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A SURVEY OF ATMOSPHERIC CONTROLS
IN MUSEUMS AND HISTORIC BUILDINGS

INDEPENDENCE NATIONAL HISTORICAL PARK

Philadelphia, Pennsylvania

By
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December 1960

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INTRODUCTION

ATMOSPHERIC CONTROLS IN HISTORIC BUILDINGS

This report has been prepared in response to a request from the office of the Director (Memorandum to Regional Director, Region Five, June 27, 1960, transmitted to Superintendent, Independence National Historical Park, July 13, 1960). It is designed, in compliance with that request, to provide information on the use of atmospheric controls in historic structures which may be pertinent and helpful in establishing policies and guidelines not only for the Independence group but also for important historic structures elsewhere in the National Park System.

Section I of this report briefly describes the various elements of atmospheric control and their relationship to problems of conservation.

Section II deals with the experiences of museums in the use or non-use of atmospheric controls.

Section III deals with current use or non-use of atmospheric controls in historic buildings.

Section IV contains suggestions for a general policy in regard to use of atmospheric controls in historic buildings administered by the National Park Service.

Section V contains recommendations in regard to the application of this policy at Independence National Historical Park.

The writer is especially indebted for assistance in preparing this study to Miss Anne Clapp, former Conservator at

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Independence National Historical Park; Mr. Charles S. Leopold,
Mr. Ralph Lewis, Chief, Branch of Museums, National Park Service,
and to the staff members of over 30 institutions who contributed
information relative to the problems of atmospheric control in
museum and historic buildings.

Section I

ATMOSPHERIC CONTROLS AND CONSERVATION OF ANTIQUE FURNISHINGS AND WORKS OF ART

The four major types of atmospheric control are heating, cooling, regulation of relative humidity, and air filtration.

The necessity for heat in winter, even in a historic structure, is universally admitted. Heating by historic means alone, such as open fires or stoves, is rarely attempted because of the fire hazards involved and because the results are seldom adequate in terms of visitor and personnel comfort. Most historic buildings, therefore, employ central heating.

One effect of keeping temperatures at a comfortable level in cold weather (68° - 72°) is excessive dryness of the internal atmosphere. The warmer the air the more moisture it takes to reach the saturation point, or, conversely, if the absolute humidity remains constant, raising the temperature lowers the relative humidity. Wood, leather and the natural fibers which go into picture canvases, fabrics, and paper react quickly to change in relative humidity by expanding and contracting. A heating system without humidity controls tends to accentuate these stresses and thus accelerate deterioration of valuable furnishings.

During the warmer months, when buildings are not artificially heated, indoor relative humidity in a non-air conditioned situation tends to fluctuate in direct response to changes in the weather outside. If these fluctuations are frequent and severe, the sensitive materials contained in wood panelling, furniture, fabrics, paper and

prints are constantly subjected to weakening stresses. In humid climates, moreover, extended periods of high (above 65%) relative humidity encourage mold growth. Continuous exposure to the extremes and to rapid fluctuations in relative humidity are equally to be avoided if at all possible.

An air cooling system, with automatic relative humidity controls, is the most satisfactory method of avoiding these warm-weather dangers. Combined with a comparable heating system for the cold months, it provides year-round protection against deterioration of perishable objects from the effects of uncontrolled relative humidity.

Contaminated air is the other great contributor to the gradual destruction of antique materials, particularly in large cities and industrial areas. The modern urban atmosphere contains many pollutants, including smoke, dust, and various gases, such as sulfure dioxide, carbon monoxide, and hydrocarbons produced by vehicular exhausts and by coal, gas and oil-burning furnaces. The incidence of these contaminants varies from one locality to another and some are more destructive to decorative arts materials than others. Probably the most harmful is sulfur dioxide which converts readily into sulfuric acid and attacks a wide variety of materials. "The corrosive effects (of sulfuric acid) are obvious in specimens exposed to the weather - building stones - or metals," writes H. J. Plenderleith in The Conservation of Antiquities and Works of Art (1956), "but a more subtle and equally damaging form of deterioration due, in the

first instance, to sulphur dioxide is to be observed in organic materials which have been exposed to traces of the resulting acid over a long period of time. The rotting of paper and textiles can often be traced to the action of sulphuric acid, and it is this acid...that is so often responsible for the powdery and decayed condition of old leather bookbindings."

Although the effects of this and other chemical pollutants are difficult to assess scientifically, because they operate slowly and in conjunction with other factors (such as unfavorable relative humidity conditions), there is no question but that "works of art can be most seriously affected by pollution." (A. R. Meetham, Atmospheric Pollution, 1952, 220.)

It is important to the protection of perishable objects, as it is to the health of people, that polluted air be filtered as completely as possible before it is circulated through an exhibition building. This can best be accomplished by incorporating air filtration into a system which includes both heating and cooling and thus obviates the necessity of opening windows in the summer.

In summary, the elimination or minimization of the two greatest hazards to perishable museum pieces - uncontrolled humidity and atmospheric pollutants - can be accomplished on a year-round basis through a coordinated system of heating, cooling, regulation of relative humidity and air filtration. The efficacy of such a system was dramatically demonstrated in England during the Second World War. "In a large repository used during the war to house the British

Museum and Victoria and Albert Museum collections (antiquities, books, textiles, prints, drawings, manuscripts, furniture, etc.) the air was controlled at the constant figures 60 percent R.H. at 60° F., and," Plenderleith reports, "not a single case of deterioration was recorded in this repository."

Section II

ATMOSPHERIC CONTROLS IN MUSEUM BUILDINGS

In order to gauge current thinking in the museum profession on the efficacy and importance of atmospheric controls in the conservation of decorative arts specimens, the writer submitted a questionnaire to thirty-seven (37) museums and restoration projects. Responses were received from thirty (30) institutions. Of these, approximately half operate in non-historic museum structures and half in restored or reconstructed historic buildings. The former are discussed in this section and the latter in Section III.

Of the museums reporting, four now have full atmospheric controls, six have something short of full control and four plan to introduce full controls throughout new or existing museum buildings. Their individual comments are summarized below:

National Gallery of Art, Washington, D. C.: Full air-conditioning, installed 1939-40 at a cost of \$1,000,000 to \$1,500,000; annual cost of operation, \$150,000.

Frick Collection, New York City: Full air-conditioning added during remodelling, 1932-35; no cost estimates available for installation or operation.

Museum of Modern Art, New York City: Full air-conditioning in all gallery and storage areas; date and costs not given.

Freer Gallery, Washington, D. C.: Full air-conditioning, recently installed, no costs given.

National Gallery, London: Full air-conditioning in some rooms, recently installed. (See Museum, IV, 1957, 195-200).

Victoria and Albert Museum, London: "modern atmospheric controls exist only in a portion of this Museum and... have very recently been introduced."

Isabella Stewart Gardner Museum, Boston: heat, regulation of humidity and filtration throughout, cooling only in part of building. Installation in 1945-59 at a cost of about \$40,000, annual operation cost about \$2,000.

Museum of Fine Arts, Boston: heat and filtration, regulation of humidity (in storage), no cooling. "Any changes would be expensive."

Art Institute of Chicago: heat, regulation of humidity, filtration, no cooling. "We hope to eventually have all of our storages and exhibit areas totally air-conditioned."

Metropolitan Museum of Art, New York City: heat, cooling in "very few areas," regulation of humidity "in some areas" including the American Wing, filtration in "all areas, different types." "A variety of small units have been added over the past 20 years," using both permanent and portable equipment.

Smithsonian Institution, Washington, D. C.: plans to install full atmospheric controls in new Museum of History and technology, as well as in new East Wing. (see Appendix A).

H. F. du Pont Winterthur Museum, Winterthur, Del.: plans to install full atmospheric controls by 1962. Anticipated cost of operating system is \$30,000 a year.

Pennsylvania State Museum, Harrisburg: plans full atmospheric controls throughout projected museum building.

Illinois State Museum, Springfield: New museum building will contain "a system to control dust, moisture and temperature throughout with special humidity and temperature control apparatus in the art storage rooms and in the art gallery."

In regard to the effectiveness of atmospheric controls in reducing the rate of deterioration of antique furnishings and works of art, the museums were generally in agreement that they were effective. Several comments follow:

"Although we have only a limited number of antique furnishings, we believe the air-conditioning equipment has been of great importance in the preservation of the many paintings which the Gallery owns and of others which are on loan" (National Gallery of Art, Washington.)

"[The system] has been extremely effective" (Frick Collection.)

"[The system has proved] generally effective" (George L. Stout, Director, Isabella Stewart Gardner Museum, Boston.)

"A properly controlled system will unquestionably reduce the rate of deterioration of collection objects" (Wesley A. Adams, H. F. du Pont Winterthur Museum.)

On the question of obsolescence, the Art Institute of Chicago feels that its 1938 system, which does not include cooling, is somewhat out-dated. The Frick Collection and the National Gallery are satisfied with their systems, installed respectively in 1932-35 and 1939-40, and foresee no danger of their becoming obsolete for a good many years.

Section III

ATMOSPHERIC CONTROLS IN HISTORIC BUILDINGS

Fourteen agencies operating restored or reconstructed buildings of historical importance are considered in this section: Three of them have introduced full controls into at least some of the buildings in their charge, primarily for the protection of their

contents. The others have introduced only partial controls. A summary statement on each of these agencies follows.

"Monticello," operated by the Thomas Jefferson Memorial Foundation, Charlottesville, Virginia, is fully air-conditioned. The system was installed in 1954 at a cost of about \$225,000 during the restoration of the building. It was designed by Wiley and Wilson and installed by Wachter and Wolff, both firms of Richmond, Virginia. The writer visited "Monticello" in March 1960 to investigate its air-conditioning. In general the system is unobtrusive to the eye, the vents being placed mainly over cornices and door-frames and in fireplaces. The Superintendent felt that year-round air-conditioning had cut the deterioration rate for the furnishings by about 50%. Some difficulty has been experienced with the automatic humidity control system owing to mechanical troubles. This installation is regarded as a model by the National Trust:

This latest restoration of Monticello, with its all-year atmosphere control, sets an unmistakable pattern for future projects in historical preservation. [states-Robert H. Emerick in his article "heating of Restorations," originally published in Progressive Architecture, August 1957, reprinted and distributed by the National Trust for Historic Preservation. See Appendix B]. The objective is not human comfort, but to delay the decay of the aged fabrics, manuscripts, and furniture normally on display in the rooms and halls. As an indirect benefit, the building itself will last longer, since the controlled humidity and temperature discourage termites and dry rot. We can expect more of this in the future, not only for new projects, but also for additions to the old; the reasons are sound

Colonial Williamsburg has full air-conditioning in the following buildings: all hotel properties, all three reconstructed

restaurants, the Margaret Hunter Shop (craft shop), the museum storage building and three major reconstructed exhibition buildings - Capitol, Governor's Palace, and Raleigh Tavern. Air-conditioning is also shortly to be installed in the restored Wythe House. In all exhibition buildings the temperature is kept at 72° and the relative humidity at 50%. The systems were designed by Colonial Williamsburg's own Engineering Department in collaboration with Wiley and Wilson of Richmond, and the mechanical installation was made during the 1950's by Wachter and Wolff of Richmond. The systems are maintained by the Engineering Department of Colonial Williamsburg.

The writer visited Williamsburg in October 1960, looked over the air-conditioning plants in the Capitol, Palace and Raleigh Tavern, and discussed them with Mr. Otis Odell, Director of Mechanical Operation and Maintenance, with Dr. Edward M. Riley, Director of Research, and with Curator John M. Graham, III, and his assistant, Miss Lanier. From these discussions it is apparent that air-conditioning has been very successful at Williamsburg, both as a means of protection for its extremely valuable collections and as a means of contributing to the comfort of visitors and the welfare of the staff. The writer inquired particularly of Doctor Riley and Mr. Graham as to visitor reaction to visible vents and summer cooling. Both expressed the opinion that unfavorable reactions were exceedingly rare, that vents were noticed or commented on by very few visitors, and that the beneficial effects of air-conditioning far outweighed

in their experience, the anachronisms inherent in these modern intrusions.

In the placement of vents Williamsburg has tried a variety of locations. Some are in baseboards, some in cornices, some in fireplaces, some in windowseats, and one common return in the Palace is located in a closet. A majority of the vents, however, are in the floor, usually in the corners. This arrangement appears to be the most satisfactory from an engineering standpoint, and since the floors tend to be dark in color, does not seem to attract undesirable attention from visitors.

Since humidity is kept at a level of about 50%, Williamsburg has encountered the problem of condensation on windows in cold weather. They have found a partial solution to this by installing under each lower sash removable tin gutters which carry the moisture outside and thereby prevent soiling of curtains and drapes. In Raleigh Tavern, placement of some supply vents in window seats cuts down on condensation, since the warm air dries the windows as condensation takes place.

The staff at Williamsburg feel that its air conditioning systems are very effective in preserving furnishings and interior woodwork. Miss Lanier of the curatorial staff estimates that it has cut the rate of deterioration by at least 50%.

Mr. Odell, Director of Mechanical Operations and Maintenance feels that the systems "will be adequate for many years."

Tryon Palace, New Bern, N. C., the recently (1956-57) reconstructed mansion of Governor Tryon (1767), has been fully

air-conditioned by the Air-Conditioning Corporation of Winston-Salem and Greensboro, N. C. The temperature is maintained at 72° and relative humidity at 45% to 55%. In response to the writer's questions, Miss Gertrude Carraway, Director of Tryon Palace Restoration, expressed complete satisfaction with this system. "The cost was high," Miss Carraway wrote (she was unable to cite cost figures) "but in my opinion worth every penny." Miss Carraway felt that the system was "very satisfactory and effective" in protecting furnishings and provoked no unfavorable comment from visitors.

A questionnaire submitted to the British Ministry of Works produced the following interesting response:

Atmospheric controls, other than heat, have been introduced into a small number of historic buildings and museums, for which the Ministry is responsible. While keeping these buildings in good condition, our main aim in providing atmospheric controls is to protect the contents rather than provide overall perimeter protection for the whole structure. Generally, however, our mild and equable climate does not call for a high degree of air-conditioning.

Most of our buildings, particularly historic ones and those of not very recent design, are of massive construction in materials and in depth, and atmospheric changes have little effect in internal rooms and galleries and on their contents....

The letter goes on to state that permanent heating, humidity regulation, and filtration apparatus have been introduced into three buildings under the care of the Ministry of Works. Cooling apparatus is not used in any of the three. The work was done in 1932 in one building and in 1958-59 in the other two, and none of the systems is considered obsolescent.

In regard to the effectiveness of these systems, the following statement was made:

It is difficult to assess correctly how effective the air control system is in reducing rate of deterioration...but general impressions are satisfactory.

Large corrosive dust particles are prevented by air filtration from entering the conditioned space. Potentially, they represent the greatest danger to furnishings, etc.

No unfavourable comments [on intrusions] have been brought to our notice. Generally, architect and engineers endeavor to make installations as unobtrusive as possible in such buildings.

The Old Stone House in Georgetown, D. C., operated by National Capital Parks, has both heating and cooling, but no humidity controls or filtration.

When the writer visited the Old Stone House in October of this year he was disturbed by the obtrusiveness of the vents (especially those located in the white ceilings and on the stair risers,) by the noisy operation of the system and by two conditions which stem from the lack of humidity controls and air filtration - the presence of active mold in the basement (particularly noticeable on one leather specimen) and dirt streaks around the supply vents in the plaster ceilings of the dining room and bedroom. Both conditions adversely affect interpretation of the house and the former is a serious danger to objects displayed.

At Mount Vernon, where extensive restoration and rehabilitation have been carried out in recent years, air-conditioning has not been

introduced, except for dehumidification in storage areas containing documents and records. Although the Mount Vernon authorities agree that "it would be desirable to have a complete air-conditioning and de-humidifying system installed," they feel that such a system would not be very effective there because a constant stream of visitor traffic requires that four outside doors be kept open at most times.

In the opinion of Mr. Charles C. Wall, Resident Director of Mount Vernon, the "lack of air conditioning has had no adverse effects through the years on the house structure or the contents. Fabrics, of course," he continues, "do suffer from exposure to dust and dirt; draperies are necessarily classified as expendable over a period of ten or twenty years. The structure itself, however, despite its age, shows no signs of deteriorating influences which might be offset by air conditioning."

Mr. Wall goes on to say that the heating system at Mount Vernon has been a factor in their favor in this respect. Although it is centrally heated, all heat is supplied by hot water coils in the basement, the heat rising through the fireplace openings on the first floor. "The amount of heat delivered," he states, "would not make the house comfortable for normal occupancy, but our visitors are in their out-of-door clothes and our guards all necessarily dress to the condition. In periods of extreme cold the temperature within the house...may fall as low as fifty degrees, but the amount of heat provided through the years has been adequate to the physical well-being of the structure[and] dampness as a destructive factor has been offset."

The State of Maryland provides no atmospheric controls, other than heat, for any historic buildings, including the old Capitol at Annapolis. It does, however, maintain optimum temperature and humidity conditions in the storage vaults of the modern Hall of Records, "with permanent heating and cooling air-conditioning equipment."

Two restoration organizations in the South - Old Salem, Inc., Winston-Salem, N. C. - and the Historic Charleston Foundation, Charleston, S. C. - report that they have only heat and, at Old Salem, attic fans. At Old Salem, it was felt that heat and humidity conditions were not hazardous enough to justify the expenditure involved in air conditioning.

In the Southwest, air conditioning is not considered necessary in the Museum of New Mexico, Palace of the Governors, Santa Fe, "due to dry climate, nature of exhibits and collections, and nature of sole historic building in Museum custody (adobe Palace of the Governors...). Also - lack of funds."

Three institutions in the Northeast felt that atmospheric controls other than heat were not needed in the historic buildings in their charge - The Office of the New York State Historian, Albany, N. Y., Sleepy Hollow Restorations, Tarrytown, N. Y., and the Society for the Preservation of New England Antiquities, Boston, Mass.

Dr. Albert B. Corey, State Historian of New York, stated in explanation simply that such controls were not needed.

Dr. Robert G. Wheeler, Director of Research for Sleepy Hollow Restorations, stated that "While we have made provision for the circulating of air[through the use of attic fans], we have felt that air conditioning destroys any illusion of that earlier period to which our buildings are restored."

The most severe attack on the whole idea of atmospheric controls, other than heat in winter, comes from Mr. Bertram K. Little, Director of the Society for the Preservation of New England Antiquities, which owns many historic properties throughout New England. Most of these properties are leased to individuals or organizations for non-museum uses.

In reply to the writer's question as to reasons for not introducing such controls, Mr. Little wrote as follows:

Because installation of any system of atmospheric controls we have seen to date involves damage to original structural and decorative elements of historic buildings; appears objectionably anachronistic; requires water and power resources either unobtainable at location of property or constituting too much of a drain on limited endowment income; and because in our experience the natural adaptation of an old building and its contents to the changing seasons, with the exceptions due to particular local conditions, has not proven to be as deleterious as is often claimed.

Speaking generally on the question of atmospheric controls, Mrs. Helen Duprey Bullock, Historian of The National Trust for Historic Preservation, has this to say:

The National Trust takes the position that this[air conditioning] like heating and lighting is a desirable addition to a historic structure and must be introduced with a minimum of damage to the surviving architecture.

A superb example is the introduction of both heating and air conditioning at Thomas Jefferson's Monticello in Charlottesville, Va.

Not only does air conditioning make the building more comfortable and attractive to visitors but in urban areas especially it controls direct fumes and destructive elements that damage both furniture and paintings. This is a particularly important argument in regard to Independence Hall where you are surrounded by office buildings and downtown traffic.

Section IV

A SUGGESTED POLICY FOR THE NATIONAL PARK SERVICE

If it does nothing else, the foregoing survey of professional experience and opinion on the subject demonstrates that there is no generally accepted view regarding atmospheric controls in historic buildings. Mr. Little's statement tersely sums up the chief arguments against such controls. The elaborate systems at Monticello, Colonial Williamsburg, and Tryon Palace bear witness to a contrary view of the problem, which in general has the endorsement of the National Trust. The problem faced by every administrator of historic buildings is essentially to balance the proven benefits of atmospheric controls (and on this point Mr. Little stands almost alone in his opposition) against the expense factor, interpretive problems, and, most important, the danger of violating the structural integrity of an architectural monument. As Mr. Little himself suggests, "particular local conditions" must be the determining factor in striking this balance.

Because of the widely varying atmospheric conditions throughout the vast area over which the National Park Service operates,

it is manifestly impossible for the Service to adopt a simple, unvarying policy in regard to the use of atmospheric controls in the historic properties under its care. Its policy should, therefore, be a flexible one, determined in each case by local conditions.

The following guidelines are suggested as aids to determining what atmospheric control measures are needed in each case:

(1) Take careful stock of the building's contents.

Decide just how important they are in relation to the interpretation of the structure. If furnishings play a central role, and especially if they include irreplaceable originals, measures for their preservation are accordingly of great importance.

(2) Make a study of local atmospheric conditions. With

the aid of local weather bureau, air pollution control board, or other interested agencies, get an objective view of climatic conditions, such as variations in relative humidity and temperature, and of air contamination levels, which may adversely affect the contents of your building. If the climate is equable and dirt or chemical contamination levels low, elaborate atmospheric controls will not be necessary. If, on the other hand, the outside humidity fluctuates wildly from day to day, or remains above 60% or below 40% for long periods, and if dirt or other air contaminants are present in appreciable quantities, air conditioning should be seriously considered.

(3) Determine your own air conditioning requirements. Not

every situation calls for the full range of atmospheric controls.

Filtration of air, for instance, is likely to be less of a necessity

in the country or in small towns than in cities. Air cooling may be unnecessary, likewise, in non-urban situations where windows may safely be opened to promote air circulation. The use of permanent or portable equipment (such as humidifiers and dehumidifiers) will depend also on local conditions. In general, it is probably safe to say that the more rural the situation the less complex the problem and the solution.

(4) Obtain an air conditioning plan and cost estimates.

Based on your specific needs, have plans drawn up by a qualified air conditioning engineer. It is helpful to have more than one alternative plan to choose from. One may show the most efficient method of air conditioning the building; another the method which least affects the original structure; a third a compromise. Every effort should, of course, be made to avoid tampering with original structure and to make visible elements of the system as unobtrusive as possible. Cost estimates should include cost of installation, operation (water, power, etc.), and maintenance.

(5) The decision. Once you have a plan and cost estimates, you can decide whether or not it is feasible to obtain the measure of protection you deem necessary for the contents of the building. The cost factor or the threat to the integrity of the building may in the end tip the balance in favor of leaving the contents to fend for themselves. The value or historical importance of the furnishings will however, in some instances, outweigh these factors and provide sufficient justification for a considerable capital expenditure. Each case must be decided on its own merits.

Section V

SUGGESTED POLICY FOR THE HISTORIC BUILDINGS AT INDEPENDENCE NATIONAL HISTORICAL PARK

Following the guidelines suggested in the preceding section, the writer submits the following estimate of the atmospheric controls problem as it affects Independence National Historical Park.

(1) The interpretive program now in operation in the Independence Hall group and proposed to be expanded to include several other historic buildings in the Park depends to a large extent on giving the visitor the feeling that he has momentarily stepped back into the 18th century. To this end the buildings are being furnished as they were at that time. Some of the furnishings are those originally used in these buildings, the "Rising Sun" chair, for instance, used by Washington at the Constitutional Convention in 1787, the Silver Inkstand used in the signing of the Declaration of Independence, and 25 of the chairs used by members of the United States Congress meeting in Congress Hall from 1790 to 1800. These are irreplaceable objects of prime historical interest whose interpretive value is greatly enhanced by their being seen in their original setting. Their preservation is, like the preservation of the buildings to which they have been returned, a matter of prime importance. The same is true to only a slightly lesser degree of other antique furnishings which have been or will be placed in these buildings as loans from private individuals and public institutions, and for those to be purchased for this purpose at an over-all cost of many hundreds of

thousands of dollars, Prevention of unnecessary deterioration is always better in principle than repairing damage, and in the long run probably will be less costly than repairs and replacements.

(2) In an effort to determine the atmospheric conditions to which these objects are exposed at present, the Park staff has conducted some independent tests and has consulted with the Air Pollution Control Section of the Division of Environmental Health, Philadelphia Department of Health.

During the present year the Park staff has been recording the temperature and relative humidity in Independence Hall. At first, test readings were taken with a sling hygrometer three times each day in five locations within the building. These readings, taken during the heating season, showed that the present heating and humidity control system was not equally effective in all parts of the building in preventing excessive dryness. The result has been most obvious in the cracking and shrinking of wood panelling in the Supreme Court Chamber. (See Appendix C).

From June through October 1960 temperature and relative humidity have been recorded in two locations in Independence Hall, using Brown Recorders which operate constantly. The attached charts (Appendix D) show the daily high and low relative humidity readings at these locations. It is readily apparent from these graphs that the relative humidity in Independence Hall during the summer of 1960, without any sort of atmospheric control, was subject to rapid and wide fluctuation and rarely fell within the optimum

band of 45-55%. The generally lower humidity level in the first floor Assembly Room is owing to the fact that the recorder in that room was placed in a relatively sheltered position while the one upstairs was deliberately placed near an open window.

Because of the generally high humidity Philadelphia experiences during its summers and the large number of visitors passing through Independence Hall, the air inside the exhibition rooms becomes very uncomfortably close unless the windows are opened. From the point of view of preserving the objects on exhibition, this is a very unsatisfactory solution of air circulation problem, since it intensifies another serious problem, that of dirt and other types of air pollution.

While no scientific tests have been conducted in Independence Hall on the types and quantities of various contaminants in the air which adversely affect antique furniture, paper, and the like, information of this sort is being collected in various parts of the city by the Air Pollution Control Section of the Division of Environmental Health, Philadelphia Department of Public Health. According to the most recent information (~~See Appendix E~~), the atmosphere of Philadelphia contains typical urban concentrations of sulfur dioxide, hydrocarbons, and particulate matter. In respect to the last, Philadelphia's city-wide mean concentration of particulates in 1959 was 147 micrograms per cubic meter, which is below average for a city of this size, but the mean concentration at City Hall, the sampling station closest to Independence Hall, was 190, which is average for

cities of over a million people. Sulfur dioxide and various hydrocarbons, produced by combustion of solid, liquid and gas fuels, are also present in the city's atmosphere in measurable quantities, though samplings have been too limited to give a clear picture. In general it can be said that Philadelphia's air pollution problem, while less serious than that of Los Angeles, London, New York, and some other large cities, is serious enough to worry public health officials and anyone interested in preserving valuable museum specimens from airborne elements of destruction.

(3) In view of atmospheric conditions in the center of Philadelphia, it is felt by the writer and his associates that this Park's major historic buildings and their contents should be given maximum internal protection against the effects of uncontrolled humidity and air pollution. This means heating and cooling, filtration and automatic humidity controls to provide, as nearly as possible, a constant humidity level of between 45% and 55% and a minimum influx of air contaminants. None of these elements of atmospheric control can be omitted without impairing the effectiveness of the whole system. Equipment should be permanently installed.

(4) Plans for atmospheric controls in the Independence Hall group of the buildings are being submitted in a separate report by the firm of Charles S. Leopold, Inc.

(5) The writer feels strongly that full atmospheric controls are a real necessity in the Independence Hall group and other Park exhibition buildings to preserve their valuable and, in part, irreplaceable furnishings. This necessity arises out of particular local atmospheric conditions which are a serious threat to these furnishings.

A P P E N D I C E S

- Appendix A: "Temperature and Humidity Control of Period Room Installations," memorandum of John C. Ewers, Smithsonian Institution, May 14, 1960.
- Appendix B: "Heating of Restorations," by Robert H. Emerick, reprint from Progressive Architecture, August 1957.
- Appendix C. Relative Humidity in Independence Hall, March 1-23, 1960.
- Appendix D: Relative Humidity in Independence Hall, May - October 1960.

September 7, 1960

Memorandum

To: Regional Director, Region Five

From: Chief, Branch of Museums

Subject: Atmospheric Control of Congress Hall - Independence

The following information, and the attachment, are supplied for possible use in Museum Curator Wallace's study of atmospheric control for Congress Hall. Curator Malcolm Watkins, of the National Museum, informed us that the National Museum has heretofore stored its furniture collections without special atmospheric control. They have found that veneered furniture has suffered particularly. In the new Museum of History and Technology they expect to maintain throughout the exhibit and storage areas a summer temperature of about 75°, with a relative humidity of 50%. During the winter the temperature will vary from about 70-75°. They will try to keep the humidity to 50%, but expect at times it will drop briefly to 35-40%. The attached report was made in connection with their preliminary studies.

The National Gallery of Art informs us that in the new Widener rooms they will maintain a temperature of 72° in winter, with a relative humidity of 45-50%. In summer they will let the temperature rise, but will keep the humidity within this range. At present they are experimenting with shutting off the air conditioning at night. The system will come on in the summer whenever relative humidity reaches 55% and in winter if it gets down to 45%.

Ralph H. Lewis
Chief, Branch of Museums

In duplicate

attachment

Mr. J. C. Ewers

May 14, 1958

G. C. Lindsay

Temperature and Humidity control of period room installations.

No study of air conditioning especially oriented to the period room has been made. Available reports and experiments deal only with specific objects and materials.

The objects most critically affected by temperature and humidity are (1) paintings on wooden panels. Ideal temperature and humidity conditions for the preservation of wood panel paintings are as follows:

Temperature: 65° F.
Humidity: 58% Relative Humidity¹

These same conditions may be taken as the ideal for almost all other objects and materials except certain types of ancient soda glass for which a relative humidity in excess of 48% is dangerous.²

In instances not involving these critical objects and materials (i.e. wood panel paintings and certain glassware) considerable variation from the ideal conditions is permissible, though adherence to the ideal conditions is desirable for all types of woodwork, textiles, and metalwork.

Organic materials are susceptible to damage by desiccation at R.H. less than 50%, and mould may occur on mould nourishing types of material if the R.H. is in excess of 65%.³

For period-room installations the permissible limits of R.H. would appear to be as follows:

Minimum: 45% R. H.
Maximum: 65% R. H.

However, both desiccation and mould growth can be inhibited by free circulation of air. With a maximum of air circulation and the careful examination of dead air pockets, the permissible limits of R. H. might be as low as 40% and as high as 68%.⁴ It is not however wise to approach these absolute limits.

So long as the R. H. falls within the permissible limits, temperature may be held at any reasonable point. As noted above, the ideal temperature appears to be about 65° F. The National Gallery in London maintains a temperature of 68° with excellent results.

Generally speaking, the higher the percentage of air recirculation (i.e., the reuse of already-conditioned air as opposed to drawing fresh air from outside and conditioning it "from scratch") the cheaper the operation of the air conditioning system. Cost wise it is desirable to work at the highest possible percentage of recirculation of air. No deleterious effects of this high percentage of recirculation are reported so long as no noxious or damaging gases, dusts, etc. are produced by the air-conditioning machinery or from other sources inside the air conditioned area. Using a high percentage of recirculated air is not advisable, however, in conjunction with electrostatic precipitation of dust particles. The electrostatic precipitation process creates a certain amount of ozone and nitrogen oxides which are not desirable and might in extreme instances prove dangerous.

Recirculation of 90% of the air is used with success in the National Gallery in London.⁵

One of the earliest attempts of air conditioning applied to large collections was undertaken by the British Ministry of Works during World War II. Air conditioned war-time storage was provided in a Welsh slate mine. Excellent results were obtained within the following limits:

Temperature: $60^{\circ} \pm 50^{\circ}\text{F.}$
Humidity: $60\% \pm \text{R. H.}$ ⁶

Of paramount importance in temperature and humidity control is the constant maintenance of the selected temperature and humidity. Rapid change in temperature and humidity are to be avoided at all costs. Sporadic or intermittent operation of the temperature and humidity controlling machinery must not be permitted. Operation of the system at only certain times (for example, during visiting hours only) would be more damaging for specimens than the complete absence of such control.

The National Gallery of Art (Washington) finds that the machinery may be shut off for several hours before an appreciable change in the air occurs. At this gallery R. H. varies between 45-50% and the temperature is kept between 70°F. and 75°F.

In the humidity control of any sizable area, fluctuation of at least 5% is to be expected. More precise control should not be anticipated.

SUMMARY: & RECOMMENDATION:

Period rooms are by their nature furnished with heterogenous materials. It is impossible to air condition a period room in a manner ideal for each individual object in the room.

Almost all objects, however, may be safely maintained within rather wide limits of temperature and humidity.

A room maintained at a temperature of 65° plus or minus 5° F., and at a relative humidity of 55% plus or minus 5% R. H. should provide an excellent environment for all objects to be placed in it.

COMPARISON OF TEMPERATURE AND HUMIDITY IN
VARIOUS MUSEUMS USING AIR CONDITIONING AND HUMIDITY CONTROLS

Installation	Temperature (degree F.)	Relative Humidity (%)
National Gallery (London)	68	58
Worcester (Textiles)	?	40 $\pm$ 1
(Wood)	?	52 $\pm$ 3
National Gallery (Washington)	70-75	45-50
Manod slate quarry (War-time storage)	63	58
Winterthur (textiles)	<u>To</u> <u>be</u>	<u>Supplied</u>
Plenderleith's recommendation	60 $\pm$ 5	60 $\pm$ 5
Recommended for MHT per. rooms	65 $\pm$ 5	55 $\pm$ 5

- 1 Werner, A. E. A., "Heating and Ventilation." The Museums Journal
Vol. 57, No. 7, (October 1957) p. 160.
 - 2 Organ, R. M., "The Safe Storage of Unstable Glass." The Museums Journal
Vol. 56, No. 11, (February 1956) p. 265.
- An example of the effect of high R. H. on this kind of glass may be seen in the Chinese glass in the Gallately Collection, U.S.N.M.
- 3 Werner, op. cit. p. 160.
 - 4 Keeley & Rawlins, "Air conditioning at the National Gallery, London,"
Museum Vol. 4, No. 3, (1957) pp. 195-196.
 - 5 Keeley & Rawlins. op. cit. p. 195.
 - 6 Plenderleith, N. J., "Preservation of Museum Objects in War-time,"
Nature (London) Vol. 152 (1943) pp. 94-97.

APPENDIX B

HEATING OF RESTORATIONS

-- By Robert H. Emerick
(Reprint from Progressive
Architecture, August 1957)

When a project comes into the office for the restoration or conversion of an old mansion, we soon face these questions: "What is the best way to heat this aged pile of materials and history? Can we do with simple heating, or is some form of summer cooling and humidity control essential? Must the system be invisible in all its parts?"

In a syllabus (Table I), the usual purposes for old mansion conversions are tabulated, together with the requirements peculiar to each. Of their individual needs, the demand for invisibility evokes the greatest ingenuity, the treatment of multiple buildings the most considered judgment, and the integration of mixed usage, the knottiest technical problems. How each of these factors may be handled, will be discussed in turn, with case histories.

Problems of Invisibility

In restored historic shrines, the sight of convectors, grills, and registers constitutes an anachronism, and must be avoided. Less severe, but more often encountered, are the requirements of public and semipublic buildings, banks and insurance companies, where invisibility is desired, but inconspicuousness will be accepted.

Invisibility is the result, primarily, of a successful marriage between the designer's imagination and the building's natural structure, but we can approach the problem from at least four points of departure.

First of these is the fireplace. By setting a register or grill well back under the andirons or

charcoal grate, and flush with the hearth, it becomes invisible to 99 percent of those who happen to glance at the fireplace. This opening may be used either as a warm-air supply, or as a return. A tightly closing damper in the flue is essential, of course, to keep air movement on the right track.

The duct serving the fireplace opening may either connect to a central-duct system, or be a short stack originating in an indirect heater under the floor. The first use of this expedient may have occurred at Mount Vernon, Virginia, immediately prior to the present century, where the forgotten designer installed indirect hot-water coils in the basement, and kept the water hot with boilers in an outbuilding, 150 yd distant.

Twenty years later, in 1917, similar use was made of the first-floor fireplaces in Washington's quarters at Valley Forge, Pennsylvania, even to the extent of bringing the hot water through underground pipes from the superintendent's house, approximately 100 yd distant. However, at Valley Forge some thought was given to heating the bedrooms on the second floor - a short stack, or warm-air flue being run from behind the lintels of the first-floor fireplaces to the hearths in the upper rooms. At Mount Vernon, the only heat for the upper floors reaches there by way of natural draft, up the stairwells.

For a restoration project, adaption of the Valley Forge scheme to heat upper floors without direct equipment has excellent possibilities; some control of air movement through the auxiliary flues becomes essential, however, to keep the balance.

For a second excursion into invisibility, we can use the doorway-cornice design. Since this scheme puts the grill approximately seven ft above the floor, it becomes invisible to all normal traffic in the room.

Cornice grills have been used most expertly at

Monticello, Virginia, where an all-year heating and cooling system was installed by the Thomas Jefferson Memorial Foundation in 1954. Incidentally, this latest restoration of Monticello, with its all-year atmosphere control, sets an unmistakable pattern for future projects in historical preservation. The objective is not human comfort, but to delay the decay of the aged fabrics, manuscripts, and furniture normally on display in the rooms and halls. As an indirect benefit, the building itself will last longer, since the controlled humidity and temperature discourage termites and dry rot. We can expect more of this in the future, not only for new projects, but also for additions to the old; the reasons are sound.

A third method, invisibility by concealment, is of course an obvious expedient. Except for running the ducts, it is especially suitable for warm-air systems, since the registers or grills slip easily into position behind draperies, or behind plate rails high on the walls. Compared with cornice grills, which must be sized and manufactured especially for the purpose, the put-it-behind-something approach has the advantage of using more or less standard equipment. We might save a little money that way - providing we can reach the opening with a duct.

Fortunately, the business of hiding an air entry in some unlikely position has much less influence on ultimate room comfort than originally was thought to be the case. If we can get enough Btu into a room to meet its needs, even if the point of entry is behind the valance over a window, these bearers of comfort will get around everywhere, sooner or later. This is not efficiency, we recognize, for hot spots and perhaps a cool corner might be found; efficiency, however, in these jobs comes second to invisibility, and certainly a livable atmosphere is established, unseen.

The fourth approach to invisibility is camouflage: We make our heat sources look like something else. A corner cabinet to the unsuspecting viewer, for example, is actually a circulating stack for a hot-water convector.

Camouflage is particularly suited to wet heat, steam, and hot water, since radiators and convectors are bulky and require some air movement over them for best results. Openings for the air circulation dare not use screens or grills to avoid the appearance of unfinished voids, consequently some other form of masking is needed. Decorative pickets do this admirably.

The corner-cabinet device is used in the dining room and study of Pennsbury Manor, William Penn's restored country estate on the banks of the Delaware, about 20 miles above Philadelphia. Incidentally, this project uses hot water and convectors throughout, not all of them effectively concealed.

Regardless of our choice of system, the problem of invisibility is complicated by the difficulties of delivering heat to the room dispensers. Piping is moderately easy to handle, primarily because of its small bulk; at Pennsbury Manor it reaches the corner cabinets from the basement simply by rising through the floor. Elsewhere, considerable snaking is possible.

By contrast, the ducts from a central system can dismay the designer. At Monticello, for example, the solid masonry walls are at least 16 in. thick, and numerous; moreover, between the floor joists at the third-floor level, Jefferson had stuffed the nogging of his day. This was an arrangement of bricks packed in clay, and served both as heat insulation and as a fire stop. Amid these obstacles, the designer discovered a lucky feature. Jefferson loved to invent, and during a bubbling of this talent, he fitted Monticello with two indoor necessities, said to be the first in a private home in the Colonies. (A similar device is in a jail cell at Williamsburg.) Each of these necessities occupied a kind of light shaft, about four ft square which extended all the way to the roof, where it was crowned by a skylight. Doubly lucky, the shafts were back to back and nearly in the middle of the building. So, into one of these went the riser duct that now conveys treated air to the

third floor. Bricks and clay were taken from between the floor joists, in a total amount of nearly 100 tons, to make room for the branch ducts and rock-wool batting. Returns find their way back to the machinery room, in a wine cellar, by way of fireplace grills on the first floor and ducts in the basement.

All old mansions do not have light shafts, but many of them do have sealed-off voids that run from basement to attic. A likely place to look for one is along side a fireplace chimney, an area in which these "secret" passages seem likely - probably because wide chimneys were the rule and a few extra inches would not be noticed. Usually there is no record of these voids, their existence may have been forgotten for 100 years, and the designer, hunting a duct chase, has no alternative but to go about tapping walls.

In extremes, we might even use a fireplace flue itself, either as a pipe chase or as a duct to the upper floors. The point is that somewhere, someway we can take advantage of the peculiarities of the building. What is needed is a combination of imagination and observation, in order to single out the peculiarity we can use.

Invisibility, of course, is inherent to radiant-panel designs, whether in the floor, ceiling, or walls. Unfortunately, unless the project happens to be a 100 percent restoration, radiant panels are not suitable from a construction viewpoint. To apply pipe coils, or electric cables to a ceiling or a floor, we must provide new surfaces - of plaster or concrete - and the result can never be a perfect match with the original. To do so is guaranteed to make antiquarians deeply unhappy.

The invisibility problem can be summed up in this way:

1. For historic restorations, invisibility is essential.
2. We have case histories illustrating four methods of achieving it, but there are many others waiting to be created by our imaginations.

3. Taking advantage of structural peculiarities is a prime route to a satisfactory installation.
4. Ducts are more difficult to handle than pipes, but registers fit in easier than convectors.

Pros and Cons of Group Heating

Which is better for heating a number of buildings: a single plant with an underground distribution system; or a local heater in each?

Experienced judgment, sitting in criticism on an economic comparison in each case, is the only source of answer to this question. The major factor concerns the life and maintenance of the underground distribution system, and here are some interesting records.

At Valley Forge, the restoration group includes five buildings, all served from a central-boiler plant by hot water. The original installation was made about 1917, using oversize iron pipes as conduits for the hot-water supply and return lines, which were also of ferrous material. By 1949, replacements of the underground system became necessary - the new construction employing steel pipes insulated by wool felt and protected by modern conduits of clay tile. In this case, therefore, the service life was about 32 years, although some trouble had been experienced with leaks long prior to the replacement.

Mount Vernon got its first mechanical heating in 1900. Coal-fired boilers energized hot water that traveled by gravity circulation to the mansion, to the offices, museums, and living quarters of employees. The pipes were insulated with cork, set inside clay tile, and buried in the earth. Maximum travel distance was to the mansion, approximately 150 yd away.

Thirty years later, the need for a new distribution system demanded action. Designed by Prof. C. W. Killan, of Harvard, the new arrangement provided pumps for positive water circulation, and set the piping inside a concrete-pipe tunnel five ft high and three ft wide. Since the tunnel is large enough for a

man to move through its full length, and is lighted, a close watch of piping conditions and the prompt correction of leaks is practical.

This is an excellent way to build a distribution system; personal inspection suggests that the piping will last indefinitely at least from the standpoint of external attack. Internal corrosion, of course, is independent of ground conditions and must be fended off by proper water conditioning.

The joker in tunnel construction is its cost; can the project stand it?

Pennsbury Manor with its numerous auxiliary buildings was completely restored in 1937, and the heating system dates from the same year. The boilers are in the basement of the superintendent's house, and the hot water is pumped to three or four other buildings - the mansion being farthest away, perhaps 250 yd.

This system of steel pipes, thoroughly insulated, and borne on rollers in claytile conduit, is presently experiencing some leaks. There is only one way to cure them - by digging down to the pipe - and this will involve time and expense. There is some anxiety, naturally, over the condition in which the piping will be found after 20 winters of service; extensive replacement might be needed. Also, how much longer will the system be likely to last?

Monticello, likewise a group restoration project, cannot as yet present evidence one way or the other; it is too new. However, the system design approximates that of Pennsbury Manor, with steel hot-water pipes extended from the old Weaver's Cottage to the museum, office, superintendent's quarters, and the mansion, where the heat is transferred from the water to the force-air system. The pipes are encased in modern clay-tile conduit.

How many of these leaks and replacements originated in ground attack on the piping, or from internal corrosion, or a combination of both, we do not

know. However, in the absence of exact knowledge to the contrary, we might conclude that: (a) the life of underground-piping systems for hot-water heating may be expected to run from 20 to 30 years; (b) boiler-water conditioning should be regarded as an essential economy. We might also note that a single, central plant is the traditional way to heat a group of buildings.

Presently the concept of the separated, local heating facility is gaining favor, primarily because the traditional reasons for the single plant no longer exist. Fifty years ago, a boiler needed somebody to shovel coal and take out the ashes, and by concentrating these needs in a single boiler room, the designers saved operating labor. As a second reason for keeping boilers out of historic basements, the existing fireplace chimneys, more often than otherwise, were crooked, unlined, and fire hazardous. This meant the erection of a new chimney, somewhere, for the new boiler - a bit of construction hardly in keeping with the spirit of the mansion or its architecture. In the circumstances, locating the boilers in an auxiliary building was the simplest solution.

Today, thanks to automatic firing and the availability of gas and oil fuels, one man cares for three boilers as easily as he cares for one. He can go about his duties in a coat and tie, if he wishes. As for the aged chimneys, we have flues that can be inserted from the roof and even go around corners, staying gas tight and safe all the way. A new heater in an old basement, therefore, is no longer impractical.

Which system is better will show up, to some degree, in a comparison of owning costs. On one hand we have three or four boilers, three or four chimney remodelings, three or four oil tanks or gas connections. On the other hand is a single boiler, one chimney, one fuel system, and a network of distribution piping, all new. These constitute the capital investment, and for each alternative we must add the maintenance costs expected over the next 20 years.

In this way we come to the predicted owning costs; and whichever is the least will have a strong claim on our acceptance.

Predicting maintenance costs is where judgment becomes of prime value. A suggested formula based on the records of other systems, similar to the construction of the new project, follows:

$$M = \frac{X \times Z}{Y} \times 20$$

M = predicted maintenance for a period of 20 years.

X = total recorded maintenance costs for one average year of three or four similar systems.

Y = total linear feet of underground piping in the systems included in X.

Z = total linear feet of underground piping in the project for which the prediction is being made.

20 = twenty years.

Developing the comparative owning costs over a 20-year period is desirable for accuracy, since maintenance needs seldom become important until the second decade of service.

Situation with Mixed Usage

Mixed usage follows conversions rather than restorations. It means that part of the converted building will be satisfied with simple heating and part will require all-year air conditioning; or that part of it must be ventilated positively, while the remainder does very well with infiltration. Any of these combinations can be additionally complicated by differences in the hours of use.

The prescription for handling these diverse situations must be tailored to fit the peculiarities of each case. For example, consider a conversion to a school, with classrooms needing daily ventilation on the lower floors, and dormitories needing simple heating on the upper. The solution can be in either of two forms: (1) a duct system throughout, with the designer running his air channels as best he can, and

zoning with motor-operated dampers both time and temperature controlled; (2) the so-called split system, which is widely liked, has simple radiators or convectors in the dormitory, and hot-water or steam coils in the air ducts that serve the classrooms. The basic heater for a split system is a steam or hot-water boiler.

Occasionally, two separate heating systems will be selected, based on the assumption that operating two small units at high efficiency is economically preferable to a large one that merely simmers at very low efficiency much of the time.

The Irish castle reproduction of the Carrolls, built on a hilltop and frowning over the Hudson at Tarrytown, New York, provides an illustration of the two-system treatment. Constructed during the 1890's, it was originally heated by warm-air ducts operating on gravity; conversion, however, caught up with it 50 years later. Today the great baronial hall, with its knights' shields and heraldic devices, is a truly imposing office, and in the rooms and cellars below, typewriters click and filing clerks hustle from one stack of steel cabinets to another throughout the working day. The old gravity ducts are still there, but served by a modern oil-fired heater with a fan to keep the warm air moving.

Meanwhile, in a wing built about 1900, the present owner lives, and since home life does not shut down for nights, Sundays, and holidays, a different heating schedule is appropriate. Comfort comes to these rooms from a hot-water boiler and circulating hot-water pumps in the basement.

Once in a lifetime, we might find a combination of heating and ventilating problems largely solved for us by the designer of the original mansion. This is true of Biltmore House, near Asheville, North Carolina. More than 60 years ago, during the building of this massive French chateau, vertical masonry air stacks, approximately 10 x 14 in. inside dimensions, were incorporated in the walls perhaps 50 in all. In the

base of each stack is a horizontal steam radiator; the air that is heated by these radiators and rises to the rooms above is 100 percent fresh air, inducted from an air tunnel as shown.

From an engineering viewpoint, this arrangement is wanting in two aspects. First, air movement is not subject to close control - meaning that rooms can be overheated or underheated; second, 100 percent fresh-air makeup is plain waste of heat. Should Biltmore House ever come up for conversion, the designer's first step would be to provide recirculating connections in the basement, and his second would be to introduce fans for warm-air propulsion. Nonetheless, this early dream of air treatment is remarkably adaptable to present practices. Any converting architect or engineer would be lucky to find another like it.

Summarizing the heating problems of restoration and conversion projects, we observe that the guides to their solutions look like this:

1. Invisibility is essential for historic projects. It can be achieved by four established methods, plus those born in our own imaginations.

2. The heating of multiple buildings is in a time of transition. We must evaluate a single, central plant against a group of scattered local units, paying particular attention to the life and health expectancy of underground piping systems.

3. Mixed usage is all engineering, involving the applications of warm air, steam, and hot water in different parts of the same building, and perhaps the relative hours of service. We can mix the systems as necessary to satisfy the mixed demands.

4. Nothing is impossible, but the cost of doing the impossible might be unacceptably high.

HEATING OF RESTORATIONS

Table I: Syllabus of Building Factors

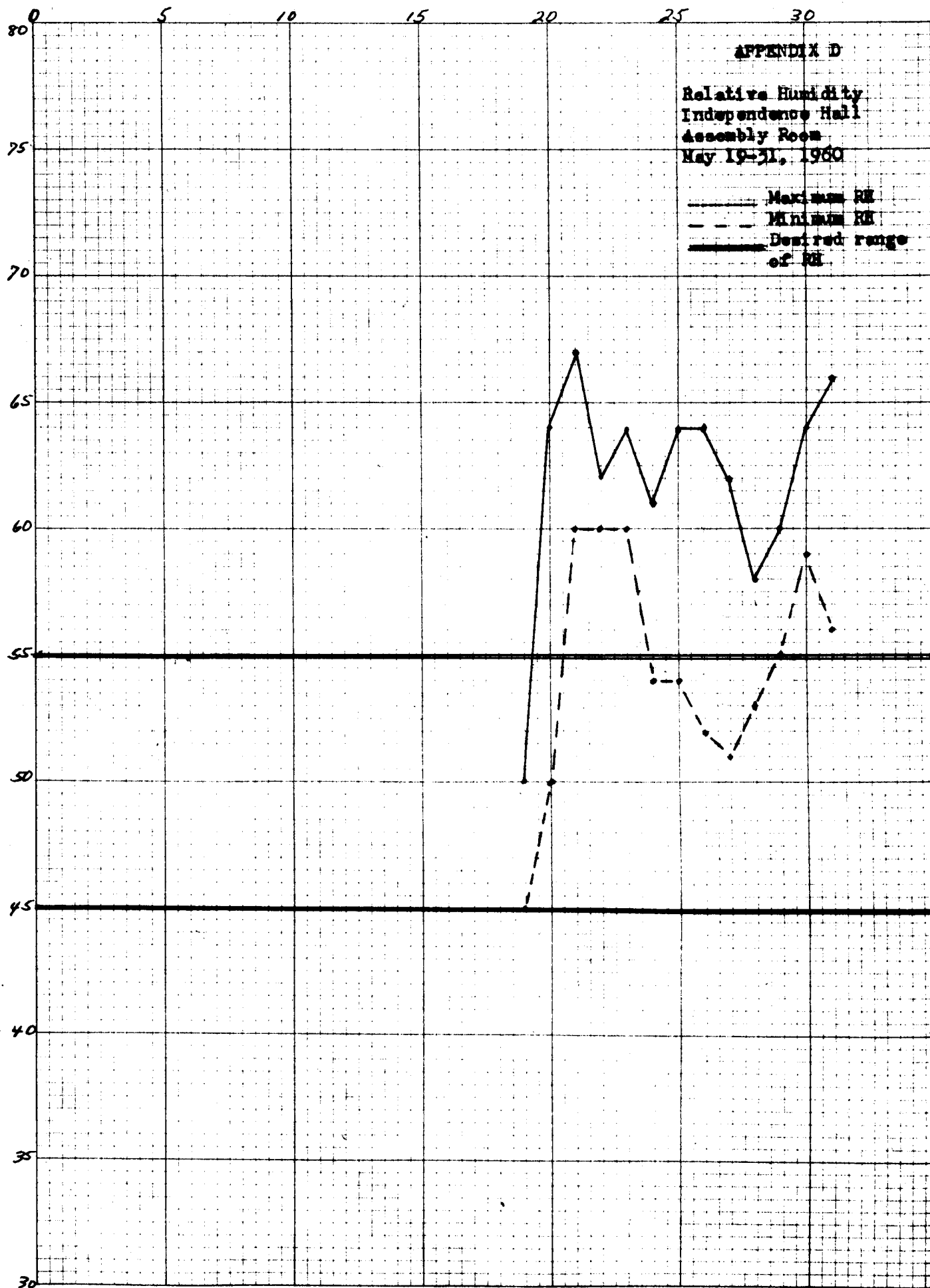
Proposed use of building	Humidity control ¹	Summer cooling	Integral ² ventilation	Multiple buildings	Invisibilty
Offices	No	Yes	Possibly	No	Sometimes
Orphanage	No	No	No	Yes	No
Convalescent home	No	No	No	No	No
Home for Aged	No	No	No	Possibly	No
Historic shrine	Yes	Possibly	Yes	Yes	Yes
Classrooms	No	No	Yes	Yes	No
Dormitories	No	No	No	Possibly	No
Country club	No	Partial	Partial	Possibly	No
Museum	Possibly	Possibly	Possibly	Possibly	No
Insurance or foundations	No	Yes	Yes	Possibly	Sometimes
Lodge rooms	No	Perhaps	Perhaps	No	No
Religious	No	No	No	Yes	No

¹ All year control.

² Integral with either the heating or summer cooling system.

NOTE: This syllabus applies to the average project. Deviations will be encountered from time to time.

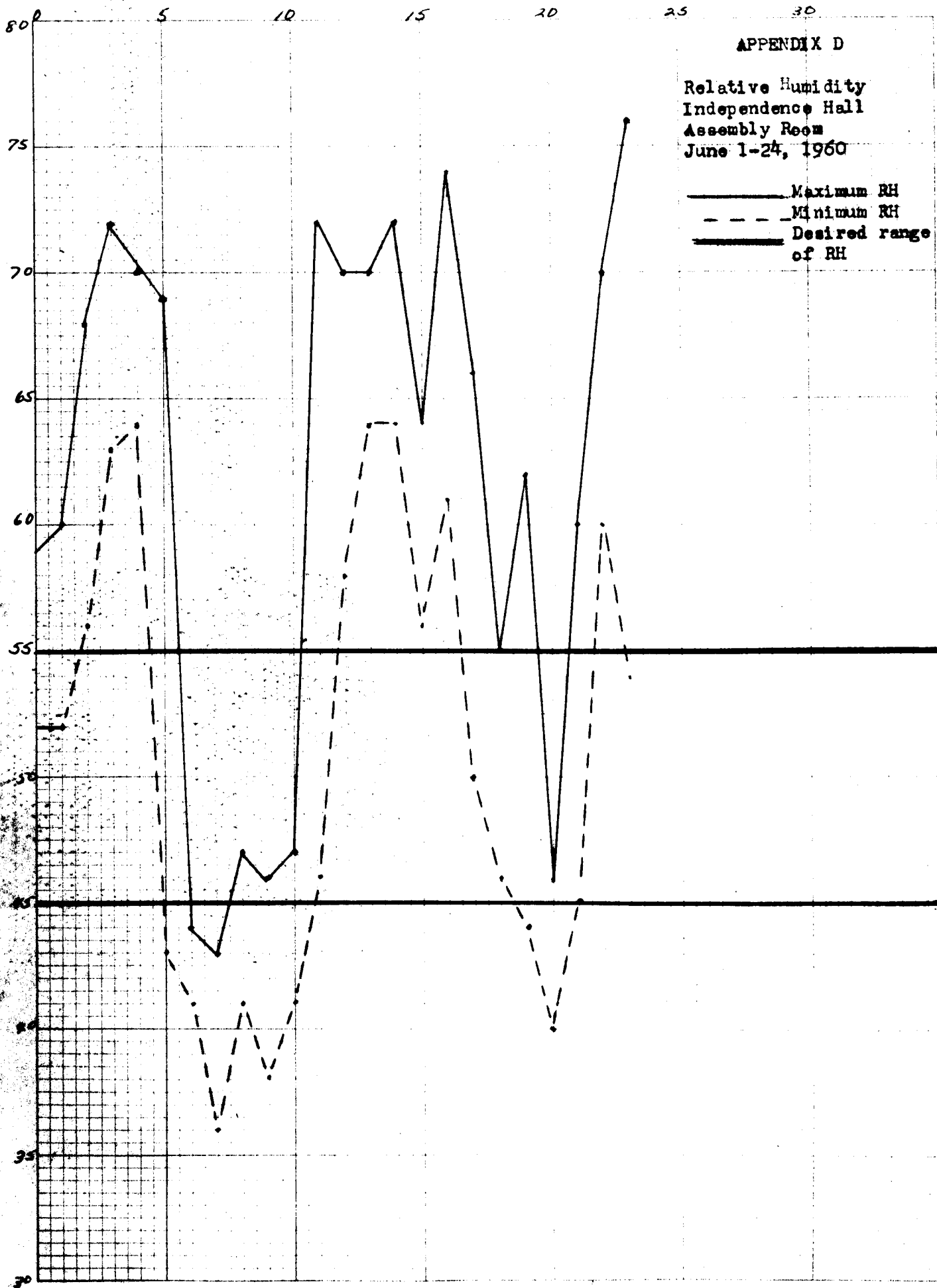
NATIONAL TRUST FOR HISTORIC PRESERVATION
2000 K Street, N. W., Washington 6, D. C.



APPENDIX D

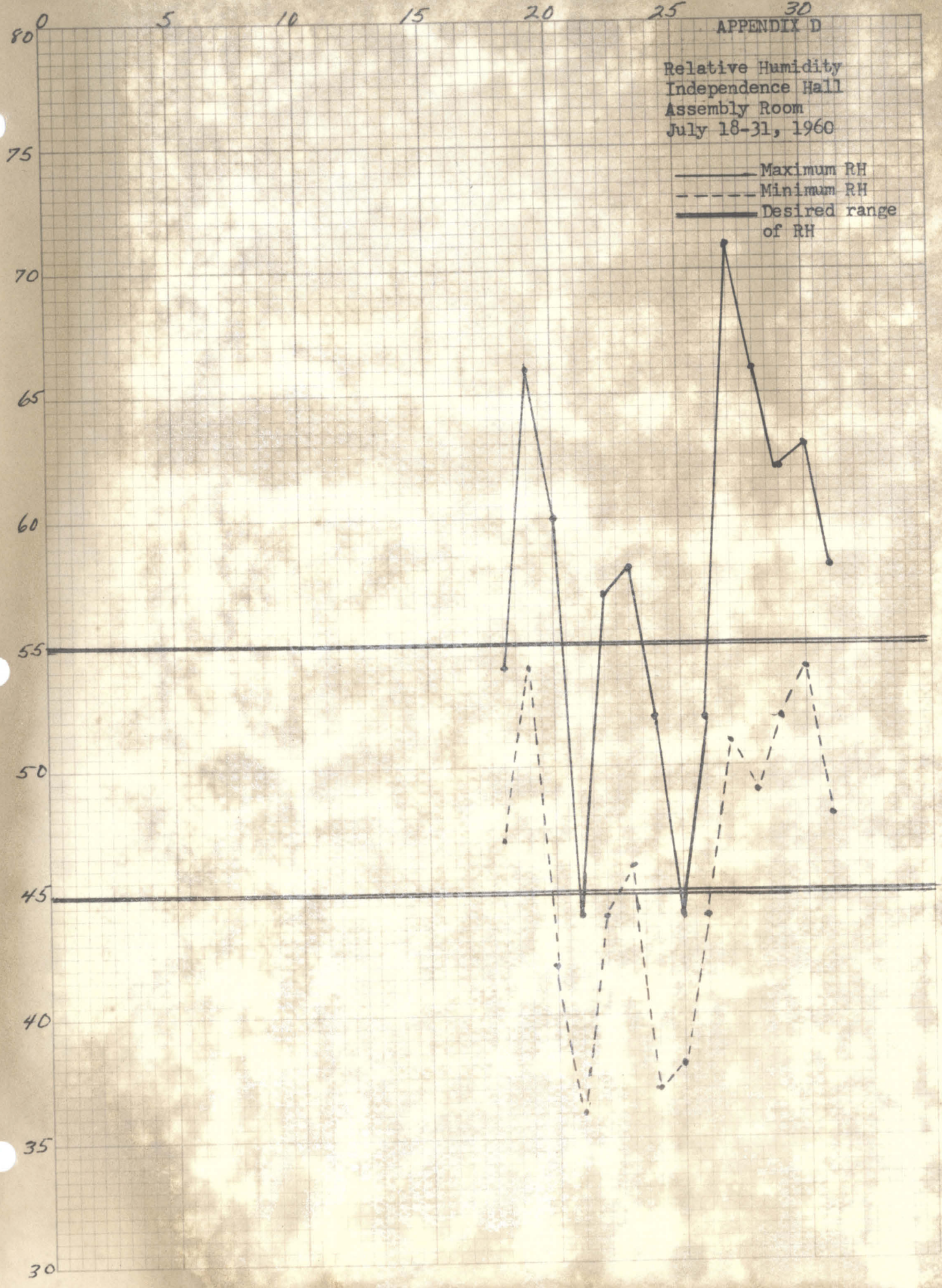
Relative Humidity
Independence Hall
Assembly Room
June 1-24, 1960

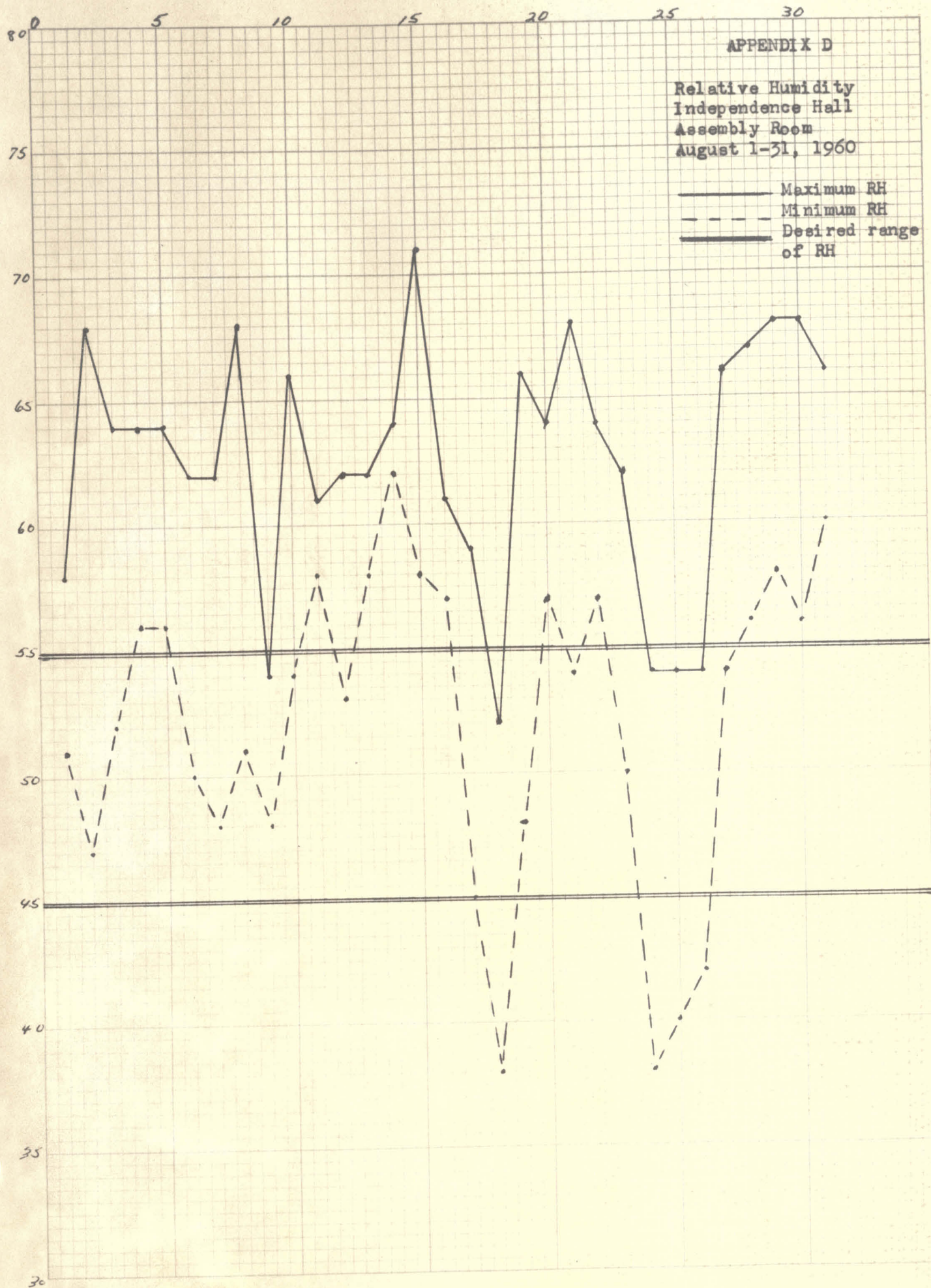
— Maximum RH
- - - Minimum RH
= Desired range of RH

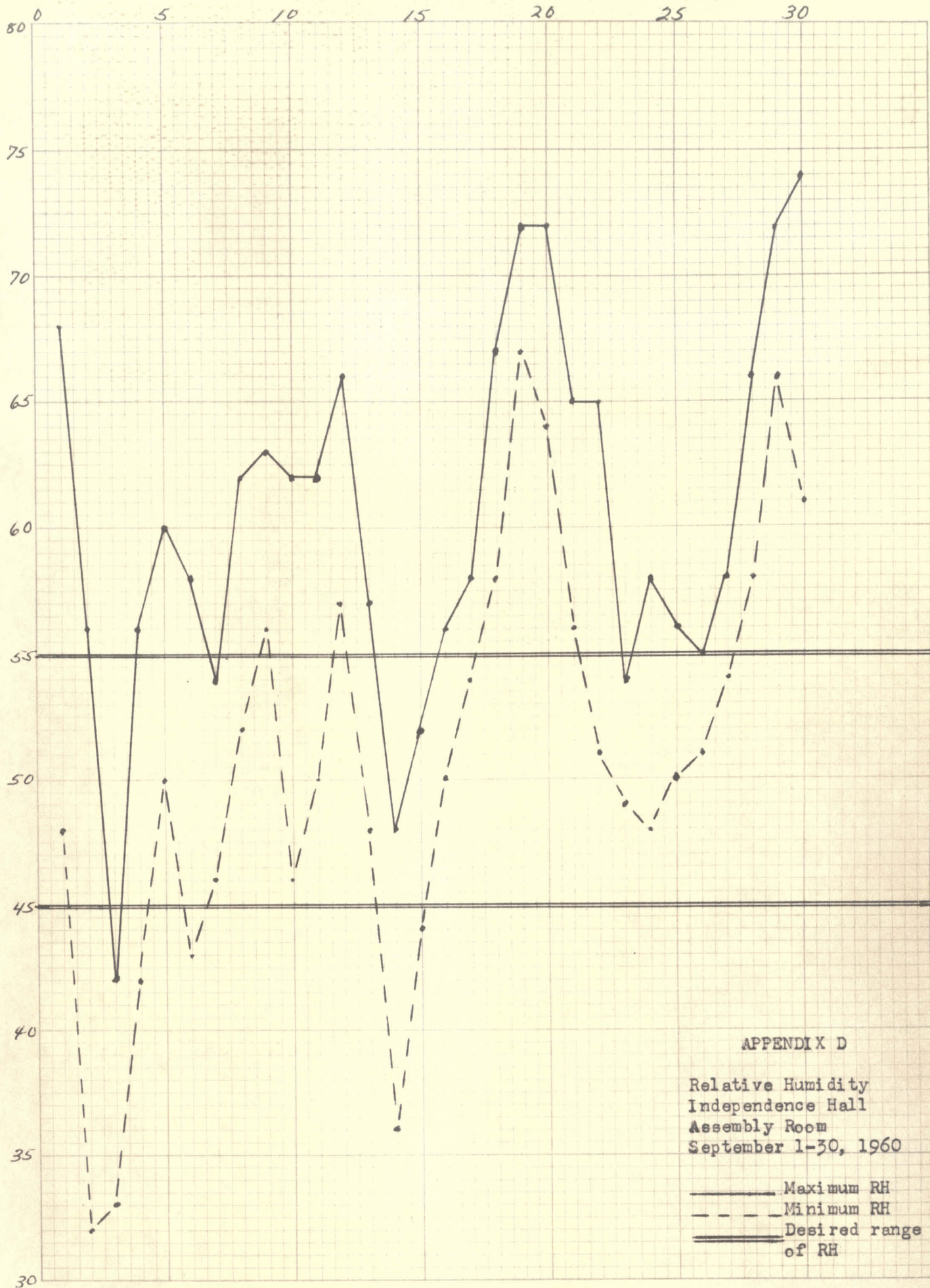


Relative Humidity
Independence Hall
Assembly Room
July 18-31, 1960

— Maximum RH
- - - Minimum RH
= Desired range of RH







APPENDIX D

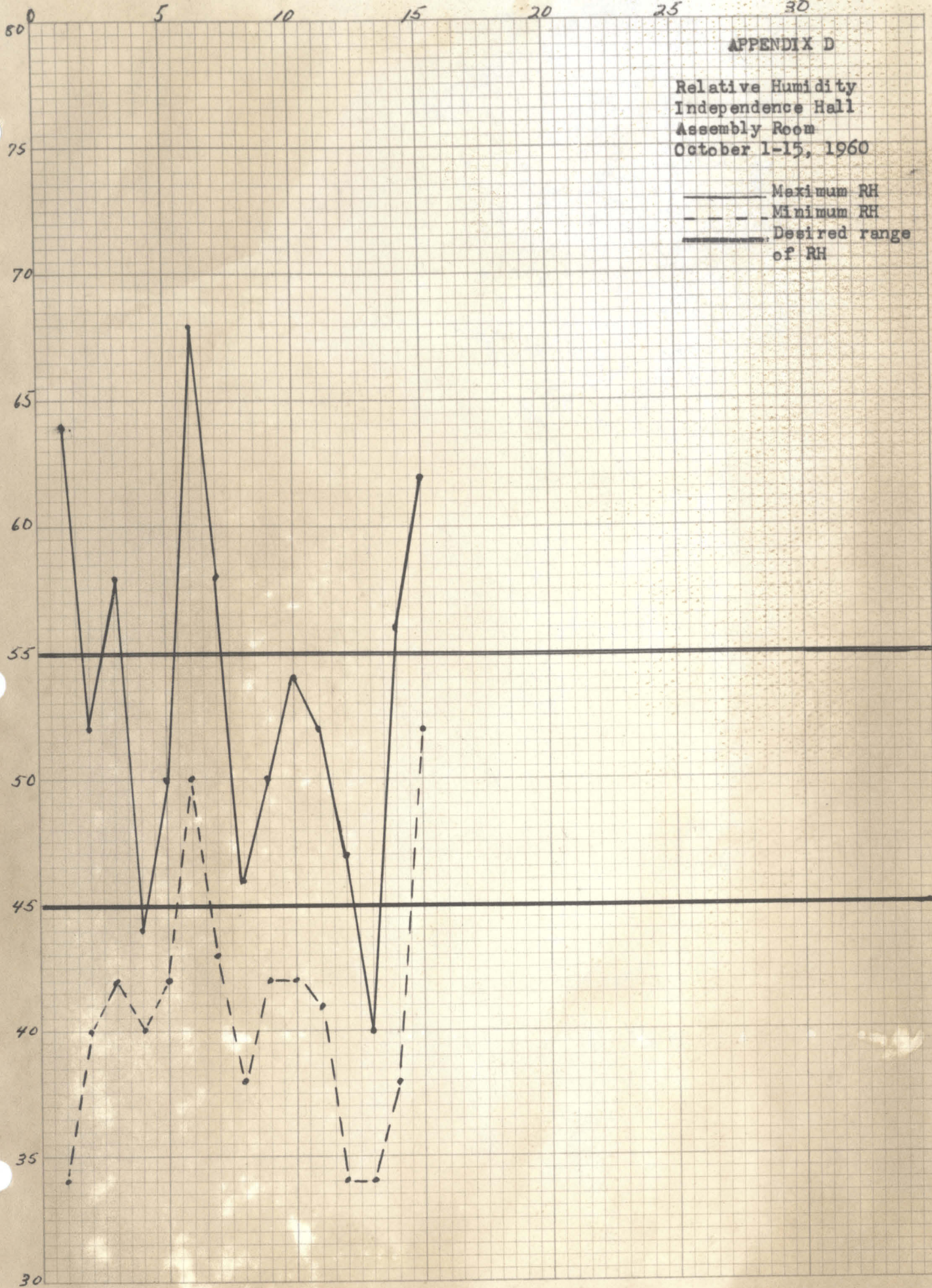
Relative Humidity
Independence Hall
Assembly Room
September 1-30, 1960

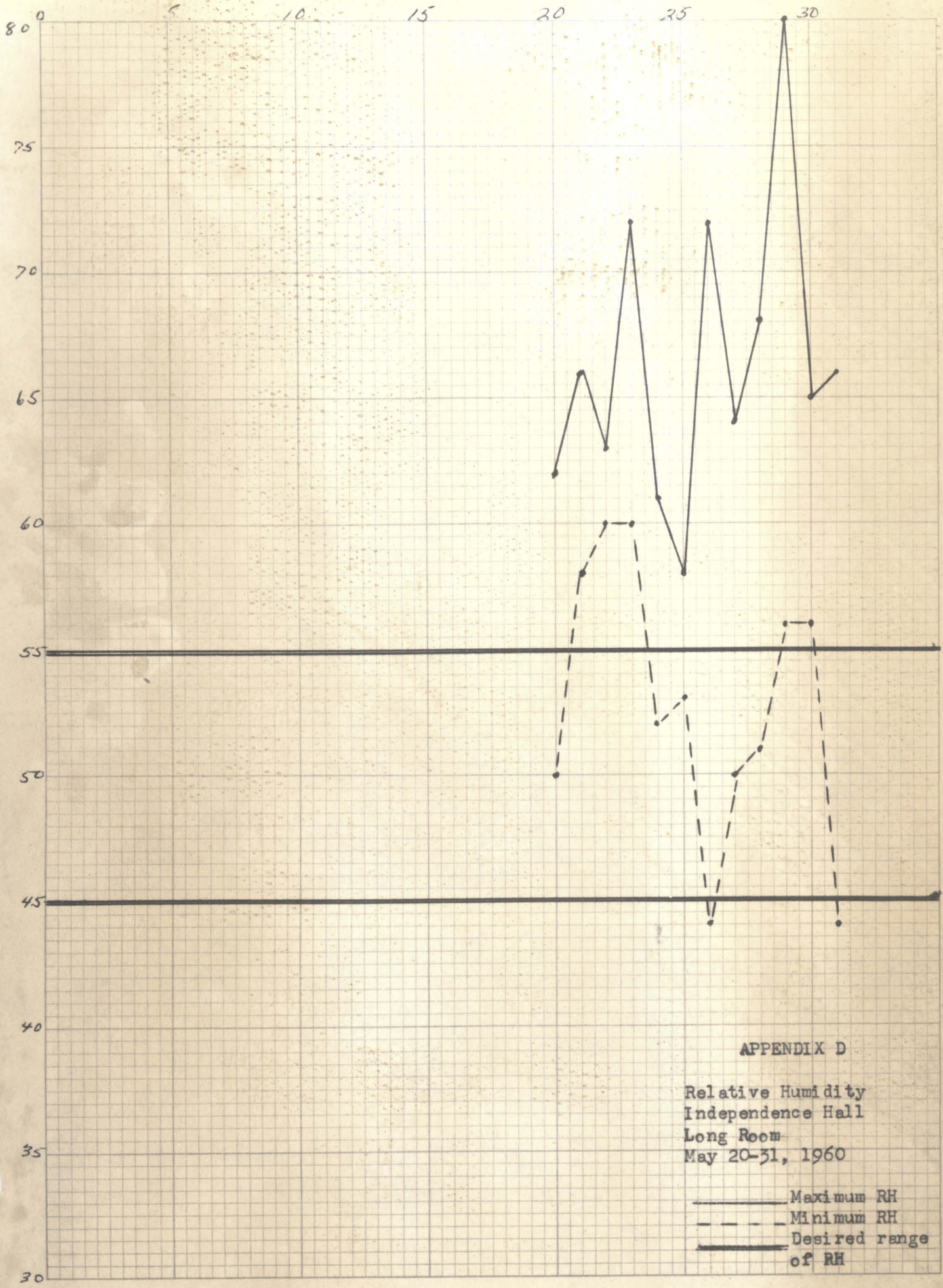
—•— Maximum RH
- - - Minimum RH
= = = Desired range
of RH

APPENDIX D

Relative Humidity
Independence Hall
Assembly Room
October 1-15, 1960

Maximum RH
Minimum RH
Desired range
of RH





APPENDIX D

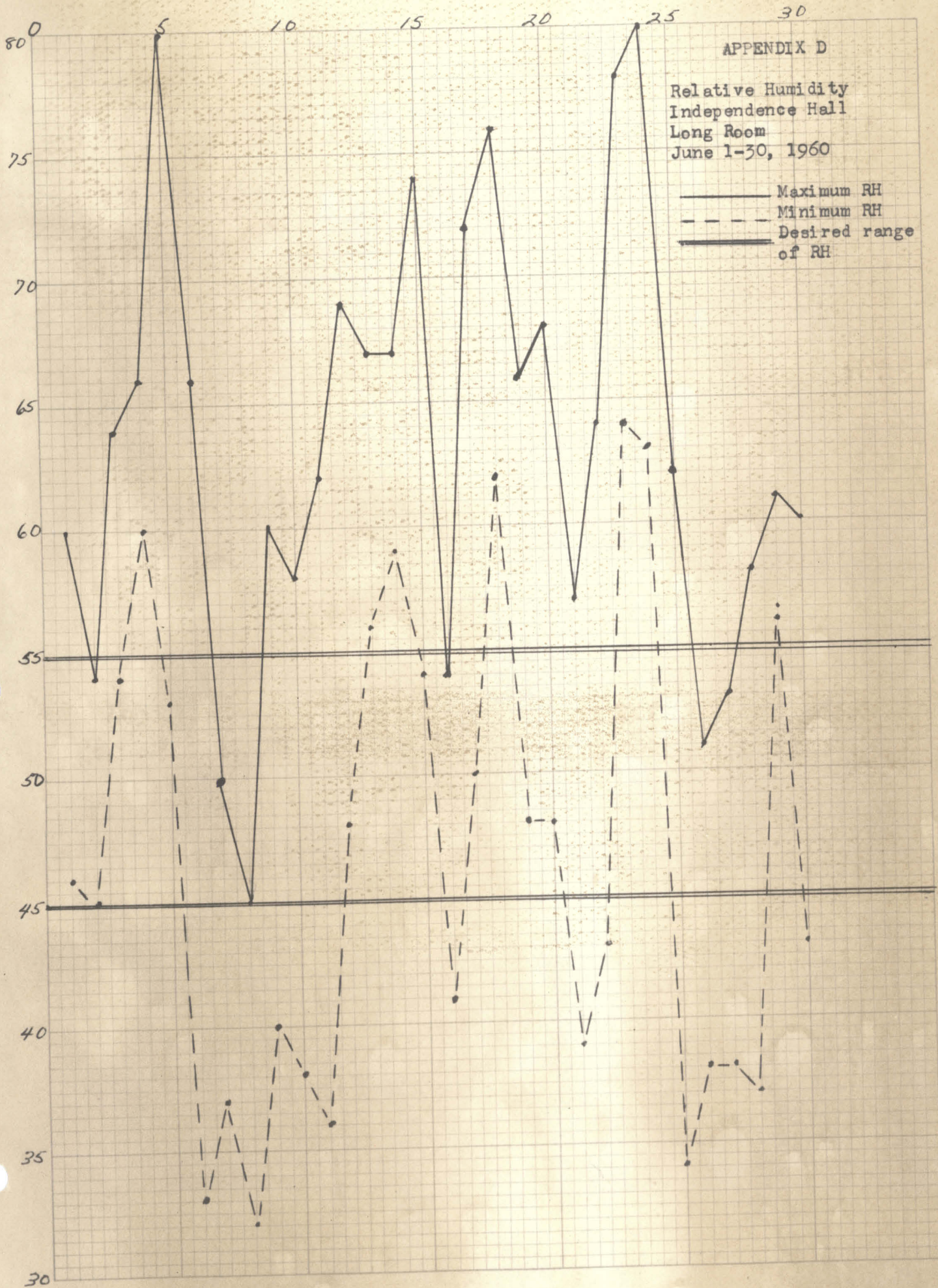
Relative Humidity
Independence Hall
Long Room
May 20-31, 1960

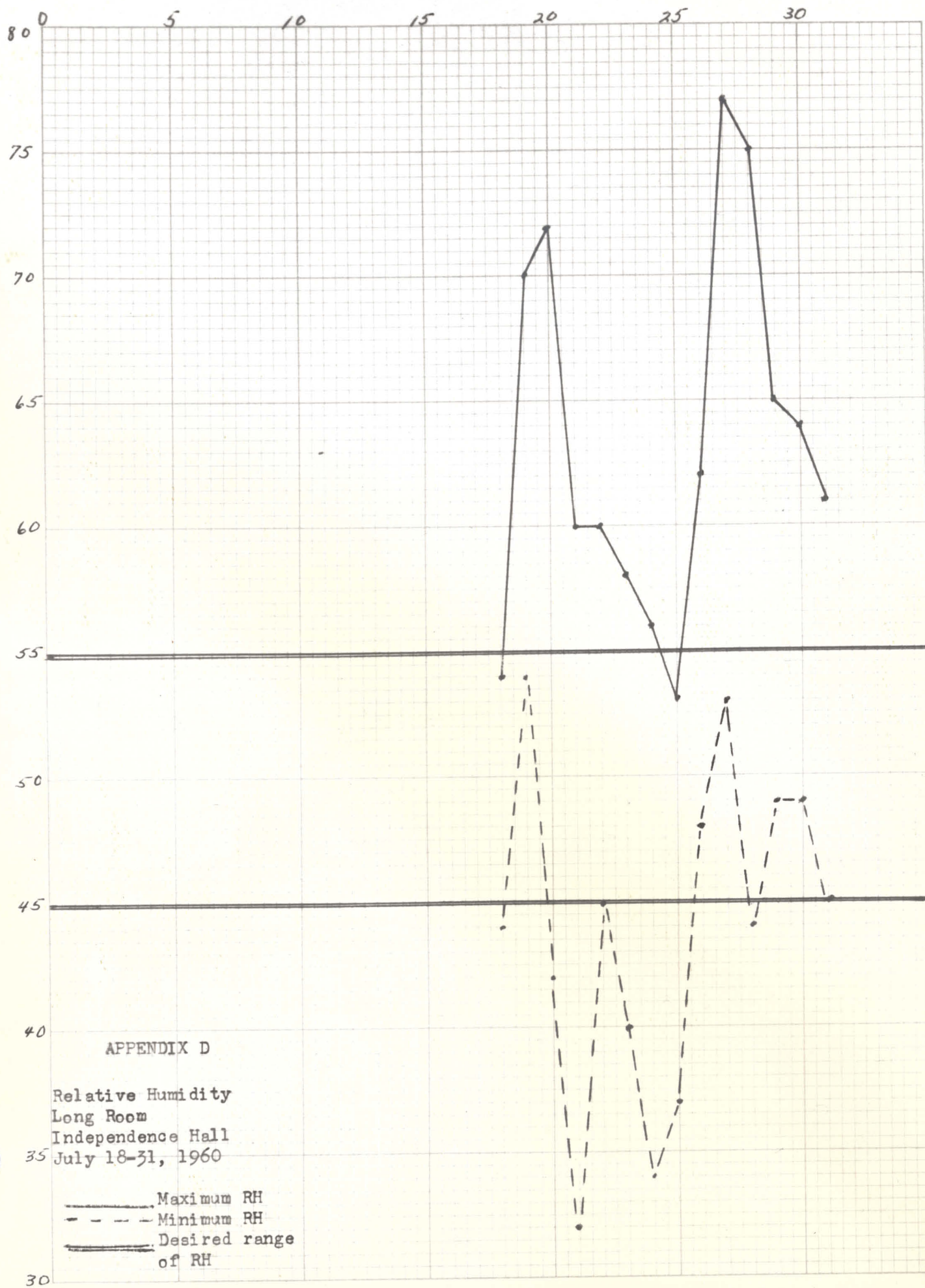
———— Maximum RH
----- Minimum RH
———— Desired range
of RH

APPENDIX D

Relative Humidity
Independence Hall
Long Room
June 1-30, 1960

— Maximum RH
- - - Minimum RH
= Desired range of RH



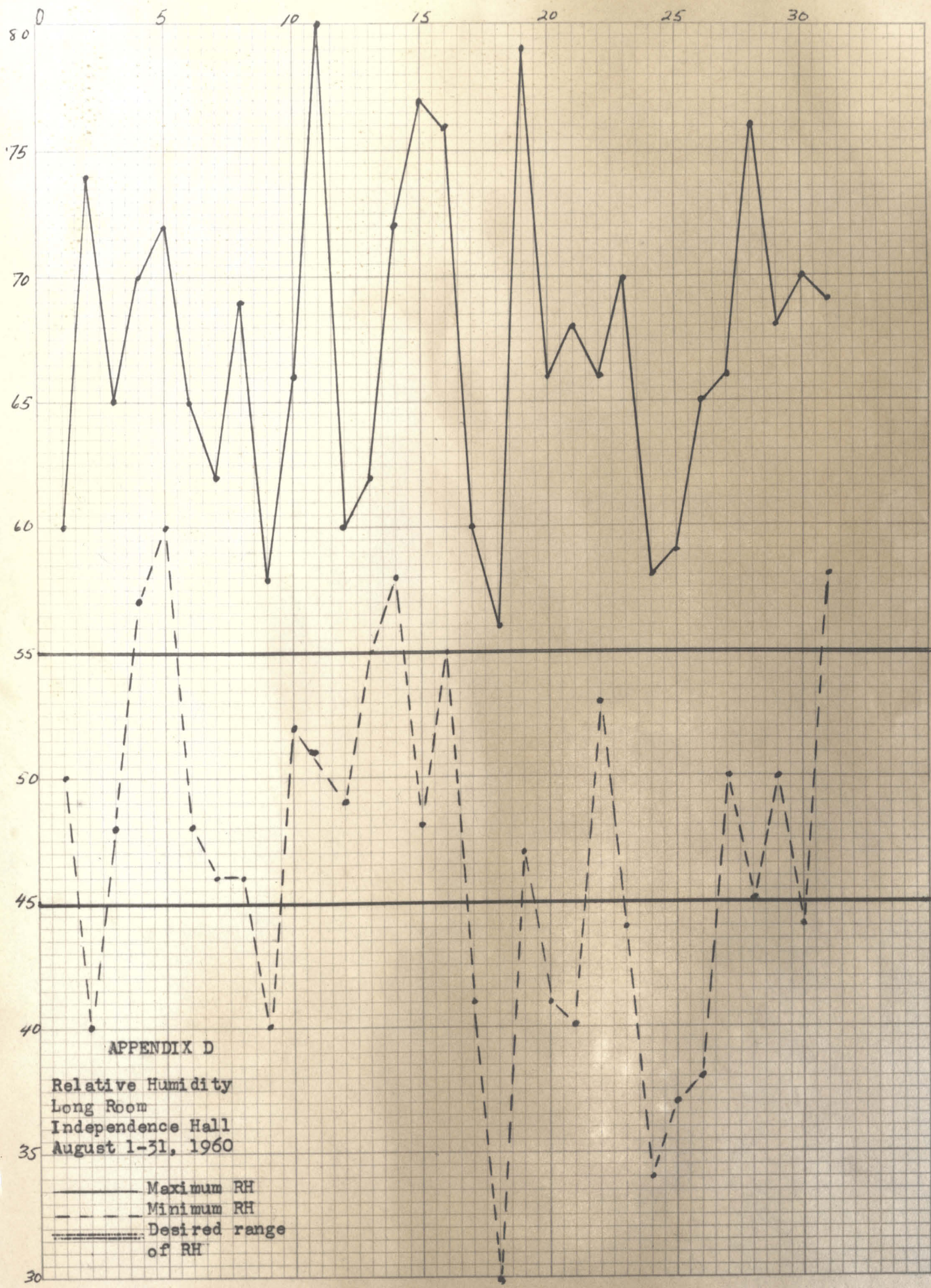


APPENDIX D

Relative Humidity
Long Room
Independence Hall
July 18-31, 1960

Maximum RH
Minimum RH
Desired range
of RH

30 TO NCH 58-5
REUFFEL & ESSER CO. MADE IN U.S.A.

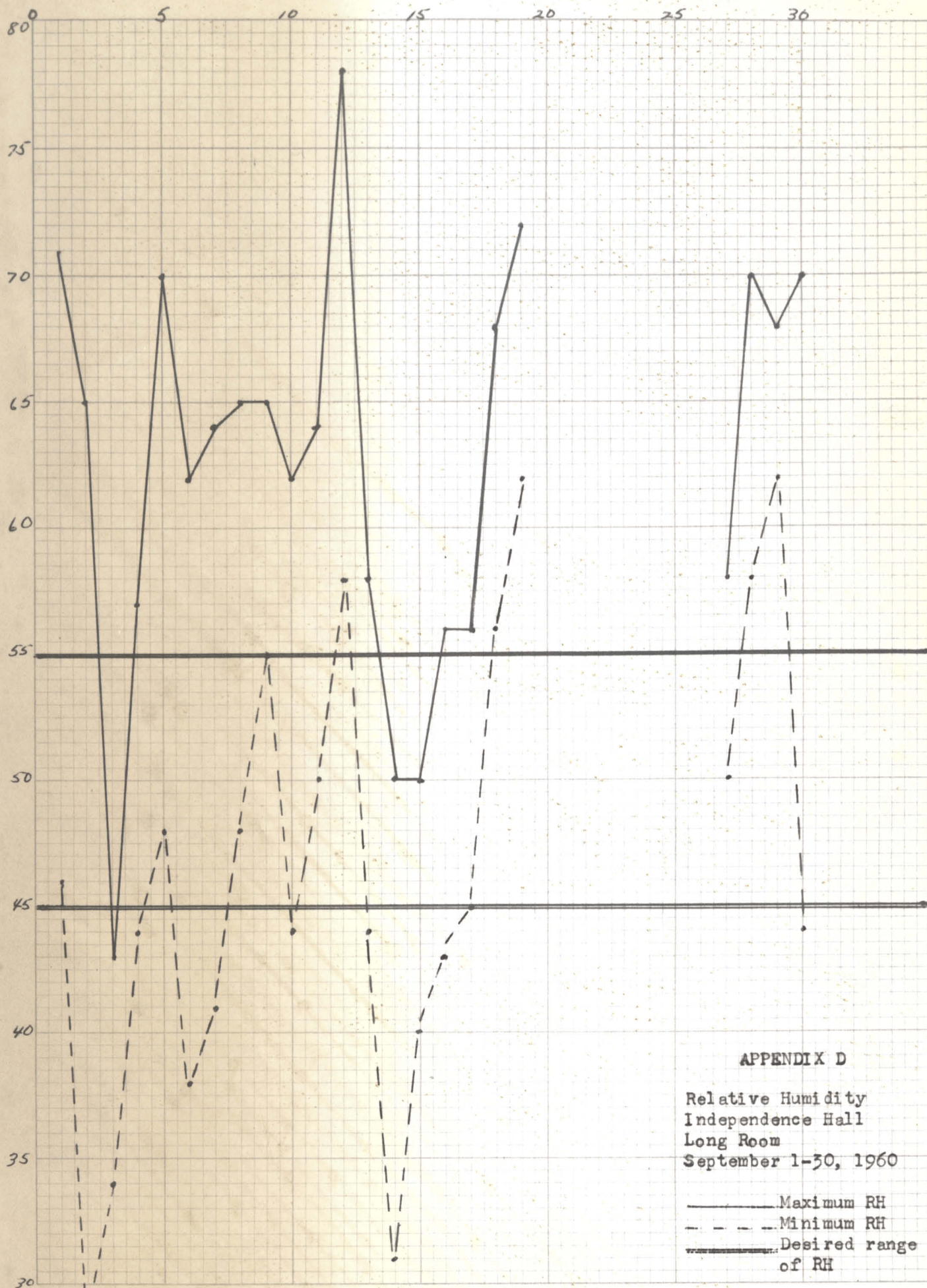


APPENDIX D

Relative Humidity
Long Room
Independence Hall
August 1-31, 1960

— Maximum RH
- - - Minimum RH
= = = Desired range
of RH

10 TO 1 INCH 158-4
K E F NEUFFEL & ESSER CO. MADISON, WIS.



APPENDIX D

Relative Humidity
Independence Hall
Long Room
September 1-30, 1960

— Maximum RH
- - - Minimum RH
—— Desired range
of RH

80 0 5 10 15 20 25 30

APPENDIX D

Relative Humidity
Independence Hall
Long Room
October 1-16, 1960

— Maximum RH
- - - Minimum RH
= = = Desired range of RH

