thousand four hundred and thirty of the Arten canisters were used in this one exhibition!

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[6] For a more detailed discussion of this subject see "Fixtures at an Exhibition Part II: Microclimates with Silica Gel: Efficiency Testing of Deck Designs", by Ann Boulton in this publication.

[7] Made by Art Preservation Services, 253 East 78 Street, New York, NY 10021, tel. 212/794-9234.

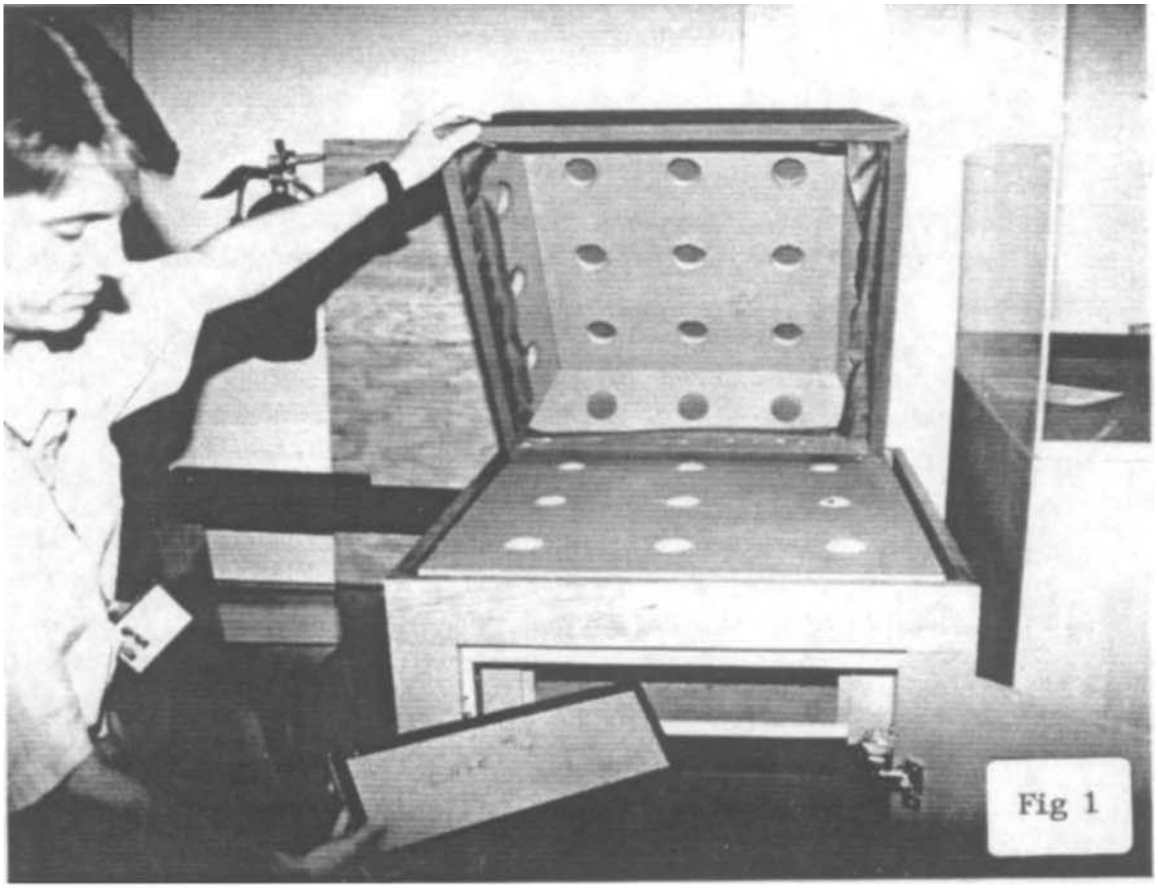

Fig 1

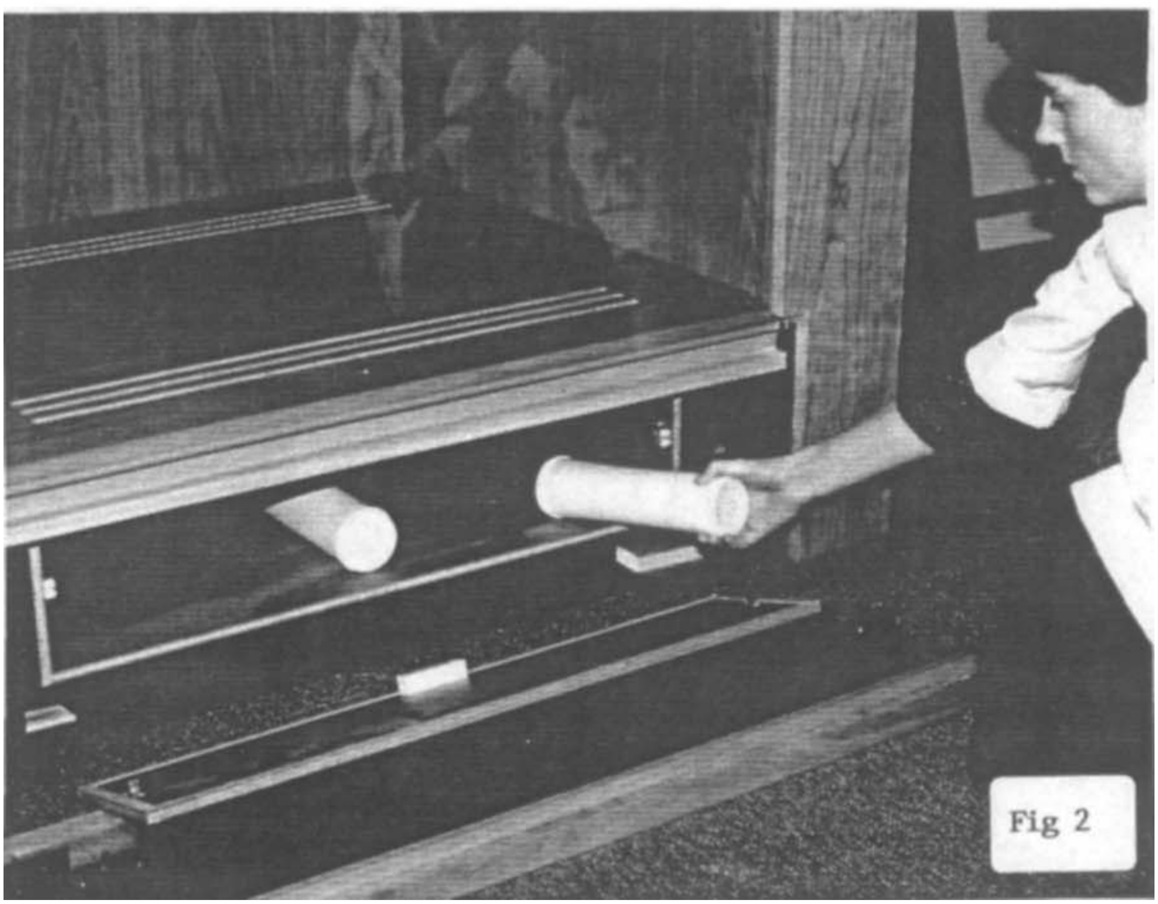

Fig 2

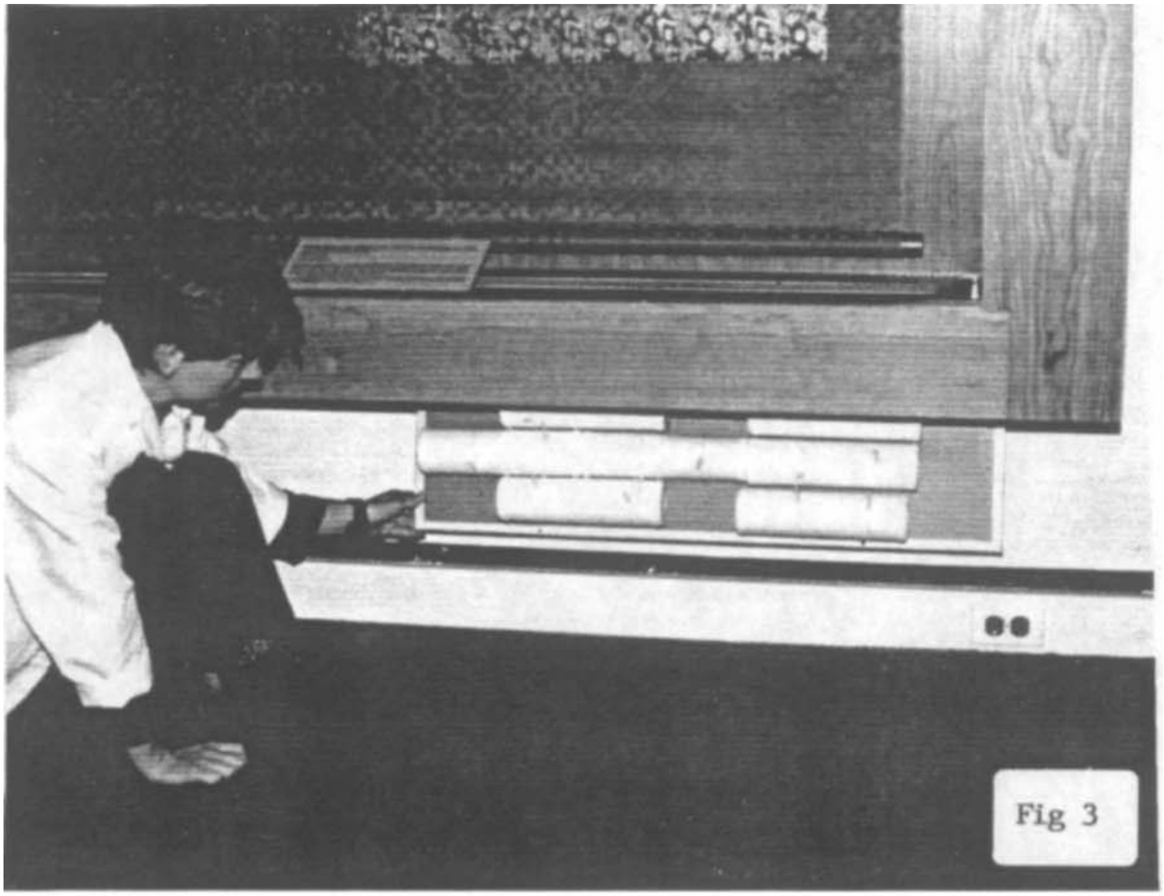

Fig 3

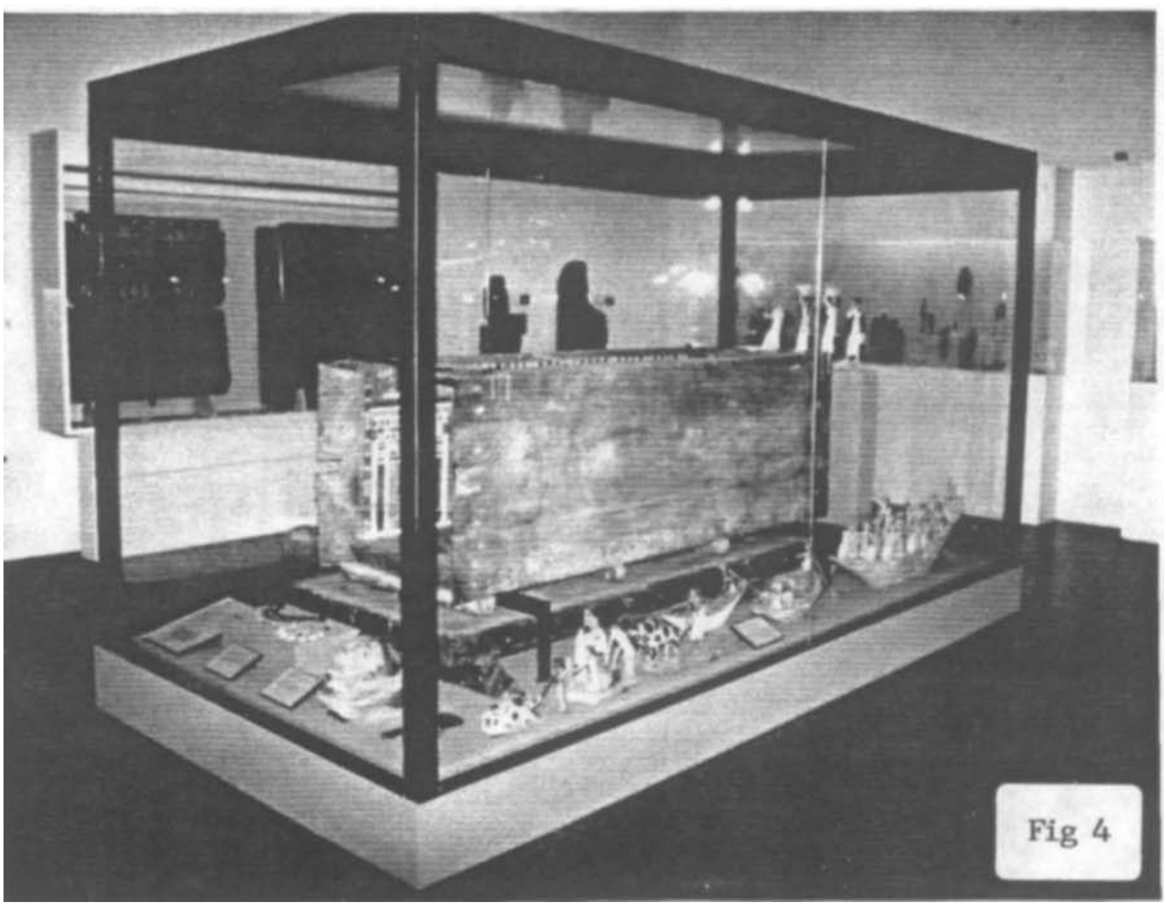

Fig 4

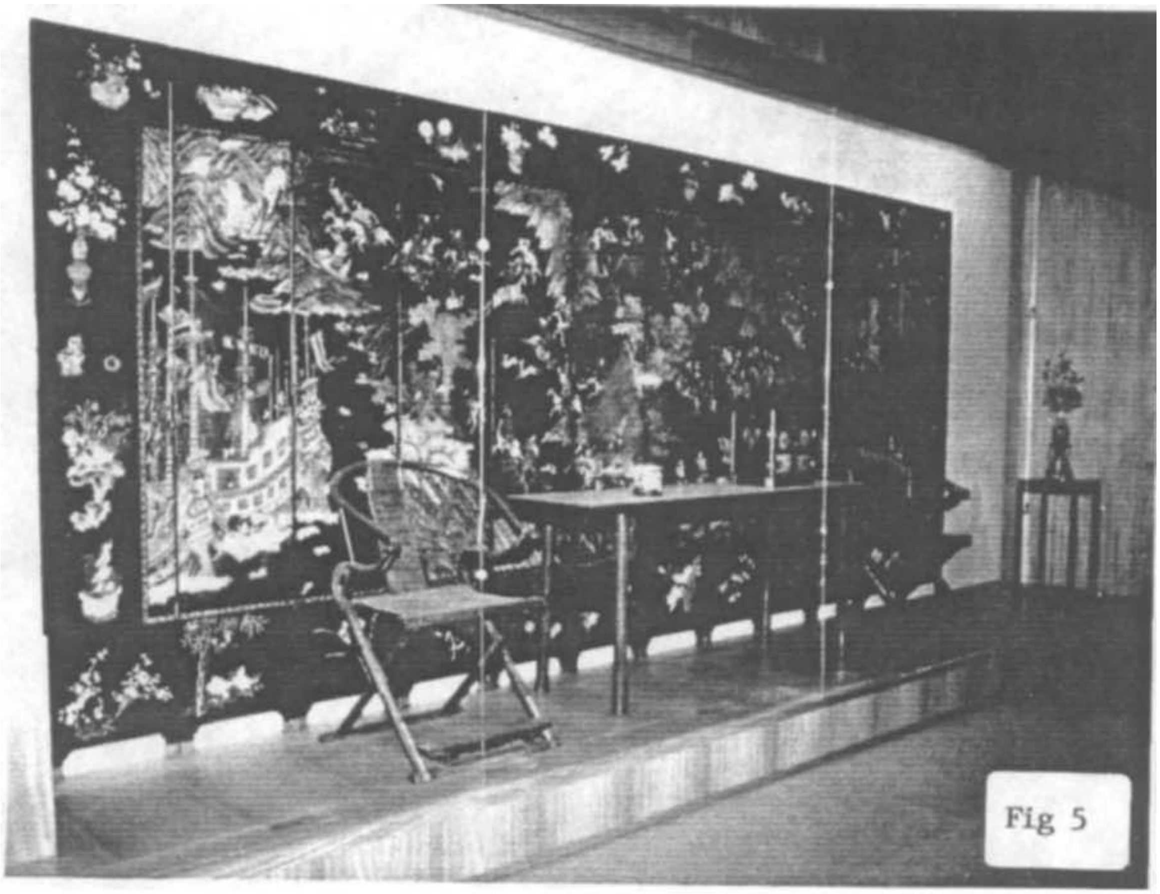

Fig 5

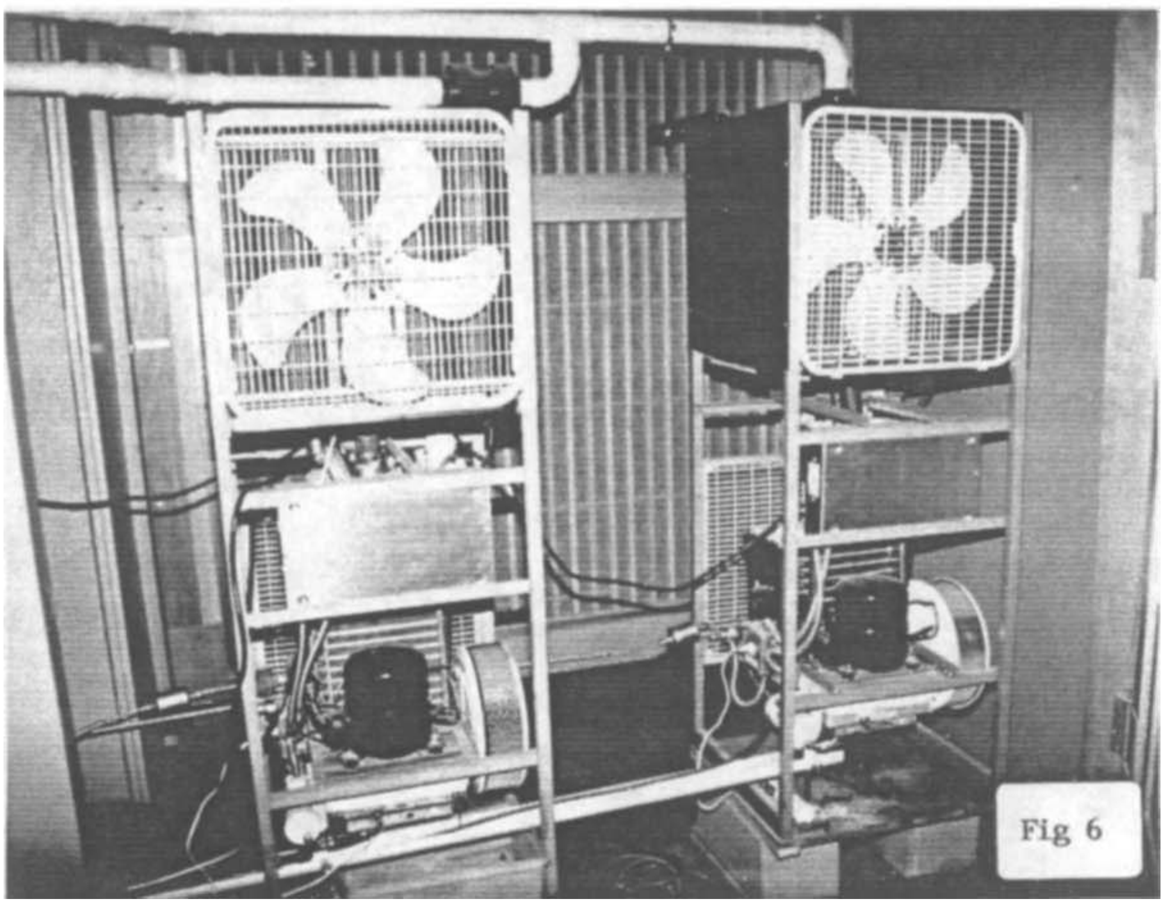

Fig 6

In order to make these cases as air tight as possible, in addition to the case construction details already mentioned, three other materials were used. These were principally employed to seal either the large movable plexiglass door fronts or smaller movable sloping plexiglass panels on very long 30′ hand scroll cases. Once fixed in place in order to seal the separate plexiglass pieces, butt joints were covered with 3/4" wide J-Lar clear tape.[8] At the perimeter edges where plexiglass was fitted behind wood, two very different types of flexible tubular gasketing were used, polyethylene HRR backer rod or Green·rod[9] from the construction industry and various sizes of silicone tubing from a laboratory supply house.[10]

The Arten Gel Modules were all preconditioned to 60% RH before being placed in the cases. The relative humidity in the galleries was kept as close to 60% RH as possible for several weeks before and during installation of the objects and the Gel Modules. This allowed the casework and room furnishings to equilibrate at 60% RH. Once the cases were gasketed, closed and sealed, humidity levels were further refined where required by installing open 4 oz. glass jars of water inside the silica gel compartments. The jars were closed with their screw-top lids when the desired humidity level was reached, usually in about 12 to 24 hours. The hand scroll cases presented the only persistent difficulties in maintaining 60% RH. Although the ballasts for the internal fluorescent lights were not placed inside these cases, the lights themselves gave off enough heat to cause a 2% to 5% RH drop in relative humidity when they were on. To correct this problem, water jars were left open and filled most of the time as makeup moisture in these cases. In addition we used cotton wicks in the water jars to accelerate the rate of evaporation.

These passive systems and cases worked extremely well in this application in climate controlled spaces even when swings of as much as 20% RH in twelve hours were experienced in the galleries. However, most of the larger cases built for "Courtly Splendor" are not airtight enough to work efficiently in the non-climate controlled parts of the Boston Museum. In these older galleries other cases have been devised. For example, we have very successfully used the Arten Gel Modules to hold a 50% steady relative humidity for nearly a year without any reconditioning in a large 12′ x 6′ x 6′ case in our non-climate controlled Egyptian Galleries (Figure 4). The basic difference in this case is that the plexiglass elements are fixed and not easily movable. This is a "permanent" installation where accessibility is not as much of an issue as it is with temporary exhibition hardware.

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8 This tape comes in various widths and is made by Permacel of New Brunswick, N.J.

9 Green·rod is made by nme, inc., 51 nme Drive, Zebulon, N.C. 27597, tel. 800/345-7279. It comes in eight diameters from 1/4" to 1 1/8".

10 Silicone tubing No. L-06411-62 Cole Parmer Instrument Co., 7425 North Oak Park Avenue, Chicago, IL 60648, tel. 800/323-4340.

Finally, I would like to briefly describe how we have successfully been able to create a very stable environment by active means in several very large cases of a similar design to those made for "Courtly Splendor". These two large 33" x 9' x 30' long cases each containing about 850 cubic feet of air are connected to two Kennedy-Trimnell Relative Humidity Control Modules, Model No. 3 (Figures 5 and 6).[11] The cases are located in the Bernat Galleries for Chinese art which are not climate controlled, but also not surrounded by any exterior Museum walls. Internal incandescent case lighting is isolated from the exhibit space and vented with fans and ducted to an attic. The conditioned air from the Kennedy-Trimnell units is piped through 2" ID PVC to balancing valves located every 6' over the cases and reduced down to 1/2" silicone flexible tubes which enter the cases through a translucent plastic ceiling panel below the lighting compartment.

Since much has already been written about the Relative Humidity Control Module, I will only report here on our specific findings.[12] We tested a Kennedy-Trimnell unit for about a month in the spring of 1989.[13] A 468 cubic foot exhibition case similar to the one shown in Figure 4 was connected to the unit with a 2" PVC pipe. The room in which it was tested contained a heat source, air-conditioning unit, humidifiers and de-humidifiers. By using these climate control devices we were able to simulate conditions in our non-climate controlled galleries through all seasons. Room temperatures varied from around 70° to 96° Fahrenheit. Relative humidity in the experimental room ran from a low of 43% RH to a high of 65% RH. Although the experiment was not run under ideal circumstances or for a long enough period to get good statistical information, we were satisfied that the Kennedy-Trimnell Relative Humidity Control Module, Model 3 had applications in our Museum. The most significant finding was that it performed better in conditions of moderate to low relative humidity than it did at higher relative humidities such as we experience in our galleries when windows are opened for ventilation in the summer. As a result we ultimately installed the units, as have been mentioned in galleries, in the center of the Museum that do not have outside windows and which are in addition half bordered by climate controlled spaces. I would characterize these Chinese galleries as having fairly stable temperatures throughout the year, but their relative humidity can vary widely and be especially low in the winter. Since we were showing very important Chinese lacquer ware and wooden furniture in these cases, RH control at 55% ±2% RH was imperative.

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[11] Kennedy-Trimnell Company, 109 North Kenilworth Street, Oak Park, IL 60301, tel. 708/386-6476.

[12] The most recent article is found in the Journal of the American Institute for Conservation Fall 1991, Volume 30, No. 2, "The Development of the Humidity Control Module at Field Museum", Cathrine Sease pp 187, 1960.

[13] This research was conducted by Margaret Leveque, Associate Conservator in the Research Laboratory of the Museum of Fine Arts, Boston.

Four large cases were originally designed to be installed in these galleries. Although their total cubic footage did not exceed the stated upper possible capacity of 5500 cubic feet of one Kennedy-Trimnell unit, based on four air changes per day, we decided to install two units to be on the safe side. In addition we plumbed them in such a way that by turning air control valves one unit could serve all the cases if the other was down for servicing (Figure 6). One of the four cases was not built, but still might be at a later date. A third case currently contains ceramics and is not actively on the system.

Our conclusions about the use of this active system for the control of relative humidity in large exhibition cases is not very different from those stated by Catherine Sease in her recent AIC Journal article. Our units have been operational for about two years. We allowed a full month to balance the system before putting objects in the cases. We too have experienced problems with our water supply and mineral deposits in the steam pans, although not as severe as those reported in Chicago. We plan to install some type of filtration and deionizers in the water supply in the near future.

When we installed these units originally we assumed them to be a stop-gap measure for five to ten years by which time state-of-the-art climate control would be installed in these Chinese galleries. With rough estimates of between 50 and 60 million dollars now being given to renovate and climate control the half of the Museum yet to be done, some new thinking may be in order. We are seriously considering the use of well designed, sealed exhibit cases for some of the permanent collections where internal climates are controlled by refined active and passive systems such as the ones just described. Achieving gallery climate stability may not be affordable for years to come.

Acknowledgements

Projects of the magnitude just described do not happen without the participation of many people. I am particularly grateful to Museum Designer, Tom Wong for his incredible memory and attention to detail. Warren Young, Assistant Director of Facilities, has been responsible for seeing to the successful design and operation of this active systems. Proprietors, Steven Weintraub and Ralph Trimnell were most generous with their time and advise. And finally, I would like to thank Pam Hatchfield, Associate Conservator, for her encouragement to report on these findings and her editorial assistance.