A RESEARCH LABORATORY
FOR DRAPER CORPORATION
HOPEDEALE, MASSACHUSETTS

This Thesis is submitted in partial fulfillment of the requirements for the degree of Master in Architecture,

to

Dean Pietro Belluschi,
School of Architecture and Planning,
Massachusetts Institute of Technology,
August 22, 1951

by

David McCandless, Jr., B. Arch.
A RESEARCH LABORATORY
FOR DRAPER CORPORATION, HOPEDALE, MASSACHUSETTS

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David McCandless, Jr.

ABSTRACT

Thesis submitted for the degree of Master in Architecture, in the Department of Architecture, Massachusetts Institute of Technology, August, 1951.

This thesis is the design of a Research Laboratory for Draper Corporation in Hopedale, Massachusetts. The corporation is the world's largest manufacturer of single shuttle looms, with the enviable record of one hundred and thirty five years of leadership in textile machinery development.

The activity within the proposed Research Laboratory will be essentially product development, consisting of design, fabrication, and testing. A staff of engineers and draftsmen will study and draw up the various proposed improvements and new machinery for the textile industry. A machine shop will produce each new improvement and machine for assembly. Then, after trial runs, a whole battery of looms will be set up in a weave room for long range testing under simulated conditions. To assist in this work, there will be special laboratories and services, as well as conference rooms and offices.

One of the major problems in the design of this building is making it as flexible as possible so that any research project may be carried out efficiently. A special air-conditioning system will be required to duplicate mill conditions in some parts of the laboratory. The site is a good one but it has the problem of a high water table. Draper Corporation is definitely planning to build a research laboratory in the near future, so all these and other conditions which affect this thesis are real.
Dear Dean Belluschi:

As partial fulfillment of the requirements for the degree of Master in Architecture, I respectfully submit my thesis entitled, "A Research Laboratory for Draper Corporation".

Sincerely yours,

David McCandless, Jr.
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FOREWORD

This thesis has come about through the help and interest of several men, and through my desire to work on as real a problem as is possible in an architectural school. In March, 1951, while discussing thesis subjects with Professor H. L. Beckwith and Professor W. H. Brown, I explained that I wanted to design an industrial building for my thesis, if I could find a company that would be interested and willing to act as a "client" for me. We spoke of various industrial building types and of various methods of reaching possible "clients". Two weeks later it was suggested that through the Industrial Liaison Office of M. I. T., I could contact the Draper Corporation which was interested in seeing what an architectural student might design for them for their proposed research laboratory.

At the end of April, arrangements were made for me to go to Hopedale, Massachusetts to meet Mr. Fred M. Fitzgerald, the director of research for Draper Corporation. We discussed the general problem of the research laboratory as well as the nature of a graduate thesis. At that time I met Mr. Edward Horton of the same department. Mr. Horton had studied the requirements for a new building for the Research Department about a year ago, at which time he drew up the study plans included in this report. He has given me these and other items as background material and information sources for my work. He helped me considerably in writing my program.

1. See blue line prints in Appendix
2. (a) Blue line prints, see Appendix
   (b) "Five Generations of Loom Building" by W. H. Chase, Draper Corp.
   (c) An Outline of the Textile Manufacturing Processes by General Electric
   (d) Test Borings, see Appendix
   (e) Aerial photographs and photographs of products and production
In architectural schools, both theses and regular design problems have often been called "paper architecture" because of a lack of realism. Sometimes, however, the realism of an actual client is quite a handicap to a good design solution; and, for that reason, "paper architecture" with its freedom of design, has its place in school. As a student learns the fundamentals of design, freedom of design should be kept, but a certain amount of realism is necessary so that when his studies are over, he will not graduate with his head in the clouds. An architect must learn to design freely, but, at the same time, he must recognize the disciplines of reality. For this reason, I wanted a "client" for my thesis. I am well pleased with the program which Mr. Fitzgerald and Mr. Horton have helped me set up; for it is realistic and yet it has no lack of freedom in design. I hope that Draper Corporation will find in my design solution some answers to their problems and some architectural food for thought.

David McCandless, Jr.
THE SITE, FROM ACROSS THE POND
THE HISTORY AND BACKGROUND

The history of Draper Corporation, the world's largest manufacturers of single shuttle looms, is a story of development and progress. It tells of the pioneers of the American textile industry and of the five generations of the Draper family which have sparked the expansion of the business. Today, the corporation is planning the erection of a building for research and product development. This progressive effort typifies Draper Corporation's successful position in both the textile industry and the industrial growth of the United States.

The story of Draper Corporation begins with an ancestor named Le Drapour, who went with William the Conqueror to England, and who was influential, with his sons and grandsons, in locating cotton and woolen manufacturing in the famous Manchester district of England. One of his descendants, James Draper—the-weaver, emigrated from England to Boston in 1647 and settled in Roxbury, Massachusetts. He was the first professional weaver and fuller of cloth in the American Colonies. James' son and grandson were farmers in Dedham, Massachusetts with an interest in a fulling mill at Green Lodge in that town.

1. All the facts and a great many of the general thoughts found in this History and Background are taken from "Five Generations of Loom Building, a History of the Draper Corporation" by William H. Chase, published and copyrighted by Draper Corporation, 1950, printed by the University Press, Inc., Cambridge, Mass. This text was given to me by Draper Corporation as a source of background information.
Ira Draper, the great-great-grandson of James-the-weaver, founded in 1816 the company which has become the Draper Corporation. That was in the days when the artisans and craftsmen of the 18th Century were being succeeded by the beginnings of the American factory system, of which the textile industry was a pioneer. There were then 170 textile mills in the whole United States, but they were all small. Nearly all of these were yarn mills, with their product sold to home weavers and a few groups of hand-loom operators.

In England in 1785, Edmund Cartwright had invented the power loom, but it was of no practical use to the English industry until 1803 when invention of a dressing machine and warper made it possible to prepare a warp able to stand the increased tension of power loom weaving. There were scarcely 2400 power looms in English mills in 1816 when Ira Draper started his business. That was also the year when cloth was first sold from the first power loom in America, in Waltham, Massachusetts.

Ira Draper was a man of outstanding inventive ability. Although he invented a road scraping machine used for a century, and a threshing machine which influenced McCormick's, his main work was with textile machinery, and his family's traditional interest in the manufacture of cloth was not to be denied. In 1816, Ira was granted a patent on an improved fly-shuttle hand loom. The advent of the power loom, however, made this untimely, though the patent covered his invention of the first self-acting loom temple which was practically
automatic. The temples of that time had to be taken off and re-adjusted so often that they required a considerable part of the weavers' time and labor. Draper's temple greatly increased the product of the new power looms and enabled the weaver to run two looms instead of one. Ira Draper's invention was second to Eli Whitney's cotton gin in inventions by Americans in the textile field. It was also the foundation of the business of Draper Corporation, now the oldest concern in the United States continuously engaged in originating and producing improved machinery.

In 1829 Ira Draper took out a new patent for improvements on his loom temple, and one year later sold his patents and the business to his eldest son, James, of Wayland, Massachusetts. James and his brothers, Ebenezer D. and George, all had a part in the business for thirty nine years. During that period the company patented many improvements to common loom mechanisms, and even improved the machines used in yarn preparation. In that time the business found a permanent home in Hopedale, Massachusetts. In 1841 the first Draper shop was built on the site where the present plant is located. That first little red frame shop still stands, preserved as a museum.

The second epoch of Draper History opened in 1868 and ended with the death of George Draper in 1887. During this period George became the leader and driving force in the great development of ring spinning which proved so far superior in cost of operation and quantity of cotton yarn production that the spinning mule was relegated to a very narrow field. George Draper owned the patent rights or controlled
XD MODEL LOOM FOR WEAVING RAYONS - REGULAR CONSTRUCTION

XD MODEL LOOM WITH DRAPER DIEHL DRIVE AND ELECTRIC TRANSFERRING MECHANISM
the sales of twelve named varieties of ring spindles. He was a good merchandiser, and his energy in pushing the sale of his products soon established him as a leader in the American textile industry. His ring spinning improvements gave the cotton industry of the United States a tremendous boost on its way to future success and greatness.

George Draper's three sons, Gen. William F., George A., and Eben S., were in the company before his death, and in 1886 decided to undertake the design and manufacture of an automatic loom. They started from scratch with their large force of inventors and skilled mechanics who had already given them hundreds of patents on improved machines. In 1889 James H. Northrop conceived the idea of forcing the spent bobbin through and out of the shuttle, and replacing it with a fresh bobbin of filling. This led to the development of a self-threading shuttle, the two ring bobbin, the Northrop rotating battery, and such necessary devices as a filling motion to regulate the transfer of the bobbin. Charles F. Roper, of the Draper research staff designed a practical warp-stop motion after all possible patents and patentees had been investigated. In August, 1894 the first Northrop looms to be sold to a mill were shipped from Hopedale to Queen City Cotton Mills in Burlington, Vermont. There were 792 looms in the order.

The third and present epoch of Draper history centers about the invention of the Northrop loom and more than fifty years of its development to meet the standards of almost every one shuttle
weave in the cotton and rayon field. This was the beginning of a revolution in the act of weaving throughout the world, and it led to the tremendous expansion of the textile industry in the United States.

There had been in Hopedale various subsidiary companies, and in 1896, these were taken into the Draper Company. In November, 1916, the Company was reorganized as Draper Corporation and flourished under the leadership of George A. Draper.

B. H. Bristow Draper, the son of Gov. Eben S. Draper, was the fourth-generation member of the family to head the business. From 1923 to 1944, under his management, the corporation became very up-to-date with precision machines, and it turned out some fine products. These included the development of a loom for weaving rayon fabrics, and a series of high-speed looms. Although the weavers' work had been reduced to a minimum and the number of looms she could handle had reached a practical limit, the Draper Corporation went to work during the depression of the 20's and produced a loom in 1930 which ran 20 percent faster and gave a corresponding increase in output.

Before Bristow Draper's untimely death in 1944, he had organized the corporation under a number of young men who are now its present managers. Among these are Thomas West, the president, who has been with the corporation since 1923. C. Fred Butterworth is Chairman of the Board. Erwin N. Darrin is Vice President in charge of Sales. B. H. Bristow Draper, Jr. is treasurer, and he is the representative
EXPERIMENTAL PLASTIC BOBBINS
of the fifth generation of the Draper family in the business. Hamilton W. Thayer is the Works Manager, and Fred M. Fitzgerald is the Director of Research.

The main works and home office of the corporation are located at Hopedale, Massachusetts, where it has been since 1841. There is a branch manufacturing plant in East Spartanburg, South Carolina, and a shop at Pawtucket, Rhode Island for building electric warp-stop motions. Sales offices are maintained at Spartanburg, South Carolina and Atlanta, Georgia with large storehouses of loom parts and supplies in both cities. Draper bobbins are made at a modern and specially equipped bobbin shop at Beebe River, New Hampshire, which is supplied with well seasoned blanks from bobbin roughing plants at Guilford, Maine, Woodford, Vermont and Tupper Lake, New York. The corporation's holdings of forest lands in the three northern New England States and the Adirondack section of New York total more than 150,000 acres. Dogwood for Draper shuttles gathered from a score or more saw mills in southern states is received at the Draper concentration plant at Biltmore, North Carolina, and prepared there for shuttle-making at Hopedale.

Besides its business in looms and precision parts for loom repairs, the corporation builds many loom accessories, including a full line of shuttles, bobbins, temples, and drop wires, as well as the Stimson clutch spindle and mirror spinning and twister rings.
Research is a word associated with modern industrial history, but in the Draper business, it is an old story. The business was founded on an invention. Research, invention, and product development have been its backbone and life blood. Today Draper research, equipped with the accumulated knowledge of the know-how and know-why of loom building, and with every mechanical facility for advanced work, is larger and busier than ever. Now that the corporation has decided to build a special building for research, it is creating a symbol of Draper tradition. The proposed research laboratory will be not only a memorial to Ira Draper, James Northrop, and the other inventors, but also a living symbol of the corporation's continuing emphasis on industrial development.
THE NEED

To anyone who tries to find his way around the present Research Department of Draper Corporation, it is obvious that a new home for the department is needed. It is now in a portion of the main shop, and its various working areas are much too disconnected. The flexibility that should be possible on any research project is not there. The department seems to get what space is available in the main shop, and it must use this space as best it can.

The greatest present lack is the absence of good weave rooms for testing groups of looms under conditions like those in weaving mills. At present much of that testing is done in outside mills. Besides this, there seems to be no special area in the present department where the machine shop can be laid out as its foreman desires. The engineering and drafting rooms and the offices are not ideal. Altogether, the present facilities of the department are barely adequate, and they do not show the forward looking attitude that is typical of Draper tradition. It is not surprising that the corporation has decided to build a research laboratory.
THE SITE

The site which Draper Corporation has chosen for the proposed research laboratory is a large space bounded by the north wall of the main plant, a residential area to the west and north west, and by another residential area to the east and northeast. These two residential areas are divided by a stream which is dammed at the long north wall of the main plant. The actual land available for the building in this site is a small space about 150 feet deep and 235 feet long along the west bank of the pond.

Because of the simplicity of the long north wall of the main plant and the remoteness of objectionable working areas, and because of the park-like appearance of the pond and residential areas, this site has a special design significance. It does not call for a building that is massive and pretentious. Rather than that, it needs a building which seems settled in the green surroundings and at the same time has strong character.

The reasons why the corporation chose this site are really very simple. First of all, there are no other appropriate areas to choose from close to the main plant. The building will be seen from the main street in Hopedale on the opposite bank of the pond. The land is available for building now, and it is about the right size. It is relatively close to the present location of the Research Department in the main shop. Worker and trucking circulation to it are good, both from the main plant and from highways and homes. It
is not far from a large parking area, and a public bus line goes right by it. It is relatively close to the workers' cafeteria. Since the corporation had made up its mind definitely on this site, and since there were no unsurmountable obstacles involved, there was no need for further site discussion.

The one thing which presents a problem in erecting a building on the proposed piece of land is the existence of a high water table. The test borings\(^1\) show that this water table is from three to five feet below the present grade. Present grade varies from three to four and a half feet above the controlled water level in the pond. There is, however, refusal to boring at three and a half to thirteen feet below existing grade level, depending on location of test boring. The high water table is mainly a hindrance because of the problem of waterproofing. There is no real problem in going down to the bed rock.

At a much earlier date, there was a tressle across the pond and four foundation piers were built in the middle of the pond. It appears to be possible to put foundations piers down to bed rock at any point. Since the problem of water-proofing exists anywhere on the site, the conditions seem to indicate a building without a basement and at the waters edge where most advantage can be taken of the green areas.

The available land is fairly flat, sloping up very slightly to the middle and to the north. There is a rise at the north end of the land which is the embankment for the old road bed to the tressle

\(^{1}\) For Test Borings Report, see Appendix.
mentioned above. There are many beautiful trees on the site, on both sides of the pond, and through the residential areas. To some extent these trees will shield the homes from the proposed building, and vice versa. The trees on the available land are very fine elms and should be kept if it is possible. The beauty of these trees and of the site in general is shown in the photographs in this report.
THE ACTIVITY AND SPACE REQUIREMENTS

In 1950 when Draper Corporation was first considering the proposed research laboratory, Mr. E. M. Horton of the Research Department drew up some building plans as a space-requirements study. The corporation has used these plans in discussing the various activities within the new building. They feel quite satisfied that all needs are indicated. Though these plans were made available for the writing of this thesis, I did not accept them without challenging every detail. In this way, I have learned the basis for decisions on many points, and I have acquired a more thorough understanding of the problems.

The activity within the proposed building will be essentially product development and this will consist of design, fabrication, and testing. A staff of engineers and draftsmen will study and draw up the various proposed improvements and new machinery for the textile industry. A machine shop will produce each new part or loom for assembly. Then after trial runs, a whole battery of looms will be set up in a weave room for long range testing under simulated conditions. To assist in this work, there will be special laboratories and services, as well as conference rooms and offices.

I have expressed this activity in chart form on the following page. In this simple flow diagram the functions can be traced in order, from designing, to fabrication, to testing; and the relation of the various secondary elements to these can be seen.

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1. See blue line prints in Appendix.
FLOW DIAGRAM
The purpose of this section of this report is to present a description and discussion of each room or activity area. I have attempted to cover activity, space requirements, personnel and material circulation, mechanical services, and special conditions for all the rooms. The areas given must be taken as rough, approximate estimations, agreed on by the corporation. The space-requirements list in sequence of design, fabrication, and testing is as follows:

**Director's Office**

400 sq. ft.

The Director's office should have a large desk and a small conference table, several chairs, some small side tables, book cases, and file cabinets. The activity here is typical of executive office work. The room must be located within easy reach of the secretary-receptionist, the conference rooms, and the avenues of circulation to all parts of the building. The mechanical services required are general air-conditioning, electricity, good lighting, and telephone connections. Low background noise and sound absorption are necessary.

**Secretary-Receptionist**

200 sq. ft.

This activity should be near the business entrance of the building and may be in either a general open area or in a separate room. In any case, it must be near the director's office. It should have a secretary's desk, chair, and small file cabinet. The mechanical services are the same as for the director's office.

**Two Small Conference Rooms**

each 200 sq. ft.

These rooms are for meetings of personnel involved in the activities and policy making of the Research Department. Each room will have a
large table with eight chairs. Other conditions are the same as for the director's office.

Large Conference Room 500 sq. ft.

The large conference room is primarily for large meetings, with facilities for showing movie pictures with portable equipment. There should be about fifty seats besides a speaker's table and three chairs. Other conditions are the same as for the director's office.

Engineering Area 2000 sq. ft.

A large area should be provided for sixteen or eighteen men to work at office type desks. Each man should have a 3' x 5' desk, two chairs, and a book reference table. The activity of this area is engineering study and designing of new ideas. The area can be part of a larger area for a similar group of draftsmen and a clerical section. It should be near these activities certainly. It should be centrally located with respect to three offices, the library, the photo and printing laboratory, and main circulation. The mechanical services required are general air-conditioning, electricity, and telephone connections. Good, overall light, low background noise and sound absorption are necessary.

Drafting Area 2000 sq. ft.

A large area should be provided for sixteen or eighteen men to work at drafting tables. Each man should have a Hamilton Autoshift Drafting Table, a book reference table, and a chair or stool. In
this area working drawings of new improvements and new machines are made. This can be part of a larger area with considerations similar to those described above for the Engineering area.

**Clerical Section**

1000 sq. ft.

The clerical section is a small force of four stenographers, each requiring a desk, typewriter, and typists' chairs. They are available for typing work for the Engineering and Drafting areas, and the three offices connected with them. In this space there must also be file cabinets and supply cabinets for Engineering and Drafting areas, and the three offices. The clerical section can be part of a larger area with considerations similar to those described above for the Engineering Area.

**Three Offices for Engineering and Drafting**

Each 200 sq. ft.

There should be three offices for the project leaders, the men who supervise the work of the engineering and drafting. Each office should have an office desk, a large reference table, four chairs, a bookcase, and a file cabinet. These offices should be located close to the Engineering, Drafting, and Clerical areas. They should also be within easy reach of the library, the Director's office, the photo and printing room, and the main circulation. The mechanical services are the same as for the Director's office.

**Library**

350 sq. ft.

The research laboratory should have a library for anyone's use. It would be used mostly by the project leaders, the engineering and
drafting sections and the chemical laboratories so it should be centrally located for them. The library should have a librarian's desk, a reading table, six chairs, and book shelves. The shelving should be organized for holding books, reference materials, magazines, and manufacturers' literature. The mechanical services should be the same as those for offices described above.

**Photo and Printing Room**

600 sq. ft.

A room for reproducing drawings and a photography dark room should be provided. A photostat machine and a Bruning white print machine as well as a desk, table, chairs, and work bench go in the printing room. The dark room, reached through the printing room, should have the typical photography work bench with sink, washer, print dryer, enlarger, and shelves for equipment. Both of these areas should be able to be closed and made light tight. Good ventilation through the air-conditioning system is mandatory. This facility should be convenient for the engineering, drafting areas and near the general circulation. Other mechanical services are water, light, electricity and telephone connections.

**Machine Shop**

2500 sq. ft.

The machine shop is the area where new ideas are produced. After the new ideas are investigated by the Engineering section and drawn up by the Drafting section, they are turned out in the machine shop. The foundry of the main plant provides castings when necessary. The shop will have to be near the assembly and trials area, the delivery entrance and the supplies storage. About two dozen machines and
benches will be set up in the shop. It will be necessary to install a traveling hoist for movement of heavy parts, and, especially, shop equipment. The floor of the shop will have to be a firm foundation for the shop machinery, and at the same time, provide a flexible electrical outlet system. The machine shop needs 110, 220, and 550 volt outlets. It is suggested that Draper Corporation use rubber-in-shear vibration absorption pads under each heavy piece of shop machinery. Good overall light, general air-conditioning, and sound and vibration absorption are necessary. Besides these considerations, there should be an office for the shop foreman, and a tool crib.

**Supplies and Storage**

1200 sq. ft.

There must be adjacent to the delivery platform, a place where parts, equipment, and supplies may be stored. This storage should be located within easy reach of the shop, the assembly area, the yarn preparation room, the weave rooms, and the other testing laboratories. Its physical requirements are that it be well ventilated and lighted, and that it be planned for good circulation.

**Stress Coating Room**

100 sq. ft.

This small space is a place where parts are sprayed with a coating which shows stress lines after testing. Its only requirements are a bench with sink and water connections, and very good ventilation because of the toxic fumes from the spray coating procedure. It should be located adjacent to the assembly and testing areas.
EXPERIMENTAL SHUTTLE WITH STAFFORD THREAD CUTTER OPENING ELIMINATED

STANDARD TYPE SHUTTLE
Yarn Preparation

It is necessary to prepare the various types of cotton and synthetic threads before they are put in the looms for weaving. The yarn preparation room has the machinery required for this work. Draper Corporation is a loom-building business, not a textile mill, but it is necessary to make fabrics in the research laboratory when testing the looms. This room should be close to both the assembly area and the weave rooms. The mechanical services required are water connections, general air-conditioning, good lighting, and electrical connections.

Assembly and Trials Area

There must be an area, centrally located with respect to the shop, storage, yarn preparation, the stress coating room, and the weave rooms, where pilot models can be assembled and given their first test runs. This is the assembly and trials area. Sometimes special improvements will be put in standard looms and sometimes whole new looms will be assembled. In any case, they will be test-run here until it is decided to make changes, abandon it, or set up a whole battery of looms in one of the weave rooms for long range testing. This space which is a general activity and circulation area on the shop floor, should have good lighting, power outlets, and sound absorption treatment. It is recommended that looms tested here be cushioned on rubber-in-shear mats.
EXPERIMENTAL SHUTTLE IN SHUTTLE BOX, ILLUSTRATING ACTION OF THREAD CUTTER.
Electrical Laboratory

The electrical laboratory will be a fabrication and testing area for the electrical parts of the looms. Among other things, power tests will be run on loom motors. It should be equipped with work benches, tools, and equipment for electrical work. It should have good lighting, general air-conditioning, 110, 220, and 550 volt power outlets, and sound absorption treatment. This laboratory should be located near the shop or assembly area if on the first floor, or near the elevator if on the second floor.

Analytical Chemistry Laboratory

This laboratory is devoted to chemical analysis of and testing of various loom improvements and new ideas. Much of this work is the development of finishes. The laboratory should have a long, island-type, work bench with a central trough and sinks at both ends. It should have a wall bench equipped with a fume hood at one end. The benches should be equipped with outlets for air, gas, water, and electricity. This laboratory should have good lighting, general air conditioning, low background noise, and sound absorption treatment. It is very important that this laboratory have a vestibule with an emergency shower head installed in it for personnel safety. This laboratory should be next to the Product Development laboratory since their activities overlap. If it is on the second floor, it should be near the elevator and stairs to the shop floor.
Weighing Room

100 sq. ft.

Next to the Analytical Chemistry Laboratory, there should be this small room with one balance table and drawers. It should have good lighting, air-conditioning, low background noise and vibrations, and electrical outlets.

Product Development Laboratory

600 sq. ft.

As stated above, this laboratory should be next to the Analytical Chemistry Laboratory. The work done in both laboratories is quite similar, but here the work is of a heavier nature. An example of the work done here is the present research on plastic bobbins. The physical and mechanical requirements of this laboratory are the same as for the Analytical Chemistry Laboratory.

Physical Testing Laboratory

500 sq. ft.

The activity in the Physical Testing Laboratory is mostly the testing of yarn, fabrics, and loom parts. Tests are made on the properties of the various materials used in loom construction. The physical and mechanical requirements for this laboratory are the same as for the Analytical Chemistry Laboratory, except that here there is the specific requirement of a separate means of controlling the temperature and humidity, with as much range of control as is possible.

Office for Laboratories

200 sq. ft.

This office is for the man who heads the work in the three laboratories mentioned above. It should be located near the three laboratories it serves. All physical and mechanical requirements are the same as for other offices mentioned above.
Weave Rooms

The weave rooms are the final testing rooms of the research laboratory. Here whole batteries of looms are set up for long range testing under conditions similar to those in weaving mills. Sometimes new looms are tested, and sometimes new parts are tested in standard looms. In either case, it is necessary to have the highly controlled air-conditioning that exists in most weaving mills. Because cotton weaving requires higher temperature and humidity than does rayon weaving, it is necessary to have separate air-conditioning control in each weave room. There must be a range of control of temperature from 50° to 80° F. and of relative humidity from 50 percent to 80 percent.

Draper Corporation has asked that the whole area for the weave rooms be designed for flexible room arrangement with movable partition walls. Their present plans call for testing three standard type looms and one special new type. It is expected that they will occasionally have a special project of some advanced idea in weaving. It is impossible to say what future conditions may be sought, so flexibility is mandatory. While the minimum ceiling height on the shop floor is twelve feet, it might be well to give a little more than that to the weave rooms for future flexibility.

Because of the high noise level in the weave rooms, acoustical considerations are necessary. Much noise and vibration might be eliminated right at the source if Draper Corporation would use rubber-in-shear for cushioning the looms. Some noise will be eliminated through sound absorption treatment in the weave rooms. Good masonry walls will
STUDYING LOOM OPERATION WITH THE AID OF A STROBLITE
give low sound transmission out of the building to the neighborhood. If the weave rooms are contained in a unit that is structurally free from the rest of the building a great deal of noise will be prevented from being transmitted to other areas of activity.

The weave rooms should be located near the assembly area. They should have good lighting, though it is best not to have windows. Power outlets of 110, 220, and 550 volts should be provided, so that they can be located on the floor at intervals of no more than eight feet.

**Cloth Room and Office** 600 sq. ft.

The fabrics produced in testing in the weave rooms are brought to the cloth room for inspection, folding, and temporary storage. A large table, a folding machine, and two wash basins are required. Next to, or within the Cloth room is a small office of 100 sq. ft. for the man in charge of the weave room testing. Good lighting, general air-conditioning, electrical and telephone connections are required.

**Services**

Besides the space requirements outlined above there should be some consideration given to other services. The usual standards for hallways, stairways, and general circulation areas must be maintained. Good lighting and general air-conditioning are essential. The stairways must meet safety code requirements as well as the requirements for adequate circulation of personnel and equipment for efficient operation of the research laboratory.
If any of the fabrication testing activities are above or below the first floor, it will be necessary to have a large elevator, 18' x 8'4", of five tons capacity. If these activities are all on the same floor only a small elevator will be required. This can be of 5000 pound capacity and 12' x 8'4". Both of these would be freight elevators. It may be necessary to stop the elevator at the truck loading level if it is not the same as the floor level.

On each floor there should be toilets for men and locker rooms with industrial type wash basins. A toilet for women should be provided near the clerical section or the administrative area.
TEMPERATURE AND HUMIDITY CONTROL

One of the major mechanical requirements of the proposed research laboratory for Draper Corporation is the control of temperature and humidity conditions. It is known that the temperature and humidity must be higher for looms weaving cotton than for rayon and other synthetic fabrics. The good control of air-conditioning which is typical of the many mills in the textile industry must be made possible here, especially for the long range testing under simulated conditions in the weave rooms. Air-conditioning is most important in the weave rooms, but it is necessary in other parts of the building, too. With the piped steam that is available as a by-product of work in the main plant it would be practical to have air-conditioning for all parts of the research building.

For flexibility of weave room planning it has been decided that movable partition walls will be used to divide the various weave room projects within the main weave room structure. It is expected that the partitions will usually be set up so that the weave room floor is divided into four testing areas. The ordinary partition wall is an adequate barrier to the temperature and humidity differences involved, as these differences are slight in comparison to the capacity of the air-conditioning equipment used. The outside walls, roof, and floor slab should be of heavy construction to keep the heat loss coefficient less than 0.10.

The range of temperature and humidity control in the weave rooms, and the equipment used to create this control have great significance in the adaptability of the building to the projects attempted.
At this time it is felt that it will be adequate to install an air-conditioning system in which the temperature can be controlled from 50°F to 80°F and the moisture controlled from 50 percent to 80 percent relative humidity.

Four separate duct systems will be required to condition the four probable weave room areas. The ducts should be run above the ceiling so as not to interfere with partition arrangement. They should have ceiling diffusers with manual controls, so that some diffusers may be closed in one duct when the partition arrangement makes it overlap another duct. The diffusers should be placed about 12 to 15 feet apart. Fan-and-coil type air-handling units should feed the ducts from a central apparatus room. Four heating coils in the apparatus room should heat the air in the ducts individually. Filters and lint screens should be provided. A split type system is recommended, so that humidification is added in the individual weave room areas by atomizing nozzles. With this arrangement, and with a thermostat and a humidistat in each room, the required conditions can be set and automatically controlled.

The physical testing laboratory is a room which requires separate air-conditioning control. In this case a maximum range of control is desired. A system similar to that in the weave rooms is indicated, though the air-handling unit and an independent freon compressor might better be placed in a small utility room adjacent to the laboratory. A two or three horsepower condenser unit should be sufficient. With such a great range of control for such a small
area, it is necessary to eliminate windows from this room; in fact, it would be advisable to make it an inside room if practicable.

The shop floor should have a separate unit for air-handling, too, if possible. The same type system without auxiliary humidification is desired.

The stress-coating room, a very small room where toxic fumes are present will require some system of evacuation. A hood and fan should be sufficient with a duct to carry the fumes to a high level, to be exhausted into the air away from the apparatus room intake. The air supply for the stress-coating room can come from the shop floor or from an outside wall-vent.

The personnel air-conditioning for the engineering, drafting, and administrative areas is somewhat different from the systems already discussed. Here it is preferable to have under-window units, supplied with primary air from a duct on the ceiling below. A heating-cooling unit, an air plenum, and controls are built in. Each unit should be about five to eight feet apart or under each large window. With this system each area has its own air-conditioning control. Because the ordinary under-window unit controls an area extending only about twenty to twenty five feet from the window, it will be necessary to supplement this system with an overhead duct and outlet system, down the center of the building. This system will control an area fifteen to twenty feet wide, the length of the building, and it should have diffusers similar to those in the weave room.
The central apparatus room should have a high location and might well be part of a penthouse. Since steam from the main plant is available, it is more economical to use it with an absorption machine for refrigeration than to use electric power and reciprocating equipment. The absorption machine will be used to pump water to all the air-handling units, except the one for the physical testing laboratory which has an independent freon compressor. There should be located here, also, the air-handling units for each of the weave room ducts, and for the personnel air-conditioning. The air-handling units have basic filters, humidifiers or dehumidifiers, lint screens, heating coils, and fans.

The ducts from these units to the weave rooms should each be about three and a half square feet, and the ducts to the personnel system should be about ten square feet. The return air ducts should be the same size as the supply ducts or a bit larger. Their inlets should be located close to the supply outlets to encourage a complete air circulation.

The use of high speeds of air supply is a relatively new development in air-conditioning, and might well be used in the system of the proposed research laboratory. Because of the high velocity of the air supply around 6000 c.f.m., small ducts can be used. The high speed is cut down to 1000 c.f.m., and the system silenced, just ahead of the nozzle-type outlets in the ceiling. The under window units would be eliminated with this system, imparting greater flexibility to office planning, although manual control
of air condition is forfeited. The great advantage of this system is the reduction of costly cubage and valuable space required by large ducts, and especially the elimination of units from the valuable window areas.
FLEXIBILITY AND DESIGN

If the proposed building is to adequately fill its job as a center for research, it should be so designed as to make it possible for the Research Department to conduct practically any test or development it may choose. It would be asking too much to expect the department and the designer to predict all such conditions of the future. It is not, however, unreasonable to assume that the three functions: design, fabrication, and testing will remain in any case. To design these areas with as much inherent flexibility as is possible, will be to make the most comprehensive solution to this major problem.

Among the first things which Draper Corporation asked to have incorporated in the design of the new research laboratory was movable partition walls. They feel that future research projects will indicate changes in interior room arrangements. This is most likely to occur within separate activity areas, as in the weave rooms, or the designing floor, or the shop floor.

Movable partitions present certain problems as well as advantages. Unwanted noise transmission through the average temporary wall is generally higher than for permanent walls. This depends on a great many acoustic factors, but mainly on the tightness of the work, the completeness of the separation, and the materials used. It would seem advisable to have permanent separations between areas of completely different activities when on the same floor.
The areas where movable walls are put should be designed to make erection and demounting a relatively simple job. The partitions must, of course, be fastened to the floor, other walls, the ceiling, and to window mullions. The windows, too, control the flexibility of partition arrangement since the walls must meet the windows on the mullions.

Another thing which the corporation suggested for increased flexibility is an electric conduit system in the floor, so that power outlets and telephone connections can be spotted anywhere. There are a number of systems on the market that are satisfactory. Each has its own good and bad points, so choice depends on the specific demands of the design scheme.

Mechanical services in a building can greatly effect the flexibility of its use. In the proposed research laboratory, the major services besides the electrical and telephone outlets already mentioned are air-conditioning, lighting, acoustical treatment, water, and gas. Probably the most complicated of these is air-conditioning, especially when it becomes necessary to install duct systems. On this point there is more written in this report. An understanding of the activities that need piped services can, through coordinated relation in designing, greatly increase the freedom of the building's use.

One of the features which makes planning non-restrictive is space. When space requirements are only just fulfilled and the activity
areas are placed close together, like the pieces of a puzzle, the resulting arrangement might have some flexibility, but it will always be tight. Part of the job of designing for flexibility is visualizing future needs when possible and designing with open planning.

In discussing thoroughly flexible planning, the answer according to the Architectural Forum¹, is "Total absence of all obstructions, completely smooth ceilings, walls, and floors, no interior columns..."

"To keep the columns out of everybody's way, they let them project beyond the line of the curtain wall on the outside...As a result, all interior walls are smooth, ready to receive modular office partitions wherever necessary...Above the main corridor...the ceiling will be dropped to take air-conditioning ducts. Above the actual office space, the ceiling may be luminous, a pattern of suspended, translucent plastic sheets held in metal strip and illuminated from above. The ceiling height will be greater than that of the corridor, so that air-conditioning grilles on the sides of the corridor ceiling will feed directly into the office space.

"...each structural bay was divided into six windows (one module wide each)..."

"The entire office floor had been cleared of obstructions. There only remained the problem of devising a suitable module. The best dimensions the designers could find was 4 ft. 8 in. square. This gave them a 9 ft. 4 in. minimum office (less partition thickness), a 14 ft. manager's office, an 18 ft. 8 in. director's office, and an even 28 ft. structural bay...

"Although the proposed office floor is about as flexible and well integrated as any designed in the United States to date, it is not entirely without flaws... Air-conditioning, packaged ceiling lighting, and flexible partitioning would seem beautifully solved; but the problem of acoustics might yet have to be studied further. Movable office partitions do not do much to absorb sound (unless specially designed for that purpose); air-conditioning flow that takes in the entire office floor will also transport noises, and a luminous suspended ceiling (with movable partitions underneath) will permit conversations in adjoining offices to jump over any sound barrier the partition may set up. Unless the constant, overall level of sound in the offices is fairly high or a more efficient sound barrier is created, some minor executives could have little privacy. For this reason the architects will probably recommend plastered block partitions (from structural floor to structural ceiling) around conference rooms and in all the top executives' suites..."
The quotation above is a good critique on flexible planning. Though it is concerned with office space alone, the basic pros and cons are worth considering. The job of incorporating flexibility is not an easy one, but an honest attempt with a comprehensive understanding of the activities involved, often leads to a building of commendable design.
BIBLIOGRAPHY

1. Books


2. Manufacturers' Literature


Air Conditioning for the Textile Industry, Carrier Corp.

3. Periodicals

Architectural Forum:

*Flexible Factory for Upjohn*, page 146, April, 1951.
*Ford Builds a New Automobile City*, page 102, December, 1950.
*New High Velocity Air Conditioning*, page 140, September, 1950.
*Caldwell Air Conditioning*, page 114, July, 1950.
*Curtin Walls*, page 81, May, 1950.

Progressive Architecture:

*Fireproofing Steel with Vermiculite Plaster*, page 85, April, 1949.

4. Thesis Reports, Department of Architecture, M. I. T.


All borings are plotted to a scale of 1" == 4 ft. using Hopedale, Mass. as a fixed datum.

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To: McClintock & Craig, Inc.
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Location of Borings
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Hopkinton, Mass.

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Foreman: M. Little
Classification by: Sheet 3 of 7
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Classification by
Sheet 4 of 7
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Date: May 2nd, 1951
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<td>70</td>
<td>38</td>
</tr>
</tbody>
</table>

Figures in right hand column indicate number of blows required to drive sampling pipe one foot, using 140-lb. weight falling 30 inches.

Total Footage 34.5'
Foreman M. LITTLE
Classification by
Sheet 6 of 7
All borings are plotted to a scale of 1" = 4 ft. using Hopedale, Mass. as a fixed datum.

<table>
<thead>
<tr>
<th>No.</th>
<th>Elevation (ft)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>55.0</td>
<td>Loam, Gravel</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>HARD FINE GRAY SAND, GRAVEL &amp; BOULDERS</td>
</tr>
<tr>
<td></td>
<td>9.0</td>
<td>Hard Sand, Gravel &amp; Boulders</td>
</tr>
<tr>
<td></td>
<td>11.0</td>
<td>Hard Sand, Gravel &amp; Boulders</td>
</tr>
<tr>
<td></td>
<td>13.0</td>
<td>Hard Sand, Gravel &amp; Boulders</td>
</tr>
</tbody>
</table>

<table>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
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<td>3.5</td>
<td>WATER</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>HARD FINE GRAY SAND, GRAVEL &amp; BOULDERS</td>
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<tr>
<td></td>
<td>12.5</td>
<td>Refusal</td>
</tr>
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</table>

<table>
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<th>Description</th>
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</thead>
<tbody>
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<td>LOAM, HARD SAND, GRAVEL &amp; BOULDERS</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Refusal</td>
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<tr>
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<tr>
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<td>125</td>
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</table>

Figures in right hand column indicate number of blows required to drive sampling pipe one foot, using 140-lb. weight falling 30 inches.