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A Comprehensive Concept for Vocational Education Facilities: Introduction, Flexibility Through Modularity, Space Determination, Schematic Modernization, A School Planner's Guide to the Pittsburgh Building Code, Appendixes.

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Methods in use in industry are suggested for providing vocational facilities that are flexible and adaptable to changing conditions. Academic and vocational activities are allowed to intermix in order to implement interdisciplinary educational situations. A systems approach to construction enabling specification of building components to fulfill the needs of vocational activities is forwarded in this eight-volume report: (1) Introduction, containing an overview of the changing world of work and solutions that can be provided by better facilities, (2) Flexibility Through Modularity, discussing ways of increasing equipment mobility, providing adaptability in mechanical service systems, and constructing flexible space, (3) Space Determination, describing a planning technique which utilizes computer simulation, (4) Schematic Modernization, describing the hypothetical modernization of an existing building (5) A Planner's Guide to the Pittsburgh Building Code, (6) Appendix, recording the results of a nationwide survey of state space standards and the space utilization in existing vocational rooms in Pittsburgh schools, (7) Appendix, containing background information, and (8) Summary, reviewing project goals, methodology, objectives, and a copy of the project proposal. (DM)

Comprehensive Concept for
cational Education Facilities

Introduction

Flexibility Through Modularity

Space Determination

Schematic Modernization

A Planner's Guide to the Pittsburgh Building Code

Appendix

INTRODUCTION

1

Prepared By The Research Team
For A Comprehensive Concept
For Vocational Education
Facilities

June, 1966

Explanatory Note

The research and demonstrative project, A Comprehensive Concept for Vocational Education Facilities, Project Number 16003, was conducted under a combined grant of $129,311 from the Bureau of Technical and Continuing Education of the Pennsylvania Department of Public Instruction, Dr. John W. Struck, Director, and the Pittsburgh Board of Public Education. Of this, $49,211 were supplied in local funds and $80,100 were supplied in State Vocational Ancillary funds. The State Ancillary funds were created through the Vocational Education Act of 1963, Public Law 88-210.

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Preview of Unit One, Introduction

In this age of rapid technological progress, many problems face vocational education facility planners. While solutions to these problems are suggested in this report in terms of their application to the situation that exists in the high schools of Pittsburgh, Pennsylvania, the basic problem is not unlike the one facing the entire nation. It is felt, therefore, that this discussion may be of interest to all educators.

Industry has been forced to adapt to change by turning to automation in order to avoid spiraling labor costs and to produce in quantity. However, engineers of today are "trained in the use of mental skills,"[1] so that industry needs technicians skilled in the making of complex machinery. Consequently, the larger industries are putting in bids for

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[1]Henry G. Shocksnider, "Who Is A Technician?", Industrial Arts and Vocational Education, May, 1965.

greater numbers of technicians with general knowledge of many skills. These changing demands for labor are putting new strains on vocational education.

If vocational education is to meet these demands, it must be sensitive to such changes in order to prepare students for future employment in business and industry. These students may start their vocational classes in middle school, continue through high school, and, in some cases, even take post-high school courses. It is possible, therefore, for as many as nine years to separate a student's first exploration in a vocational field and his final entry into useful employment. During this time, a great expansion of human knowledge can take place and much can happen while today's student is attempting to equip himself with marketable skills.

Some educators are preparing to meet these demands of industry for skilled technicians. This is especially true in Pittsburgh where new programs are being designed to equip students with marketable skills in progressive industries and where vocational education is being integrated with academic education in comprehensive high schools. These developments imply a new emphasis on education that will not only be adaptable to progress in industry but also will be broadened through interdisciplinary cooperation. Unfortunately, however, existing facilities provide only highly specialized space which is not suitable for the generalized training required by some industries and which tends to reinforce old barriers between disciplines.

This report suggests that a completely new approach is needed to providing and planning such vocational facilities if they are to be flexible and adaptable to new and changing situations. Methods already in use in industry today can be employed to make vocational equipment highly mobile and to make service distribution systems adaptable to many different equipment layouts. Separation of academic and vocational activities can be avoided and the two allowed to intermix in order to implement interdisciplinary educational situations. The systems approach to construction, which would enable specification of building components to fulfill more accurately the needs of vocational activities, can be applied to new construction as well as to modernization.

This report further suggests that the most important single need is for new methods of relating the vast and changing complex of activities in modern vocational courses with their generated needs for space and equipment. Without these new planning techniques, educators and architects cannot hope to design facilities with long and useful lives in a progressive, technical world.

Preview of Units Two through Seven, the Technical Reports

This study suggests that better vocational facilities can be provided through the use of flexible laboratory space and the application of more sensitive planning techniques. Since a discussion of these suggestions involves a large amount of highly technical information, Unit One, Introduction, contains an overview of the changing world of work, the problems it creates for vocational education, and solutions to the problems that can be provided by better facilities. Units Two through Seven are devoted to technical discussions of these problems and solutions.

Units Two and Three present basic descriptions of techniques which provide more laboratory flexibility and better laboratory planning. Unit Two, Flexibility Through Modularity, discusses ways to increase equipment mobility, to provide adaptability in mechanical service systems, and to construct new and modernized space that is totally flexible.

Unit Three, Space Determination, describes a planning technique which utilizes computer simulation to plot all activities that occur in the duration of a course and relates them to needs for space and equipment.

Units Four and Five present material that is supplementary to the discussion of flexible laboratory space. This material relates largely to specific problems in Pittsburgh. Unit Four, Schematic Modernization, describes the application of a construction system to the hypothetical modernization of one of Pittsburgh's typical, existing school buildings. Unit Five, A Planner's Guide to the Pittsburgh Building Code, relates the construction system being proposed to the specifications of the Pittsburgh Building Code.

Units Six and Seven contain all additional information which bears a significant relationship to the technical discussions. In the first appendix, in Unit Six, are recorded the results of a nationwide survey of state space standards and the space utilization in existing vocational rooms in Pittsburgh schools. The appendix in Unit Seven contains two pertinent discussions by consultants to this project, a comprehensive analysis of vocational room dimensions in Pittsburgh schools, a history of mechanical equipment alterations in Pittsburgh secondary schools, a tabulation of vocational enrollments in Pittsburgh, and an eighteen year history of expenditures for vocational equipment in Pittsburgh schools.

The material contained in the technical sections may be of interest to professionals in many different fields, but some may choose to read only those sections which are of immediate interest to their individual pursuits. For this reason, the content of this report has been divided into booklets which cover narrowed subject areas. However, a goal of this project has been to combine the knowledge of many fields to form a truly comprehensive approach to planning and building vocational education facilities. It is hoped that most who read this report will be encouraged to examine all of its sections and to evaluate its findings from the same multi-discipline approach to the problem that is the report's main theme.

Vocational Education in a World of Change

Knowledge and Education

Man lives in a changing world. The change, however, is not so much in the world itself, but in what man knows about the world. And, man's knowledge is increasing rapidly. Because knowledge is expanding at a staggering rate, the educator is faced with the difficult task of providing higher quality education in greater quantity.

In response to the challenge of equipping students of today with knowledge and skills that will be usable tomorrow, industry is producing a wide range of new educational devices and educators are employing innovative educational techniques. Former systems of organizing knowledge into familiar courses are themselves no longer free from change. Some educators are now viewing knowledge as being a continuum of related experiences.

As educators employ new methods and new devices for instruction in a changing world, they are beginning to require new kinds of facilities that provide a suitably dynamic environment. The same situation exists to a greater extent in vocational education!

Technology

Every advance made in acquiring knowledge results in magnified implications for the technical fields. Every development in a scientific field is realized in the form of several developments in products and services. This view, held by the National Commission of Technology, Automation, and Economic Progress, is illustrated in the following statement which is made in the Commission's report, Technology and the American Economy:

> It is easy to oversimplify the course of history; yet if there is one predominant factor underlying current social change, it is surely the advancement of technology. Technological

> change includes new methods of production, new designs of products and services, and new products and new services.[2]

How technological progress is changing needs for labor is becoming clearer. The processes for making products and providing services are changing throughout industry. The Commission presents only a representative list of changes:

> Technological change is exemplified by the automation of a machine tool, reorganization of an assembly line, substitution of plastics for metals, introduction of a supersonic transport, discovery of a new method of heart surgery, teaching of foreign languages by electronic machines, introduction of self-service into retailing, communications by satellite, bookkeeping by electronic

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[2]National Commission on Technology, Automation, and Economic Progress, "Technology and the American Economy", February, 1966, Volume 1.

> computer, generation of electricity from nuclear energy, introduction of frozen foods and air conditioning, and the development of space vehicles and nuclear weapons.[3]

Automation emerges as the strongest factor influencing changing labor needs because it eliminates large numbers of jobs involving manual skills. The more significant effect of automation, as is illustrated in the following statements, is the creation of many more jobs involving technical skills.

Dr. Donald Dauwalder made this statement in Vocational Education in the Pittsburgh Public Schools:

> The United States Department of Labor estimates that 200,000 jobs a year will be eliminated due to automation from 1962 to 1970. However, if the job increase ratios reported for the past decade continue, some 500,000 new jobs will be created each year. . . . .

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[3]Ibid

> Statistically, however, there are expected to be more job vacancies nationally in the highly skilled occupations and in the technical and professional areas than there are anticipated overages in the lower level jobs due to future automation.[4]

What is not so clear is whether technicians with general skills or specific skills are more desirable to industry. Indications at this time place an equal emphasis on both. Dauwalder reported:

> The larger industries generally desire to employ a well-educated generalist possessing above average intelligence. Through their in-plant training these companies will then teach the specific skills required for the job assigned. The smaller the industry, the more emphasis is placed on specialized

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[4]Dauwalder, Donald D., Vocational Education in the Pittsburgh Public Schools, The Pittsburgh Board of Public Education, April 1963.

> training in the schools. Since smaller companies do not have employee development programs, they have been relying on the schools or on larger industries to give this training to their employees.[5]

A general picture can be developed which describes industry's evolving needs for labor. Technological progress in industry has produced automation. Automation is eliminating the need for manual skills and creating needs for technical skills. Technicians are needed with both general and specific skills. It must be remembered, however, that technological progress causes changing needs for specific skills at an increasing rate. This creates a paradox for the vocational educator who must teach specific skills and occupational mobility at the same time.

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[5]Ibid

Vocational Education

The opinions of vocational educators about the desirable emphasis of technical programs vary between two extremes. They range from equipping students with occupational mobility on the one hand to directing students toward specialization on the other hand. The following statements are representative of those who favor mobility:

> A student trained in a singular trade is simply being taught to know the kind of work he will never do . . . .
>
> . . . In an age in which we are educating youngsters for professions which cannot now be described and occupations which are not now known, we must prepare individuals to be adaptable. If we fail in this goal, our society will be too rigid to deal with the problems of the future.[6]

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[6] "The Technology of Automation", New Concepts in School Plant Design-An Accent on Accessibility.

and

> . . . the average worker will transfer several times from one job to another, sometimes in related areas, sometimes not. It is the task of education to provide him with the mobility which he needs to survive in his "carousel" of experience. It must provide him with the context into which he can fit the new and changing demands.[7]

Those educators who favor specialization tend to make the following kind of statement:

> Vocational education, by definition, tends to specialize. Its responsibility is training for employment in a job. If it fails, for any reason, to provide qualification for a job; if it concerns itself with instruction for non-existent jobs, or if it is directed to persons

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[7] The Research Council of the Great Cities Program for School Improvement, "Summary of Eastern Regional Conference", Vocational Newsletter, September 1966, Number 3

> unsuited to the field, it is education for unemployment and not vocational education.[8]

The answer to this contradictory problem lies in not following either direction exclusively. As Dauwalder says,

> The problem is not of generalized or specialized education. Our society requires both. The schools and industry must educate and train along both lines. Every employee of the future needs a combination of general and special skills and knowledge.[9]

To attain this goal requires an extremely flexible approach to vocational education which allows for presentation of both aspects of modern industry. Such an approach will place new requirements on vocational facilities.

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[8] Ibid

[9] Dauwalder, Donald D., Vocational Education in the Pittsburgh Public Schools, The Pittsburgh Board of Public Education, April 1963.

The overriding need is for vocational facilities that accurately simulate modern industries for educational purposes. This does not mean that a vocational machine shop need duplicate one particular industrial shop down to the smallest detail. On the contrary, a vocational machine shop could have the capability to duplicate all significant types of industrial machine shops. As it is important to teach both specialized and generalized approaches to industry, so is it also important to teach such aspects of industry as job shop and production line manufacturing processes.

It is also important to teach new products, processes, and services that evolve from technological progress. If vocational education concerns itself with the instruction of skills for non-existent jobs, it is education for unemployment. If vocational education is to keep pace with new developments and teach specific skills that are up to date, it would not be unreasonable to expect significant changes in equipment and facility layout on a relatively short term basis.

Automation does not create changes in employment opportunities alone. Facilities stand to be greatly influenced by the effects of automation as well. It is evident that many of the manual skills being taught in vocational programs today will be replaced by cybernetic systems. This means that the "shop" student of today with his rolled up sleeves and grimy hands will be replaced by students in white lab coats, sitting at control panels. The greasy, wooden floors of today's shops will be replaced by raised floors housing a myriad of electronic cables. The time at which all of this will happen cannot be determined exactly. It would be safe to say that this sort of change will be well on its way long before the school buildings that are built today are ready for demolition.

Ralph O. Gallington, Professor of Industrial Technology at Southern Illinois University, has said:

> . . . all human knowledge is interrelated and

any conventional boundaries are man-made and superficial.[10]

If the knowledge taught in schools actually is a continuum of learning experiences, then the areas where learning experiences occur might be better arranged as a spatial continuum. Physics students involved with horsepower and engines might be stimulated if their classes were conducted near the vocational power mechanics laboratory. If this is, indeed, a significant new direction for educational theory, inflexible cellular facilities will hamper its implementation.

The process of vocational education, though evolving, is reasonably clear. A challenge has been handed to the vocational facility planner: create facilities that relate in a dynamic way to a fast-paced technological world!

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[10] Gallington, Ralph O., "A Space Concept for New Approaches in Industrial Arts", Industrial Arts and Vocational Education, March 1966.

Response to a Changing World in Pittsburgh

Industry and Vocational Education

Dauwalder's report revealed that the effects of technological progress in Pittsburgh are similar to its effects across the nation. He established the fact that of ten major employment classifications, two, Unskilled and Semi-Skilled, showed significant projected decreases and one, Semi-Professional, showed a significant increase. In Pittsburgh the need for manual skills is being replaced by a growing need for technical skills.

In response to changing labor needs, the Pittsburgh Board of Public Education is rewriting its program for vocational education. This new outlook is reflected in the following statement:

> No longer is the term "vocational education" employed to define only those courses in the crafts and trades, etc. The new program

known as Occupational-Vocational-Technical (OVT) Education, is designed to meet the demands of space age training for space age employment.[11]

Equipment and Facilities

Until recently, vocational equipment and facilities were in a general state of deterioration. The condition of equipment is vividly described by Dauwalder:

> Most of the equipment in vocational schools is old, obsolete, and inadequate, and should be replaced. There has been no amortization of capital equipment, and total shop budgetary accounts have been bearly sufficient to replace minor items such as belts, etc. Replacement parts have generally had to be made by shop instructors. More adequate budgetary allocations for all occupational,

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[11] The Research Council of the Great Cities Program For School Improvement, "Summary of Eastern Regional Conference," Vocational Newsletter, September 1966 Number 3

vocational and technical programs must be made.[12]

The situation, however, is undergoing significant changes which are evidenced in these figures taken from the Pittsburgh Board of Public Education Minutes of the past nineteen years. These are appropriations and expenditures for repairs and replacement of old equipment and purchase and installation of new equipment from 1948 to 1966. From 1948 to 1964, total appropriations and expenditures ranged from $60,000 to $160,000 per year. By 1965, the Vocational Education Act of 1963 began to have effect in Pittsburgh. In 1965 and 1966, appropriations and expenditures had risen to between $600,000 and $710,000 per year.

Also, improvements are being made in the facilities that house vocational programs. Dr. Jerry Olson,

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[12] Dauwalder, Donald D., Vocational Education in the Pittsburgh Public Schools, The Pittsburgh Board of Public Education, April 1963

Director of the OVT Division of Pittsburgh schools, describes these improvements in the following statement:

> The implementation of such a vast undertaking involves revolutionary changes in physical facilities. In some instances, walls will literally be pushed out, wiring and plumbing will change, new equipment is being installed in most job-centered laboratories in every comprehensive school, and new buildings or additions are under construction.[13]

Pittsburgh has embarked on a course intended to keep its vocational facilities up to date with any new development created by technological progress. To be truly effective, this program will have to be continuous and relate dynamically to change as it occurs. It is possible that new alterations will have to be made on recently altered facilities in the near future. In this age of

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[13]Olson, Jerry C., "The Marriageability of Vocational Education," The School Shop, October 1965.

rapid change this is a natural process, necessary for keeping facilities up to date with the activities that they house. It is vital that flexibility for future change be built into current alterations; otherwise the cost of maintaining up-to-date facilities may be overwhelming.

Exploratory and Job-Centered Programs

Early in the process of developing new programs, vocational educators in Pittsburgh realized that the same subjects were being taught in many different vocational courses. Olson states:

> More than 50 percent of all subject matter necessary to qualify for entry level employment is common throughout the jobs within an occupational family group. This would apply to the transportation cluster where various fields such as auto mechanics and service station operation share fifty percent of their subject matter. This is also true

> with visual communication families where printing, graphic arts, technical illustration, and technical writing share subject matter.[14]

The many technical courses have been organized into four occupational families. These families are visual communications, construction, manufacturing, and electrical-transportation. Students in grades six through eight will be given broad exposure to these families. In grades nine and ten, students will undergo narrowed exploratory experiences as they develop interests and abilities in certain activities. Finally, in the tenth through twelfth and post-graduate years, specific offerings in specialized "job-centered" courses will be opened to the students. Because subject material can be shared in the early years, no significant time will be lost in false starts. Students will be given greater

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14 Ibid

flexibility to transfer within or between occupational families.

When subject material is shared, space and equipment can also be shared. This leads immediately to cluster concepts of space organization. Clusters of space can be arranged for either horizontal or vertical combining of facilities, or both. Several job-centered classes at the highest grade levels could share space and equipment in the same family cluster, or exploratory and job-centered classes at different grade levels could exploit the potentially common space and equipment in a cluster.

Vocational and Academic Programs

Formerly, vocational shops in Pittsburgh were separated from academic spaces. The shop area of a high school was conspicuous by its absence from academic areas. It was located consistently in the basement or in a separate building in the yard behind the main building. Many vocational courses were conducted in completely isolated, "vocational high schools."

Unfortunately, scheduling and subject material in non-vocational courses reinforced this separation. Students were scheduled to move from vocational to academic subjects on a "week-about" basis. Academic courses were "keyed to the vocational subjects." The combination of these factors made transfer between vocational and academic programs a near impossibility. Once a student began vocational training, he was labeled for life as a second class citizen.

This aspect of vocational education is being changed radically. The spirit of the new program is captured by Dauwalder in this statement:

> What is obviously needed is a truly liberal academic community in which the study of art and typewriting, of philosophy and metal working, of theology, and medicine, of pure

> and applied science are, though admittedly very different, judged to be equally honorable and valuable in their several ways.[15]

O. V. T. students are now meeting for classes devoted to job training and daily sessions in the regular high school academic classrooms. Teachers, counselors, and administrators are making it possible and convenient for students to move either from one curriculum area in O. V. T. to another or from vocational to academic programs.

Scheduling and course content are being changed to provide greater integration between vocational and academic programs. Creative new facility designs can contribute to this integration as well. This is possible because environmental technology has progressed to the extent that many vocational activities, formerly isolated for safety and acoustical control,

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[15] Dauwalder, Donald D., Vocational Education in the Pittsburgh Public Schools, The Pittsburgh Board of Public Education, April 1963.

now can be located in close proximity to other vocational courses and many academic courses. Because educational policies now require it and environmental technology permits it, facility planners can evolve new arrangements of space which express the continuity between the many subjects taught in high schools.

The Comprehensive High School

The most dramatic change that will take place in Pittsburgh is the construction of five large comprehensive high schools. These new structures will house all ninth through twelfth grade students and contain enrollments of 4,200 to 6,500. The structures may take advantage of Pittsburgh's conventional topography and exploit air rights over railroads and highways. The new high schools will be linked with existing schools and community facilities through landscaped malls which will create Education Parks. Buildings and parks will be located to serve communities consisting of different racial, social, and economic groups.

Planning of the comprehensive high schools is in progress now and presents vocational educators and facility planners with a unique opportunity to create facilities which satisfy the requirements of this rapidly changing age. Flexibility for future changes, clusters of space to allow the sharing of subject material, and expression of relationships between academic and vocational programs can be built into these new buildings. After the comprehensive high schools have been built, educators will be provided with new opportunities to equip students with the necessary skills for useful employment in the future. But, what can be done for students who are in school now?

Existing high schools will be converted to middle schools when the comprehensive schools are built. This restricts plans for alterations of existing senior high school vocational laboratories. Investments made in construction and the installation of new equipment may be lost when senior high school classes are moved to new buildings. If present day students are not to be made to endure the inadequacies of existing facilities until the new schools are built, a way must be found to provide adequate yet anonymous facilities that are easily convertible from senior high school job-centered programs to middle school exploratory programs.

Almost every aspect of vocational education in Pittsburgh is changing. Equipment and existing facilities are being improved. Vocational programs are being reorganized and new curricula written. A complete integration of academic and vocational programs will be created in the new comprehensive high schools. These changes are producing new requirements for vocational facilities. Flexibility and new organizations of space are needed to allow for the teaching of new skills and for the exploitation of relationships between courses. New systems of construction and methods of planning must be developed if these requirements are to be fulfilled.

A Comprehensive Concept for Vocational Education Facilities

Space

Modern vocational education requires space for the teaching of new and old subjects in areas where subject material can be shared. This study proposes that such space be conceived of initially as being open and flexible. Restrictions to that openness and flexibility can be added, sparingly, if educational practice creates the necessity. For instance, visual and acoustical barriers can be added to isolate disturbing activities. The degree of mobility built into such barriers depends entirely upon the value that educators attach to their need for flexibility.

Mechanical Service Systems

As activities are changed or moved, the associated mechanical system which supplies services for equipment and environmental control for students must be modified as well. As elements of a mechanical system wear out or become outdated, they must be replaced. This report recommends that adequate space be provided in floors and ceilings to allow for the expanding variety of mechanical systems. Modification of these systems will be facilitated if they are accessible and if elements can be connected and disconnected with ease. Independence of mechanical systems from structural frames will allow the use of the same system in different types of structures, both old and new. Flexible and independent mechanical service systems can give educators the chance to specify simple systems, which can be made more and more complex as sophisticated equipment is added or if activities change.

Equipment

Flexible vocational facilities require mobile equipment. Many units of equipment in home economics, business education, and in some industrial courses can be made mobile, simply by putting them on re-tractable wheels. Even the heavier equipment used in working with metal and wood can be moved with relative ease if methods employed in industry are used. Placing heavy equipment on vibration isolation mounts eliminates the need for bolting to floors and facilitates moving with fork lift trucks. Lack of equipment mobility need no longer prevent an instructor from simulating different industrial situations with one set of equipment.

Cost

Facilities involving the types of innovations described in this report would be extremely expensive if they were built on an individual basis. The volume of construction that is being planned in Pittsburgh, however, creates the possibility of reducing costs through mass production. It is proposed that systems of space division, mechanical service distribution, and mobile equipment be standardized in all new facilities. This standardization need not create uniformity, if the potential of the proposed systems is exploited to serve the needs of each instructor and student. Bids from manufacturers can be requested on the basis of combinations of exisitng products or of totally new products developed to meet specifications written by educators. Although this technique will not reduce facility costs below present levels, it will produce products that are much better suited to the needs of vocational education at only moderately increased costs.

Planning

Creating flexible facilities does not relieve educators of the necessity of careful planning. Courses that relate to one another; equipment and space that are shared; small, medium, and large group instruction; and new courses involving new sets of equipment all produce planning problems that are not solved within the present scope of the single course, single room oriented standards and recommendations. Educators and planners must know not only how many typewriters are needed by thirty typing students, but also how many typewriters are needed by a cluster of typing, shorthand, and office practice students. Architects must know not only how much space is required for thirty bookkeeping students, but also how much space is needed for a large area where two hundred bookkeeping, typing, shorthand, data processing, and office practice students share subject material, equipment, and space.

This study recommends that a planning technique be used which does not require experimentation with live classes in temporary facilities. One such technique is a computerized simulation of class activities. Creating class activity models enables the simulation of classes of any size, using any instructional technique for any period of time. By analyzing activities represented in a computer, educators will know more about equipment and space needs for instructional innovations and can plan facilities before students enter programs.

A Comprehensive Concept

The recommendations that appear in this report are based on the assumption that vocational education must provide training in many specific skills which are changing as industry responds to technological progress. Further, it is assumed that students can be provided with greater future occupational mobility if they are exposed to many skills in the contexts in which they appear in modern industry. This means that skills must be seen not only in relationship to industry but also in relationship to science, technology, and society. The success of this approach in a comprehensive high school depends in part on the environmental quality of facilities.

A walk down the corridors of many existing schools takes a student past a variety of educational activities occurring in classrooms, but the student sees nothing but closed doors. Everyday, several classes in a school cover similar or related subject material in different contexts, but few students will perceive this material in any but the context of the course and classroom in which he is involved. These effects are partially the results of education in permanently isolated rooms. Conversely, facilities can be equally effective in expressing continuity of subject material and displaying the many aspects of modern industry.

Facilities that are open can provide visual exposure to many educational experiences that no single student could have in his formal classes. Just seeing what goes on in another vocational or academic field may be more influencial to a student than a conference with his guidance counselor. Facilities that are flexible give instructors the opportunity to present information in the context of several different subjects areas at once. A student can more easily see his own developing skills and interests in relationship to his fellow students and their abilities.

The recommendations made in this introductory section and described in detail in the following technical sections are directed toward creating the open, flexible facilities needed to implement the new objectives of vocational education in Pittsburgh and across the nation. An attempt has been made in this research project to view facility problems in relation to one another and to offer solutions that will help release the full potential of educational innovation in comprehensive high schools.

FLEXIBILITY THROUGH MODULARITY

2

Prepared By The Research Team
For A Comprehensive Concept
For Vocational Education
Facilities

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Preview of Unit Two, Flexibility Through Modularity

The purpose of this section is to discuss elements of the vocational education facility environment which are separate from the permanent structural skeletons of buildings. This will include a discussion of the potential mobility of vocational equipment, problems of providing flexible mechanical services to the mobile equipment, and a comprehensive scheme for a modular component system which would provide all environmental and laboratory services and could be applied to modernization as well as to new construction.

Many planners consider the major obstacle to making vocational laboratories flexible to be the immobile nature of most vocational equipment. A study of the nature of vocational equipment and of the way that modern industry handles this problem leads one to believe that this is not true. Furthermore, there are good educational reasons why flexibility is desirable in vocational facilities.

Obviously, the floor space available in a vocational laboratory is limited. Planners can compensate for this limitation by providing the ability to rearrange facilities. Equipment may be set up to demonstrate one aspect of industry and then moved aside or to a new location to demonstrate another aspect. If instructors wish to duplicate industrial situations, laboratories should provide the chance to simulate different types of industrial layouts. Job shop and production line layouts are common possibilities that might be considered for instructional purposes.

In the job or process type of shop, machines are arranged by function; for example, all lathes are grouped together. This layout provides flexibility because the machines may be used for any product and for more than one product at a time, without rearrangement. Also, there are many plants in which equipment has been arranged by product. Equipment has been arranged to form a production line with the material moving, continuously, from machine to machine. Industry has found that savings in material handling as well as process inventory costs justify rearrangement of equipment as the products change or as new techniques are developed.

There are other times when instructors may choose to teach their courses by grouping equipment in terms of general processes. Ralph Gallington, Professor of Industrial Technology at Southern Illinois University, has created the following list of possible activity areas:

> Individual areas could serve, conceivably, as basis for some of the new area concepts; for example, research and development, materials testing and design analysis. Another conceivable use of areas might involve such facets of industry as cutting and dividing, binding, bonding, and attaching, coating and finishing of surfaces for protection against corrosion, wearing away by abrasion, surface finishing, casting, forming and

extruding of material while in the plastic form, and heat treatment of various materials. Still another use classification of the areas might group together such activities as management, marketing, and the like. All areas could work on a group project involving production methods in controls for quantity produced items.[1]

The list of alternatives goes on and on; however, the result is the same in every case. There is a need for highly mobile equipment and flexible space to accommodate these different demands. In the following paragraphs, the problems and solutions associated with dynamic vocational facilities will be discussed.[2]

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[1]Gallington, Ralph O., "A Space Concept for New Approaches in Industrial Arts", Industrial Arts and Vocational Education, March 1966.

[2]Data presented in the following sections was prepared by the acoustical-mechanical consultant and the mechanical engineer.

Equipment

Creating Mobile Vocational Equipment

One of the problems of making vocational equipment mobile is its weight; however, little of the equipment presently used in the schools exceeds an average floor loading of two hundred pounds per square foot. Much of the equipment now used in industry not only is heavier, but the loads are carried on small bases. A multiple spindle automatic lathe will weigh over five thousand pounds and have a base that is sixty-eight inches by twenty-eight inches. This results in a floor loading of approximately three hundred and eighty pounds per square foot. A punch press with a twenty-five ton capacity will weigh over three thousand, three hundred pounds, and be placed on a base thirty-three inches by fourty-seven inches. The average load in this case would be three hundred and ten pounds per square foot, plus an impact load. Industry has developed techniques for moving these excessively heavy equipment units to provide for rearrangement of production lines. Since these problems of heavier equipment have been overcome in industry, there is sufficient evidence that similar problems of vocational equipment could be overcome as well.

There are a number of ways that heavy equipment can be lifted and moved. Where equipment must be lifted off the ground, a fork-lift truck can be used. If it is not necessary to lift the machine more than a few inches to move it, as is the case in most rearrangements of vocational equipment in a laboratory, the base may be modified so that it can be moved with a skid truck. This is less costly and needs less maneuvering room than a fork-lift truck. Machines which are mounted on steel skids can be moved readily with manual or battery-powered skid trucks. A dollie with wheels that lower by hydraulic action could be made part of the base of a machine.

A number of examples may show what is involved in moving even the most permanent types of equipment. A gas range can be moved frequently, if casters are mounted permanently to the base. Loads of up to eight hundred pounds can be moved easily on the proper size caster. Casters can be secured with a locking feature or movement may be prevented by a foot actuated brake. A sink can be moved since it is usually light enough to be lifted onto a small four-wheel dolly. In this case, quick connect fittings will be required for hot and cold water and the drain. These fittings are commercially available.

A drill press can be mounted on a skid-type base and easily moved with a truck. Small models can be moved on a dolly. An auxiliary light could be wired integrally with the power. Consequently, a simple twistlock plug would make a quick connection for all services to a small drill press.

Mounting a milling machine on a skid base would facilitate movement with a power-lift truck. The legs of the base would be mounted on vibration mounts with leveling screws; for, the biggest problem with moving a milling machine is in maintaining its accuracy. To insure accuracy, a milling machine should be leveled before operating. Most machine tools have air lines close by, to be used for blowing off chips. This line can be attached with a quick-acting coupling.

Large equipment units must be stabilized without sacrificing mobility. In the past, most heavy vocational equipment units were bolted to the floor, although there is really no need to do so. A simple felt pad will suffice, in some cases. Where there is considerable vibration, special shock absorbing mounts are available.

The units of equipment which were discussed represent the broad areas of problems encountered in making machinery mobile. It can be seen from this discussion that mobile vocational equipment is a feasible idea, worthy of further exploration.

Equipment Replacement

Equipment should be replaced when the probable maintenance cost is greater than the cost of a new piece of equipment plus the new equipment's maintenance cost. However, the director of vocational education is usually not permitted this decision, but is presented with a budget for new equipment.

Often, in setting budgets for the next period, the maintenance account and the equipment purchase account are viewed independently. Budgets for these items are set on the basis of historical information and any unusual plans for the coming period, such as the construction of a new school. These costs, however, are not independent. Maintenance cost is a function of equipment age and usage. Consequently, both budgets should be established, jointly, to minimize the total cost of maintenance, plus replacement.

There are several mathematical models which can be used to aid in establishing these budgets.[3] A more recent model by Kolesar[4] derives optimum replacement rules when the equipment is assumed to be subject to Markovian deterioration. The Markovian deterioration theory involves viewing a piece of equipment at the beginning of a time period as having a set of probabilities that describe its chances of being in one of several other states during the period. Each of the states has a maintenance cost associated with it. Then, the costs are examined for "n" periods, the time at which the equipment is not longer usable. The replace-

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[3] McCall, J.S., "Maintenance Policies for Stochastically Failing Equipment, A Survey," International Center for Management Science, Report 6630, 1963.

[4] Kolesar, Peter, "Minimum Cost Replacement Under Markovian Deterioration," Management Science, Volume 12, No. 9, 1966, pp. 694-706.

ment equipment being considered, which has a different set of probabilities, is examined in the same manner. A choice is made on the basis of the expected minimum cost. Budgets set on this basis minimize the total expected costs of maintenance and replacement.

In the more typical situation, wherein the decision-maker must decide which equipment to replace within a given budget, a problem still exists. This decision problem, like many of the other complex problems facing a vocational facilities planner can be analyzed more easily by the use of a mathematical model. The decision model needed is one that selects those items to be replaced within a fixed budget for equipment replacement. This is somewhat analogous to equipment replacement decisions in industry, although return on investment is not a critical variable.

The main variables are maintenance expense versus the cost of new equipment and the ability of equipment to represent present day industrial machinery. To implement any type of decision model, it would be necessary to install a records system that would identify each piece of equipment and contain a history of the maintanance activity on this equipment. This record would include major overhauls, major breakdowns, down time, maintenance and usage. With this record, it would be possible to forecast future maintenance expenses, usage and other information needed in the decision model. However, the educational decision must be considered regarding the appropriateness of the equipment to the instructional task. At times, equipment becomes obsolete before it wears out.

Services to Equipment

A discussion of equipment, whether it is highly mobile or not, is not complete without a discussion of the services that must be supplied to the equipment. At times, the mechanical servicing problems associated with some equipment is most extreme and demanding.

Flexibility is essential to assure that the system will not become obsolete. In most cases, a slightly higher initial cost is easily offset by the ease with which alterations can be made. The typical services required in vocational education laboratories are electricity, compressed air, gas, and hot and cold water. Steam is required in some operations; however, since steam can be generated locally, it is unnecessary to provide this service throughout a building.

Normally, the power connections and disconnections needed in moving electrical machinery require an electrician. Often, the problem is not so much the time the electrician takes, but of securing his services. Systems are available that make it possible to do this connecting work with unskilled labor, including the school custodian or the shop teacher.

Cables can be used to distribute electrical power. Flexible access can be provided for most equipment through the use of twist lock plugs. Bus duct is of less value because it is exposed and because making the connections takes longer than coupling a twist lock.

A number of machines use gas for processing as well as heating; for example, some printing presses use a burning gas to reduce the static charge. Gas lines should be available wherever the possibility of installation of this type of equipment exists.

Often, compressed air is used for powering hand tools, because the equipment is less expensive and requires less maintenance. In addition, many machines have air cylinders to actuate their components. Also, compressed air is used for cleaning equipment. Distribution of compressed air demands consideration of the quantity and pressure required by these possible uses.

Hot and cold water and drains must be available to sinks and for processing. Some machines will require water for cooling. For example, a thirty-five KVA spot welder uses approximately two and one half gallons per minute. The ultimate in flexibility is possible when the cooling of each piece of equipment is self-contained. However, special drains may be required for machines such as the whirler in the print shop which discharges an acid waste.

Exhaust hoods and dust collectors may be required for many operations such as woodworking and grinding. Where only an occasional machine requires a collector, a small individual unit might be utilized. However, a woodworking shop with a number of units could utilize a central line for collectors which can be connected with flexible hose.

Extreme service demands are made in welding, radio repair, and machining areas. Some welding machines draw large currents of up to three hundred amps and require some shielding. Where there are a number of oxyacetylene welding setups, the vendor can attach the gas tanks to a manifold outside of the building. A small appliance repair shop requires an electrical line free from interference, for testing. Machining to close tolerances should be done in an air-conditioned room because the temperature changes can affect dimensional sizes.

Fundamental to this discussion of mechanical services is the question of their distribution. In order to provide maximum equipment mobility and educational flexibility, services should be supplied on a uniform basis and with provision for easy connection. Although this kind of service provision initially is more expensive than standard construction practice, the long range costs of not providing this kind of flexibility become exorbitant. For example, if compressed air is not supplied systematically throughout some vocational facilities, the eventual costs of supplying this service, when class areas are shifted or other areas suddenly realize a demand for compressed air, become exorbitant.

Sample work statements and cost figures for departmental repairs and changes for the Pittsburgh Board of Education are listed in the Appendix. These figures demonstrate that the relocation of equipment and conventional school structures is expensive.

An Environmental System

The Module

Because of the rising cost of field labor and the rapid advance in industrial technology, it was an opening premise of this study that a factory-manufactured element or elements could be developed to provide high quality environmental control at a reasonable cost. Cost consideration included not only first cost, but also long term operating cost.

Flexibility in the utilization of general class, shop, and laboratory space would permit the building to fit the curriculum rather than force the curriculum to fit the building. For this reason a system of components is proposed which can be factory produced and installed with a minimum of field labor. The system would provide full service for control of the environment and for installation of equipment used in space ranging from vocational shops through the most conventional academic teaching areas. The

The system is intended for installation into old and new buildings alike.

Several factors dictate the use of modularized components:

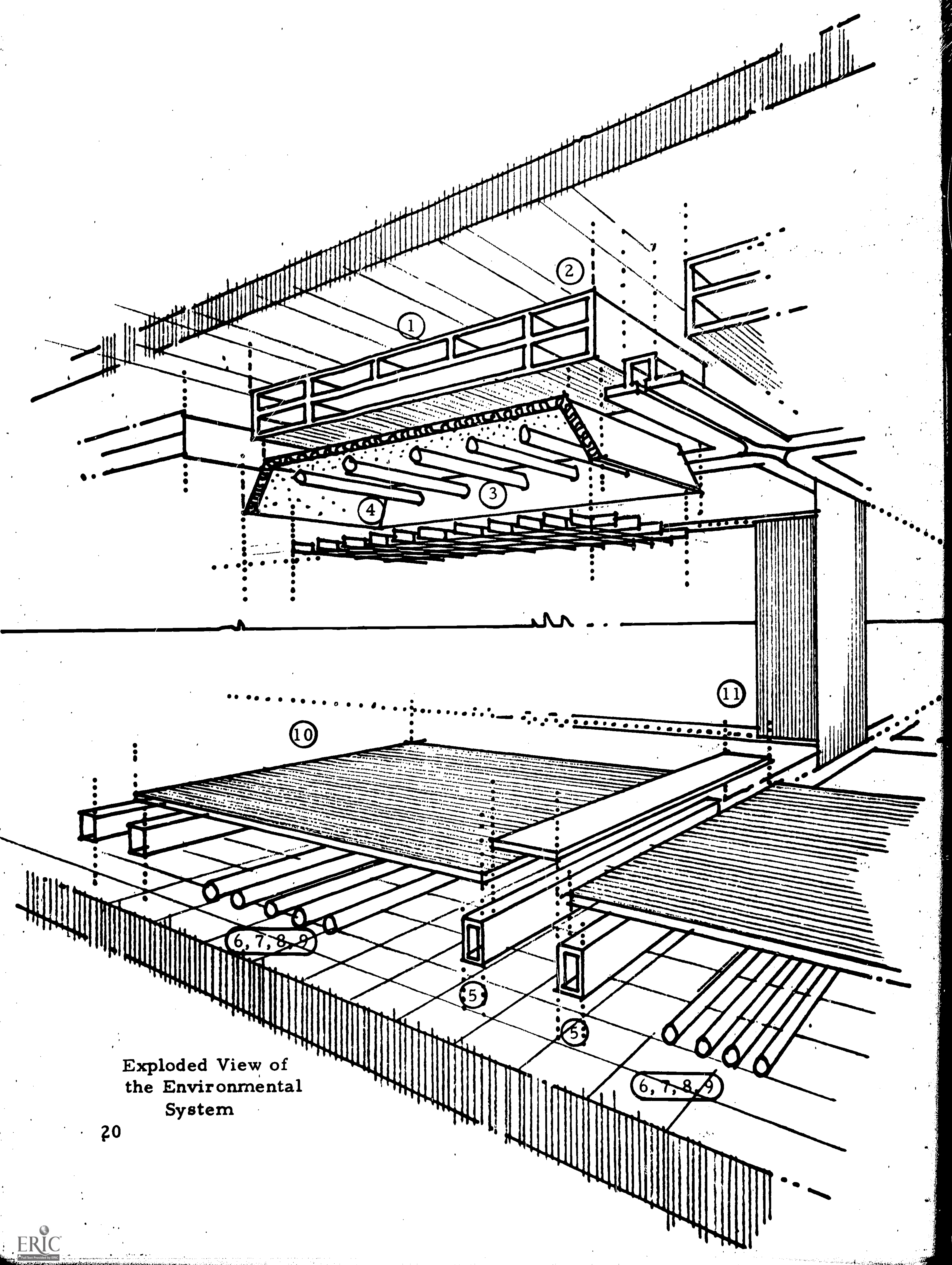
a. Production of large numbers of identical modular elements lends itself to production economies;

b. Modularity permits access to the various required services on a regular basis; and

c. Appropriately sized modules can be delivered to the site economically and can be installed with a minimum of expensive field labor.

The modularized environmental system was developed to provide the following services as illustrated in the "Exploded View of the Environmental System".

1. Air temperature and humidity control.
2. Exhaust air.
3. Lighting
4. Effective acoustical control



Exploded View of the Environmental System

5. Electrical distribution lines

6. Hot and cold water

7. Compressed air

8. Gas

9. A drainage system capable of taking conventional non-sanitary wastes as well as acid wastes

10. Various floor finishes

11. A completely relocatible partition system

Use of the Module

A space, furnished with a modular system can serve academic and vocational education programs more adequately than an existing conventionally constructed building. If the modules are properly dimensioned and if existing older buildings are adequately prepared to receive the modules, such a system can be utilized as a method of remodeling existing buildings. It can be even more satisfactory for the internal finishing and equipping of new buildings, where restrictions of existing building widths and interior columns do not exist. Thus, such a system would be suited to a full range of educational programs in existing as well as in new buildings.

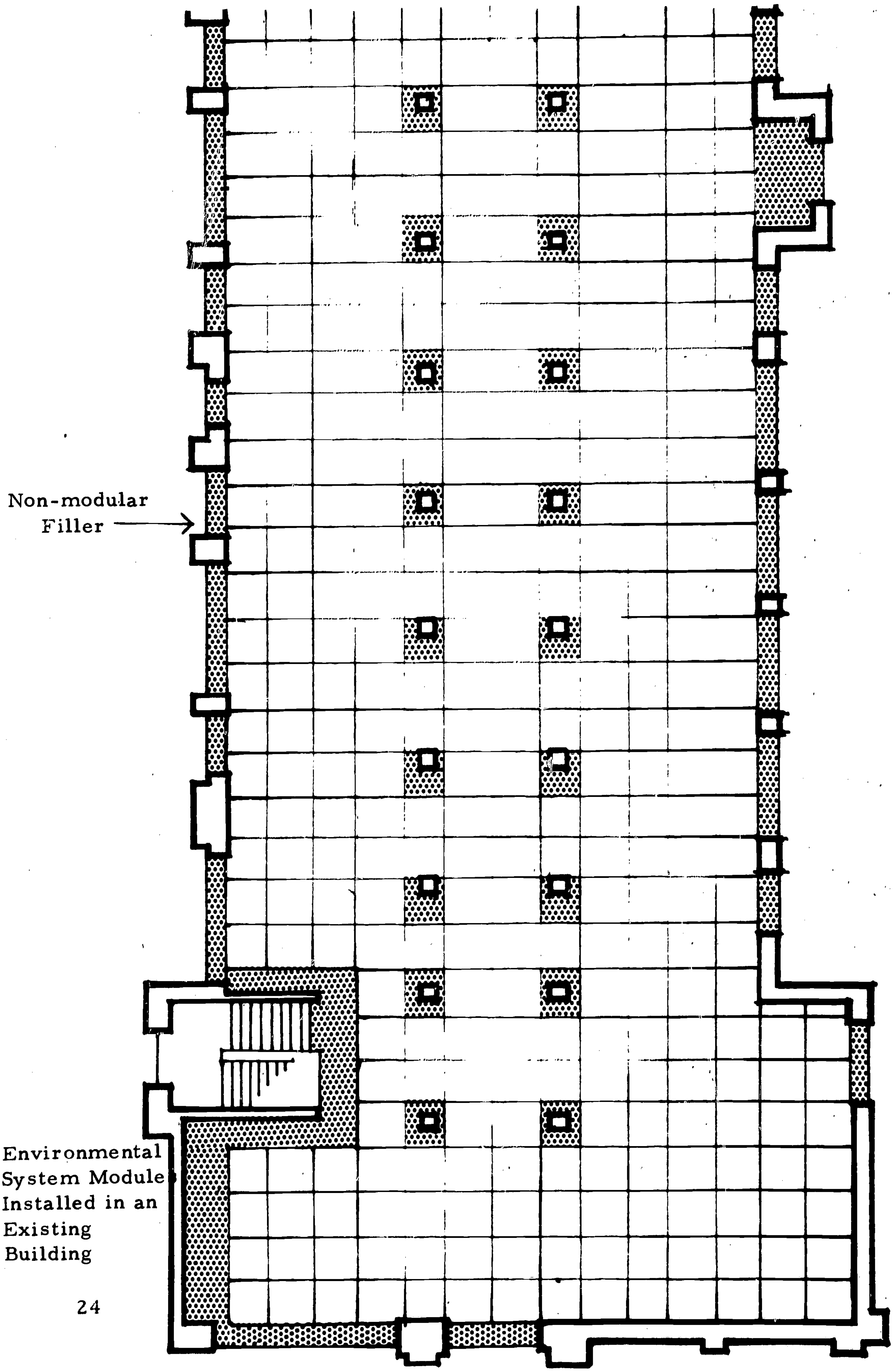
Regardless of the size of school markets, manufacturers will have strong incentive to develop maximum industrialization of the product as a standard item, for, the system is also applicable to industrial and commercial buildings of many varieties. In an industrial job shop where machine tools must be relocated every time a new contract is undertaken, both the operating and production costs could be reduced greatly by the elimination of the need for such present day techniques as trenching existing concrete floors for new electrical lines.

Module Size

One consideration has been to develop this system for use in total or partial modernization of existing high schools in the Pittsburgh system and their transformation into middle schools. Though there are broad similarities between one school and another there is an almost infinite list of variations in such fixed components as the distance between exterior walls and the corridor column line, the column dimensions and the corridor width.

Given any one wing of any one school, it is a relatively simple matter to develop the length and width of a module which comes close to covering the largest percentage of the floor area of that wing. This has been done for one wing of the school illustrated in the diagram, "Environmental System Modules Installed in an Existing Building". It can be seen from examination of this diagram that each column destroys only one module and that twelve modules fit between the exterior walls with only about eight inches of non-modular area parallel to each exterior wall.

It is not the purpose of this program to develop a module which can be fitted into a given school, but rather to demonstrate a system which could be used to find the module which fills the largest percentage



Environmental
System Modules
Installed in an
Existing
Building

of area of all of the schools under study. Solution of optimum module size by approximation or by visual means would be an insurmountable task in view of the large number of dimensions that occur in surveys or working drawings of all the schools. Therefore, we have evaluated the feasibility of utilizing a computer to determine what length and width of module will fill the largest area. It is our conclusion from evaluating the limited, available data that such a program is not only feasible but can utilize program subroutines in common use in the computer field today. A more specific discussion of this matter is given in Unit Seven.

Basic Module Design

A consideration of the relationship between the variety of services with the equipment to which such services must be attached leads one to conclude that it is neither possible to provide all of the services in the floor, making connections in an upwards direction, nor feasible to install all of the services in the ceiling, making connections in a downward direction. Furthermore, the quality of finishes in the existing schools to be renovated is such that by any modern standards both the floor and the ceiling must be replaced, anyway. For these reasons, two factory manufactured components were considered. One would be suspended from existing structural slabs to form air distribution and delivery equipment, as well as lighting and acoustical control. Another element would be supported upon the floor slab to contain the services which are most ideally connected upwards through the legs and bases of the equipment to be installed.

Lists of equipment likely to be used in a wide range of vocational courses were compiled; and standards for environmental control, such as air temperature and lighting level, were reviewed. From these, it was possible to establish loads that various distribution systems, such as duct work and wiring, would have to carry. Then it was possible to establish approximate wire sizes, pipe diameters, and duct diameters. It was established that all of the ceiling functions could be carried out within an eighteen inch depth and that all of the floor functions could be carried out within a depth of approximately twelve inches. Thus, in any portion of any of the existing schools where the vertical dimension between the floor and the underside of the slab above is twelve feet or greater, such modular elements could be used throughout. This would provide clearance of nine feet and six inches.

A preliminary survey of ceiling heights in the secondary school buildings of Pittsburgh which appears in detail in Unit Six, Appendix, indicates that over half of these are twelve feet high or more. A vast majority of these could accommodate a modification of the system which only involves ceiling modules. Available ceiling height in existing schools will not become a restriction.

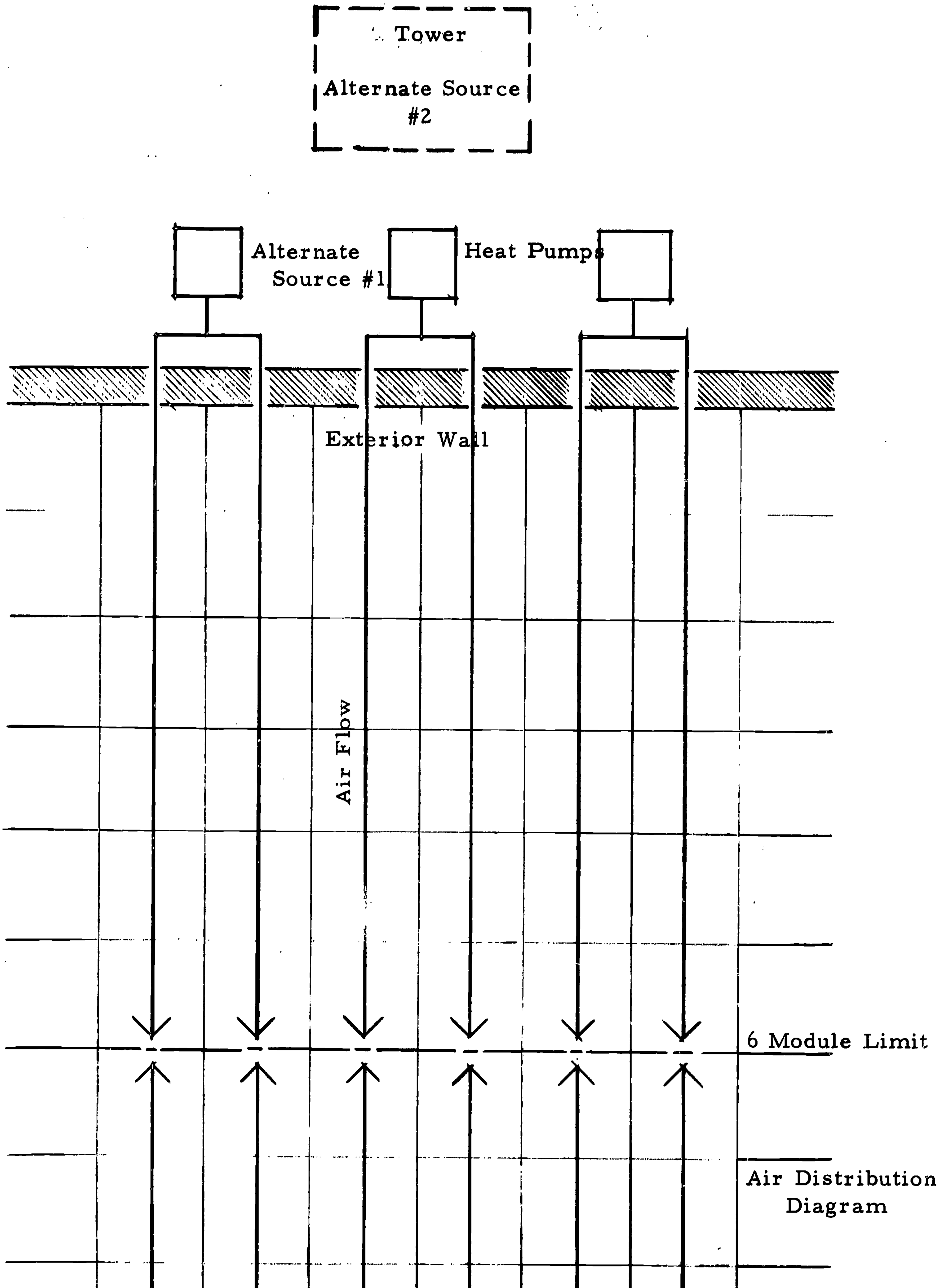
Obviously, in new construction, any desired height can be achieved. Where twelve or fourteen feet finished heights are required to accommodate certain shop programs, there will be cases where adequate height is available in the existing schools and other cases where it will be necessary to construct additions to the school.

In evaluating these proposals, we have considered the full range of methods by which energy can be distributed around the buildings. There is little choice in distributing electricity to power equipment. The energy is purchased from the power company and distributed through the building by a fairly conventional system of wires and cables.

With the provision of cold air and warm air for temperature control, the problem becomes somewhat more variable. For example, it would be possible to run electrical power to each module and within that module generate warm air by resistance heating and cold air by one of the conventional refrigeration cycles. On the other hand, it would be possible to go back to a central mechanical room at one point in the building and produce both a cold medium and a hot medium to transport the energy to and from the occupied spaces. This medium could either be hot and cold water or hot and cold air transmitted through pipes or ducts. Between these two extremes there are a number of methods of controlling temperature within the occupied spaces, including central units for each wing of the building, smaller units for one entire wing on a per-floor basis or still smaller equipment for small numbers of modules. A fairly detailed preliminary analysis of initial and operating cost was made based on commercially available heating and refrigerating equipment. This study concluded that unitary equipment to provide heating and cooling for an area of about three hundred and sixty square feet would be most economical.

Any area could be served with hot and cold air by connecting modular units end to end and feeding through the nearest module to subsequent ones. Duct sizing must be constant throughout all modules in order to maintain the repetitive character of the modules for production line techniques. If too many modules are served through the module nearest the source of air either the ducts in all modules or the air velocities in the modules nearest the source will become excessively large. An analysis of these considerations led to the conclusion that a run of six or seven modules was the longest that seemed practical, at least in existing buildings. Rows of modules, as shown in the "Air Distribution Diagram" would be reasonably sized and would have reasonable air velocities. Further, two such rows could be served by a single supply unit connected to rows of modules by header ducts.

Further study of the same line of reasoning suggested that all electrical cable should be of identical size



Air Distribution
Diagram

regardless of module position and should be sized to permit linkage of six or seven modules in a line. Identical reasoning was applied to air lines, gas lines, water lines, and drains.

Building Preparation

Portions of the building in which there are large, relatively open spaces facilitate easy placement of modules. Since all buildings are not of the same size, nor all columns placed in the same manner, this would automatically leave certain areas along the exterior wall and around columns and other irregularities, into which whole modules could not be fitted. Therefore, prior to the delivery of the prefabricated modules to the building, it would be necessary for an architect to lay out module lines in the most optimized way and design relatively standard "fillers" at the floor level and ceiling level. This phase of the work would be carried out by conventional means by a general contractor hired for a particular job. This would be coordinated with the refurbishing of existing non-modular space, such as stairways, toilets, gymnasiams, and auditoriums.

Module Installation

When portions of a building to be modernized had been prepared to receive an integral number of whole modular units, the system would be delivered to the site. Each floor and ceiling module should be made a self-contained package approximately eighteen inches smaller than the module-line-to-module-line spacing on the ceiling and six inches smaller on the floor. In addition, a system of partition tracks and ceiling filler panels and floor filler panels would be delivered with the modules. The floor and ceiling modules would be put in place and connected by means of various pieces of flexible tubing, piping, or cable and with special plugs, snap fittings, or flange attachments. The partition and partition track would be hung and the ceiling and floor fillers installed. Connections would be made between the face of the module nearest the exterior wall and the various supply and distribution systems.

At the completion of these operations, the modular area of the building would be ready to be furnished. Machine tools could be moved in and the electrical and exhaust connections made by school personnel. This might be done by the Department of Plant Operations and Maintenance, by custodial help at the individual school, or even by staff members. In most cases it should be unnecessary to call in outside contractors for the installation of equipment.

Two special considerations arise concerning the installation of modules which are identical in that they carry all services. It may be well known for one reason or another that a given area of a given school might have no need for compressed air. In this case it would be desirable to have the modules delivered without air lines. Obviously, there will be cases where educators feel that the addition of some services is not economical, in view of the relatively small number of times that space would be reallocated. Finally, the history of prefabrication in the building industry has led us to be extremely wary of union jurisdictional situations. Therefore, it would be desirable to separate the installation by the various trades where this became necessary. Of course, this would increase the field installation cost because the modules could not be pre-wired, pre-plumbed, or pre-lighted.

For example, the wiring problem might be solved in this fashion. A module-length piece of wire having a female plug at one end, a cable with suitable "T" connections to lead to receptacles in the sides of the modular unit, and a male plug at the other end could be fabricated. This wire could be installed in the module by means of specially designed snap-in connections. In the ideal situation, this wire would be snapped in at the factory and delivered, integrally, with the module. Where desired, this particular service could be installed separately. All of the wiring could be fabricated in the above described manner, but could be delivered to the electrical sub-contractor for installation into the modules on the site. Hopefully, this "snap-in" approach would resolve most of the jurisdictional disputes.

The Environmental Services

Sound Control in Vocational Laboratories

Within the context of the foregoing design decisions, it is extremely important to develop a system in which reasonable control of general activity noise is achieved and in which it is possible to have flexibility of space use without acoustic interference between activities. As is the case in all general teaching facilities, the requirements are to provide sound absorption for control of sound within the space in which it is generated and to provide separation of adjacent activities, if one is noisier than the other.

Under normal conditions, adequate general noise control within a given space is provided by installing efficient sound absorbing materials equal in area to at least half of the room area. It is proposed to incorporate this material into the ceiling module, where it can double as a light reflector. The proposed material would be a glass or mineral wool blanket faced with a porcelain enamel, perforated metal surface.

Flexibility of space on an activity-to-activity basis can be provid..l by the installation of partitions which can be moved at will or by eliminating partitions, either totally or partially. Many modern schools have been built which utilize movable partitions in the form of accordian or folding panel walls. Sometimes these do provide the necessary acoustical isolation. Unfortunately, school planners use these movable partitions in the same location that masonry walls were located. Not recognizing the full potential of movable partitions, many planners seek to isolate course areas instead of zones of differing noise level.

Any set of class activities generates several different noise levels. For instance, a Cabinetry Laboratory generates a noise level created by machinery. However, during lecture and discussion periods, the Cabinetry Laboratory can be as quiet as any library. A Latin class, on the other hand, is often typified as always being quiet; but there are times when class recitation generates a disturbing level of noise. Therefore, instead of wrapping movable partitions around total class areas, planners should use them for the purpose for which they are most effective to isolate activity areas generating different noise levels.

Some school planners have gone to the concept of open-plan space design. By using sound absorbing material, they hope to avoid the use of any acoustical wall device, Walls in these schools serve only as visual barriers. Unfortunately, no special provision is made for the separation of quiet activities from general areas and extremely noisy areas.

Both of these solutions to flexibility have produced a great deal of criticism, some of which is justified.

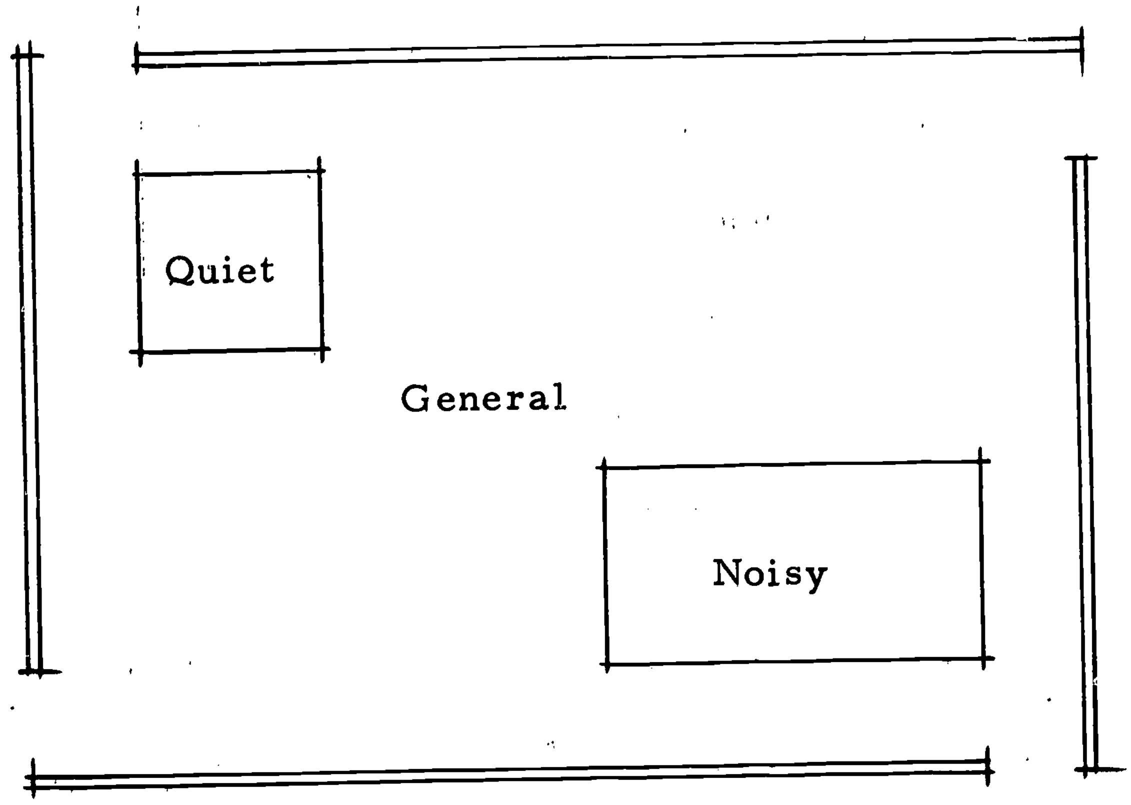
This has meant, for many people, that flexible open-plan space design was not, and never will be, a workable educational idea. However, educationally, these solutions can be valid. By not providing a limited environment which is specific only to the particular set of courses which a student is taking, we hope to provide open spaces in which other activities and courses constantly are visible and accessible. In the open-plan space there can be considerable idea spin-off and a general deepening of the educational experience. But, the major reason is that the kinds of changes which are occurring ever more frequently in today's school building can be effected more easily if they are not hampered by permanent wall construction.

Some planners have maintained that folding partitions have limited isolation value and that partial partitions could never provide adequate isolation between teaching spaces. They concluded that conventional high density, fixed partitions were the only solutions to sound isolation problems within a school. However, the folding partition argument has been strengthened greatly by recent developmental research. This development can be traced to the beneficial efforts of the research activities sponsored by Educational Facilities Laboratories. Thus today there are many folding partitions on the market which provide better sound isolation than the average inter-classroom, fixed masonry partition of a number of years ago.

Many people in education and even a few within the field of acoustics have argued that the large number of apparently successful open-plan schools gives testimony to the effectiveness of such construction. Others claim that a more careful examination reveals that although they are satisfactory for the majority of activities, these schools periodically are plagued with special conditions making their use difficult. Comparison of the noise levels of various teaching activities, the times that these various degrees of noisiness will occur, and the areas which each activity occupies indicates that a much higher degree of openness can be achieved through the proposed system. Hence much less restriction of movement can be possible while at the same time allowing for the special conditions which can produce noise interference. This method can provide large teaching spaces which are open, without interference occurring. The other areas can contain high noise levels, without disturbing the open space or can be secluded for the sound control necessary for contemplative study, examinations, or reading.

A cursory examination of the types of activities likely to take place in educational laboratories indicates that a vast majority of the area's will contain activities which generate only a moderate level of noise. These include most laboratory courses in a business education, technical education, and home economics courses. Thus the much smaller area represented by the extremely noisy activities or those requiring low noise levels can be thought of as islands in an otherwise open space.

At present, there are a relatively large number of operable partitions providing sound isolation sufficient to isolate a noisy area from a general area or a general area from a quiet area. Two such partitions providing an intervening buffer can be utilized to isolate even a noisy area from a quiet area. The intervening space can be used for storage, study resources, circulation, medium size classes or general activities.



To substantiate the above generalization, we have reviewed noise data found in an extensive noise measurement survey.[5] It was found that the noisiest piece of equipment likely to be encountered in a vocational program is a furniture parts planer. Noise levels from this machine, from the lowest to the highest frequencies, are in the range of eighty-four to one hundred and seven decibels. If we utilize measured sound isolation data for a fairly conventional accordian type folding partition, and reduce the planer noise by the amount, the resulting levels on the remote side of the partition will be about equal to the noise levels in a moderately active business office or open school area. Such levels transmitted into an occupied general school area would be audible, but rarely disturbing. In contrast, if such levels were transmitted to a lecture room

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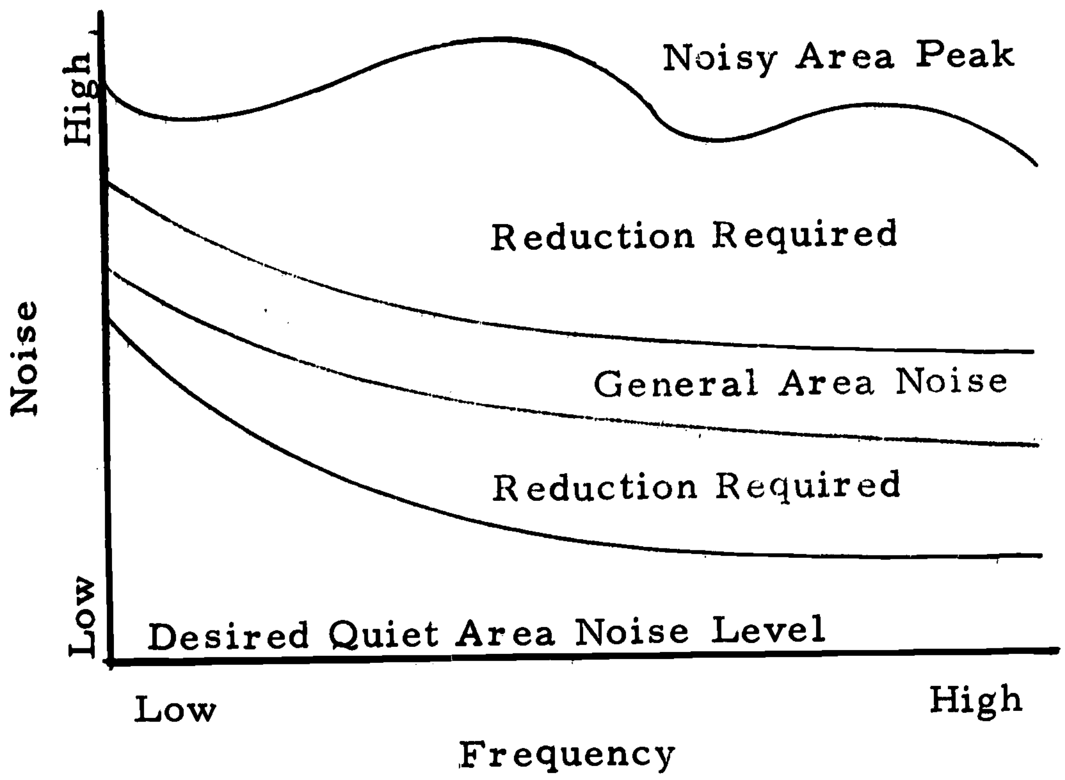
[5] Karplus, Henry B., and Bonvallet, George L., "A Noise Survey of Manufacturing Industries," American Industrial Hygiene Association, Quarterly 14, pp. 235-263, December 1953.

or study hall, they would be extremely disturbing. Therefore, if we include a second partition which enclosed the quiet activity, the noise transmitted through the two partitions should be close to, if not inaudible.



Tracks can be erected within the ceiling on a rectangular grid system throughout all general academic laboratory and shop areas. Each wing of existing schools can be furnished with sufficient lengths of operable partition so that any conceivable number of space divisions can be provided. For purposes of this section it is sufficient only to point out that such partitions should provide sound isolation in the range of STC thirty-five to forty-five. Thus two partitions spaced a minimum of five feet apart should provide fifty-five to seventy DB of sound isolation. The upper figure is more than is provided in the music suite of most well-designed conventional schools.

Electro-Acoustics

In a good educational environment we should provide systems which permit a lecturer to address a large group, allow movie projector sound to be conveyed to a large group, and permit communications to persons in various locations throughout the space. There will be times when a hundred or more students should be able to hear movie sound or a lecturer's voice. A low sound absorbing ceiling, together with noises from surrounding activities will make such large group instruction impractical without amplification. A suitable electro-acoustic sound amplification system will help solve this problem. With the use of electro-acoustic systems, it is also possible for material to be shared by students in various locations throughout the building.

With conventional amplification equipment, it is possible to provide a central control console similar to the type now used in the administrative suites of modern schools, and also local sub-control positions. Switching would permit connecting a microphone in any position in the building to any number of loud speakers distributed throughout the entire building. These loud speakers could be located in the perforated metal light reflector in the center of every module and connected through a communication circuit provided within the ceiling modules.

For transmission of programmed material to individual students located at remote points around the building, this signal may be carried in the communication channel located in the floor module. This would be accessible through the floor channel on any module line through a receptacle into which single or gang earphone plugs could be placed. Several channels of this sort could be provided, so that simultaneous programs could be distributed throughout the building. It should be noted that the sound isolation value of the earmuffs provided with most high quality earphones would considerably attenuate general activity noise, giving the student a sense of isolation without the necessity of partitioning spaces. Further it should be noted that by using telephone lines, it is possible to originate material in a central repository for the entire school system.

Mechanical Equipment Noise

Air supply and exhaust systems can be designed which will not disturb the activity in the area in which they are used. In the quiet areas, the noise of the mechanical equipment should be marginally audible, if, heard at all. It is assumed that only the hot and cold air supply systems and the return air system would be used in these areas. Since the exhaust air system would be used only in the general activity areas or the noisy areas, it is permissible for noise of this system to be considerably above the marginally audible condition.

Each module will be required to supply approximately sixty cubic feet per minute of ventilation air. With commonly available technology, the delivery of sixty CFM can be done almost silently. If, for example, six modules are connected one to another, the module nearest the source of air supply will have three hundred and [illegible] CFM of air traveling through its distribution ducts. Noise due to velocities of one thousand to one thousand two hundred feet per minute can be readily attenuated in the middle layer plenum of each module simply by providing adequate acoustical lining material. Provision is made in the dual duct mixing box for an attenuating baffle. With proper attention to detail, this baffle should be capable of reducing any turbulence noise which might occur at the mixing box damper.

Because of the high level of activity noise in most shops and because the exhaust noise in laboratories would be confined to hoods, noise control probably will not be required for the exhaust system. In any event, mechanical equipment noise control technology is well known and can be incorporated into the industrialized design of the ceiling component.

The machine providing heating and cooling can be sound isolated in a number of ways. In the first place, it could be fully vibration isolated by conventional means. It is possible to design sound attenuators both to prevent sound from traveling through the modular duct distribution system and also to prevent noise from emanating into exterior areas where it might be disturbing.

Lighting

In our original proposals it was considered desirable to have three levels of illumination available in any module at any time. These included a very low level suitable for emergency lighting, for circulation, and for limited notetaking during audio-visual presentations; a normal classroom illumination level of approximately seventy foot candles; and a high illumination level as high as a thousand foot candles for very specialized detailed work.

However, it appeared evident, on reviewing the available texts and interviewing specialists, that seventy foot candle average illumination was sufficient for all but a very small number of tasks such as operation of certain machine tools. In such cases, local illumination can be provided, powered by the floor electrical distribution system. For many activities, portable light sources are even advantageous, because shadows on woolen material or reflected glare from scribed metals can be controlled by adjusting the direction from which the local light arrives.

It was discovered that transmitted projection of visual images can be readily handled in seventy foot candles of illumination. No restriction would be imposed on audio-visual presentations and light control would be simplified. Rear projection devices containing the projector, mirrors, and screens are available as unitized portable equipment. These can be moved readily from place to place and can be used for the projection of all of the conventional photographic media, including all sizes of slides, film strips, and motion pictures.

In addition to rear projection in the conventional sense, television monitors utilize transmitted images and can, therefore, also be effectively viewed in a room illuminated to seventy foot candles.

It is presumed that as technology advances, the inherent advantages of television systems throughout citywide school systems as well as regional networks will increase their use. The basic advantage of television display is that virtually any form of program medium may be used as an input to the system and an infinite number of viewers may watch with equal acuity depending only on the number and size of monitors provided. Material projected may originate locally, projected to monitors close to the large number of viewers. At the other end of the scale a live program originating miles away may be viewed simultaneously, by any number of viewers throughout the country or even at a delayed time by video recording. It is reasonable to assume that color will be added to the virtues of television systems in the fairly near future at reasonable cost.

Lighting can be handled with one moderate level of overall illumination at no sacrifice to the quality of projected visual presentations. Providing localized, directable high level illumination in those few areas where it is required will supplement lighting from the system.

It would be extremely desirable to incorporate within the modular system a method of automatically providing emergency lighting in the event of power failure. We are proposing, therefore, that each module contain a low voltage emergency reflector lamp mounted above the lighting diffuser grid and projecting straight downward. This would be powered during emergencies by a rechargeable battery. The battery could be maintained in a charged condition by a device commonly in use known as a "trickle" charger. Power failure automatically switches on the emergency lighting system in every module and battery power is sufficient for a minimum of six hours or more of constant operation.

Heating, Ventilating, and Air Conditioning

The modular system previously described is adequate as a method of distributing air through the building and delivering it into the occupied space. However, the method of connecting the source of heating and cooling into the modular system is dependent upon the size of the installation and the economies that can be realized by modularizing into small elements those components of the supply and distribution system which do not fall within the general modular area.

If one assumes that rows of six modules of approximately thirty square feet are to be served, one can provide a packaged air conditioning and heating unit for one, two, three or more rows of six modules. If estimates are made pertaining to the number of square feet of exterior wall and window per module width, heating loads required to offset outdoor loads, heat from the lighting required to meet lighting standards, heating provided by an estimate of maximum amounts of electrical equipment which will be located within the row of six modules, and also the sensible and latent heat loads provided by occupants of the space on a per-module basis, it will be possible to estimate the total heating and cooling loads which must be handled by the equipment. Making such assumptions and recognizing that it is more difficult to cool a space than to heat it, we find that to serve one row of six modules will require a two ton air conditioner, two rows of six modules, a three ton air conditioner, and finally, three rows of six modules will require a five ton air conditioner. It can be established by consideration of size and weight as well as operating economies that a three ton unit would be most suitable. Thus, the two rows of six modules each utilizing a three ton air conditioning unit would be the most efficient unit.

In comparison with first cost, operating costs of various types of three ton package units suggest that the most economical system would utilize such a system as the heat pump. Though considerably more sophisticated, the heat pump is little different from a conventional through-the-window type of air conditioner in which by alternately compressing and rarifying a refrigerant, one of the two coils within the equipment can be kept well above the highest expected temperature of the air into which one wishes to place heat. The other coil can be kept well below the temperature of the air from which one wishes to withdraw heat. In a conventional window air conditioner, the hot coil is always outdoors and the cold always indoors. The heat pump differs only in that heat from the hot coil may be used to contribute heat to the interior zones during cold seasons.

As a result, it is possible to use one piece of equipment to provide both the required summer cooling and the required winter heating. If electricity is used to provide the energy for both the hot coil and cold coil, the need for plumbing or duct work from a central location is eliminated. This is especially important since electrical distribution is required for other equipment within the modular area and wires must in any event be installed from the city feeders up to the modular elements.

Since the load may vary from module to module and even within a module from time to time, it is desirable to provide temperature control within each module. Since it is possible to enclose any one or any group of modules to form a small room, temperature control on a more-than-one-module basis would not be compatible with the flexibility of the partition system. For this reason our engineers have proposed to provide a hot air duct and a cold air duct running through each string of six modules.

How hot or cold each of these ducts is must depend upon the average demand imposed on the system by the internal and external heating or cooling loads. However, within the module, a temperature sensing device within the return air duct can detect immediately an increase or decrease in the load within that module. A pneumatically controlled damper automatically shifts the share of the load provided by the hot and cold ducts respectively. Thus, it is possible in winter to be heating an external group of modules to compensate for losses of heat through the window to the outdoors, while at the same time cooling an enclosed group of interior modules where large numbers of people or installations of equipment are overheating the enclosed space. This system, though considerably readapted for our purposes of prefabrication and industrialization, is actually nothing but a modification of a very commonly employed system in many modern office buildings;

thus, the equipment cannot be considered novel or experimental.

The equipment described above, in addition to providing temperature control, can also provide humidity control. In winter, when outdoor humidity is very low, the amount of moisture placed into the air by bodily perspiration, cooking, and other latent loads will often be less than the amount required to bring humidity up to the optimum of thirty-five to forty-five percent. Thus, simple recirculation of most of the returned air is all that is required for reasonable humidity control. Unless it is excessive, a deficiency in humidity is not considered uncomfortable. In the summer when outdoor humidity is high, it is important for comfort to remove excess moisture from the internal air. Incidentally, lowered humidity is necessary to control perspiration in certain critical areas, such as drafting rooms. To remove moisture, it is necessary to keep the temperature of the heat pump cold coil well below the dew point of the moist summer air. As long as this is the case, moisture will condense on the surfaces of the coil just as it does on a cold tumbler of ice water, the surfaces of which are also below the dew point of the surrounding air.

Heating and cooling by air can be dealt with in either of two ways, even within the constrictions of the system described above. For example, very hot and very cold air can be delivered in small quantities or cool and warm air can be distributed in very large quantities. An engineering balance must be achieved between the power required to produce the higher and lower temperatures as opposed to the saving in duct size when high and low temperatures are used. We have evaluated this and have established that for the presumed thirty square feet modules referred to, about sixty CFM would be required for each interior module. Air would be delivered at a cooling temperature of fifty-eight degrees. A heating temperaature of eighty-five degrees and movement at one hundred CFM would be used.

The quantity of air also must meet certain requirements for ventilation to control odors. Sixty CFM per module constitutes over twelve air changes per hour for each module and one hundred CFM over twenty air changes per hour. Though opinion is not crystalized on the minimum ventilation air required, most codes call for between one and ten air changes per hour for any type of room. Thus, the heating and cooling load is the determinant in the quantity of air supplied.

In addition to a certain number of air changes per hour, most codes or minimum standards require that a minimum number of cubic feet per minute be supplied to a space on a per person basis. This usually falls between seven and one half to ten CFM per person. Therefore, it is necessary at all times to exhaust to the outdoors approximately ten CFM per module, and to draw in and condition outdoor air in the same quantity. During times of moderate outdoor thermal and humidity conditions, often it is possible to economize on operation of the heat pump by exhausting most of the air and drawing in all new outdoor air. This is true, for example, when outdoor humidities are relatively low and temperatures are in the range of fifty-five to sixty-five degrees Fahrenheit. Thus, the air system should be capable of exhausting a minimum of fifteen percent of the return air and a maximum of one hundred percent.

Many pieces of equipment in OVT facilities require special contaminated exhaust systems. These include laboratory fume hoods, automotive exhaust systems, paint booths, and dust removal equipment in association with various shop activities. Since the duct work to provide for this exhaust can be constructed integrally with the overall module packets, it is proposed to connect such exhaust duct work in the vicinity of the heat pump. When a row of six modules is known to contain contaminated exhaust equipment, then it is possible to install an appropriate blower and, if required, a dust collector. A typical chemistry hood, for example, requires around six hundred or seven hundred cubic feet per minute of exhaust air to assure withdrawing of odorous or toxic fumes from the laboratory space. Using duct systems to exhaust this quantity of air is very reasonable. However, to expect any one module to supply conditioned air at that rate to make up for the exhausted air would be unreasonable. It proposed for this reason that a restriction be imposed on the overall system in that if a typical fumehood is installed in one module, at least eight additional modules be enclosed within the same laboratory. Each of these will contribute some of its supply air to make up for the amount exhausted through the hood. Rarely, should this constitute a serious limitation, in view of the small average number of hoods utilized per square foot.

Electrical System

The electrical system in the modular components is divided into three elements: electrical distribution for powering light, electrical distribution for powering equipment, and electrical communication systems. A distribution system of electricity for lighting is to be contained in the ceiling modules. This is intended to power two forty-eight inch fourty watt fluorescent lamps and associated ballasts. In addition, this distribution system should include a one hundred and ten volt single phase sixty cycle AC current with receptacles of the twist-lock variety concealed above the lighting. These receptacles would be used for suspension of display lighting or other special low power consumption equipment.

Power must be provided through the floor modules to supply lathes, sewing machines, vacuum cleaners, and a myriad of other pieces of conventional equipment. It is proposed to distribute two hundred and eight volt three phase sixty cycle AC current with lines rated at thirty amps or sufficient capacity to handle a ten horsepower motor. This system would be used primarily for heavy-duty machine tools. In parallel with this system would be one carrying two hundred and eight volts single phase sixty cycle AC thirty amp current, suitable for powering special heavy-duty appliances. Finally, there would be two one hundred and twenty volt single phase sixty cycle AC fifteen ampere circuits capable of carrying one twelve kilowatts for smaller conventional appliances.

All of the electrical services within the floor system would be distributed over a single four wire distribution system. It is felt that the provision of these systems with these ratings should provide for virtually any installation contingency. However, since receptacles are provided for each service at two points in each modular element, the system is subject to misuse. Therefore, it is proposed that at the end of each run of six modules, an automatic resetting circuit should be provided in the vicinity of the heat pump.

Plumbing System

The design of the plumbing system is similar in concept to that for all other distribution systems. We have estimated loads based on typical laboratory or home economics sinks, clothes washers, dishwashers, chemical eye baths, emergency showers, and other fixtures. On this basis, it has been established that one inch diameter pipes are sufficient to transmit cold water, hot water, and compressed air throughout a run of six modules. The gas piping within the modules must be approximately two and one half inches in diameter both because it is not unreasonable to assume six or more burners in use simultaneously and also because it is dangerous to allow gas pressure to diminish too greatly near the ends of a run. Similarly, to assure the ready ejection of solid matter in the waste line, it is necessary to use a three inch diameter waste line. Finally, both codes and good practice dictate a waste vent two inches in diameter to prevent the accumulation of odorous gases within the waste line and to prevent the weight of waste water traveling through lower portions of the soil pipe to break the odor-containing plug of water in the trap at each fixture.

In a previous discussion, the advantages of having a snap-in detail for wiring and piping within the system were mentioned. The waste line adds a fourth justification for this clip-in detail. We wish to have every module manufactured identically with every other in the factory. However, the drain pipe is required to slope downwards toward the main pipe leading down to the city sewer. Therefore, it is proposed that a series of clamps be available at the point where the waste line is installed, so that it can be relocated in a downwards direction to allow the required slope as it is being installed in the field.

One additional consideration for the waste line is that certain wastes contain acids in an excessively corrosive quantity. It is proposed that all waste lines be acid resistant, that is, glass lined. This necessitates neutralizing the wastes at a central point. However, this retains the basic concept of being able to locate any drained equipment at any point within the modular system.

Consideration was given in the planning stages to the provision of steam lines. A number of considerations led us to eliminate this service from the system. Primary among these was the limited number of pieces of equipment which use steam today. These are limited almost entirely to laundry areas and commercial cooking areas. A further consideration is the necessity of providing condensate return lines. Where it is needed, steam can be provided, locally, by a gas or electric steam generator.

Source Location

Obviously, each cluster of modules must be fed with energy and energy-bearing media from sources external to the cluster of modules. For example, for temperature and humidity control refrigeration equipment and blowers are needed, for exhaust air blowers are needed, for lighting and for equipment electricity is needed. Each source may be located in a number of positions.

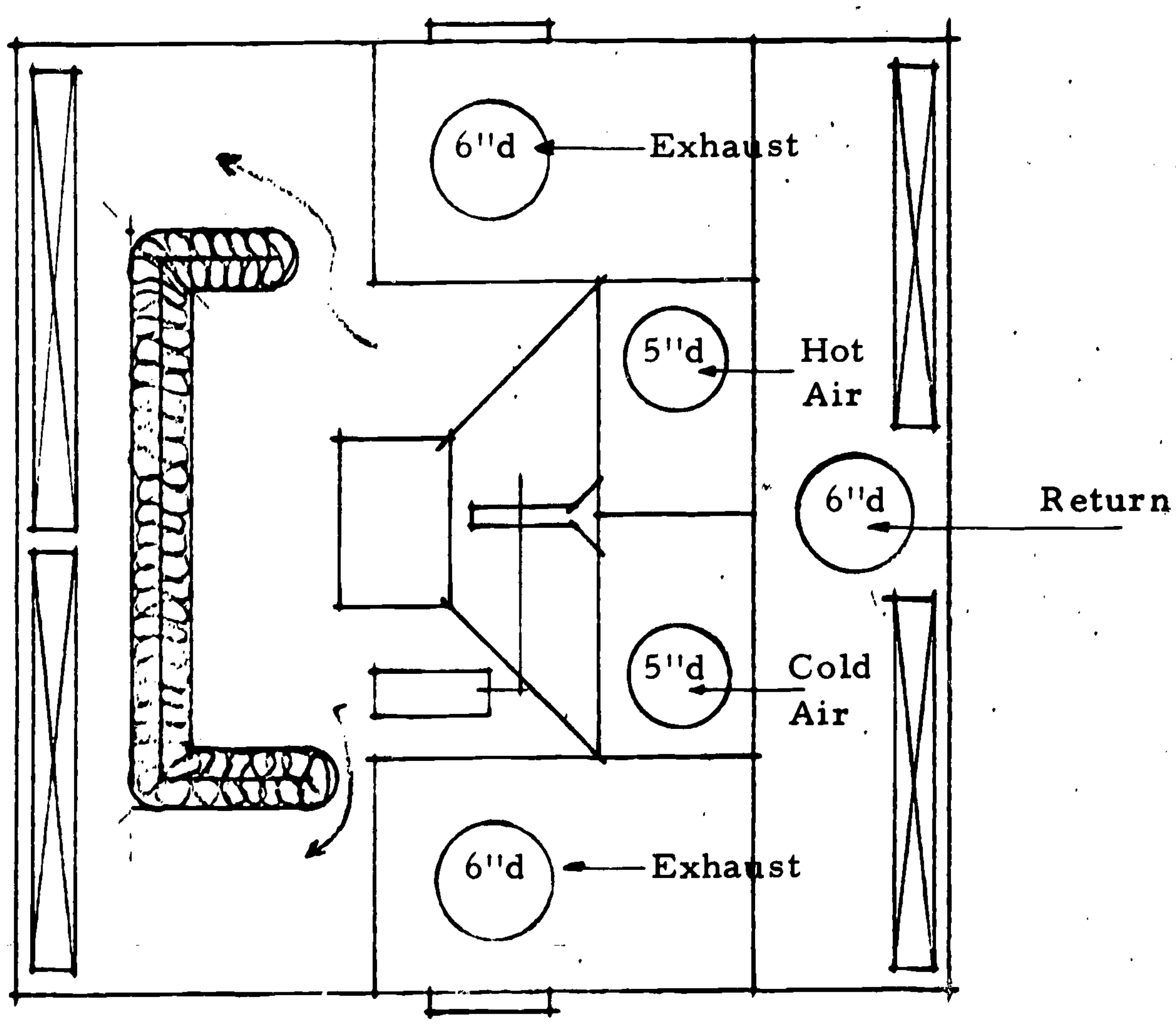
In general, gas, cold water, and electricity must be fed through pipes and wires from city services brought in from the street. These, therefore, are handled in a more or less conventional manner between the city feeder and the first module.

Various methods of installing equipment for the other utilities can be considered in terms of maximum economy of interconnecting duct work and pipes. It would seem logical to install the source equipment as close as possible to the end of the exterior module. In buildings with a large floor to floor height, this equipment might be installed within the building, immediately above the first module. On top floors, the equipment could be installed on the roof. In many cases, there would be crawl spaces or unusable basements which could be used for equipment. Still another approach is to construct enclosures, cantilever or otherwise supported on the exterior of the building. In the case of south and west walls, this leads automatically, to consideration of the use of these enclosures as solar shading devices to reduce the cooling load. When it is found desirable to add external corridors for traffic circulation, the ceilings of these corridors could be used to conceal the energy source equipment. An important consideration in source location is access for maintenance.

In new buildings, the location of source equipment, as well as distribution mains, is less restricted than in existing buildings. For example, sufficient space would be provided above the upper module and below the roof slab or the slab of the floor above. The source equipment can be located at any point at either end of any row of six modules. Therefore, if one wished to construct a building one hundred and fifty feet wide, one could have two sets of source equipment at each external wall and two sets running along the center line of the building. The only special provision needed would be the installation of conventional ducts to draw in an exhaust for condenser air and ventilation.

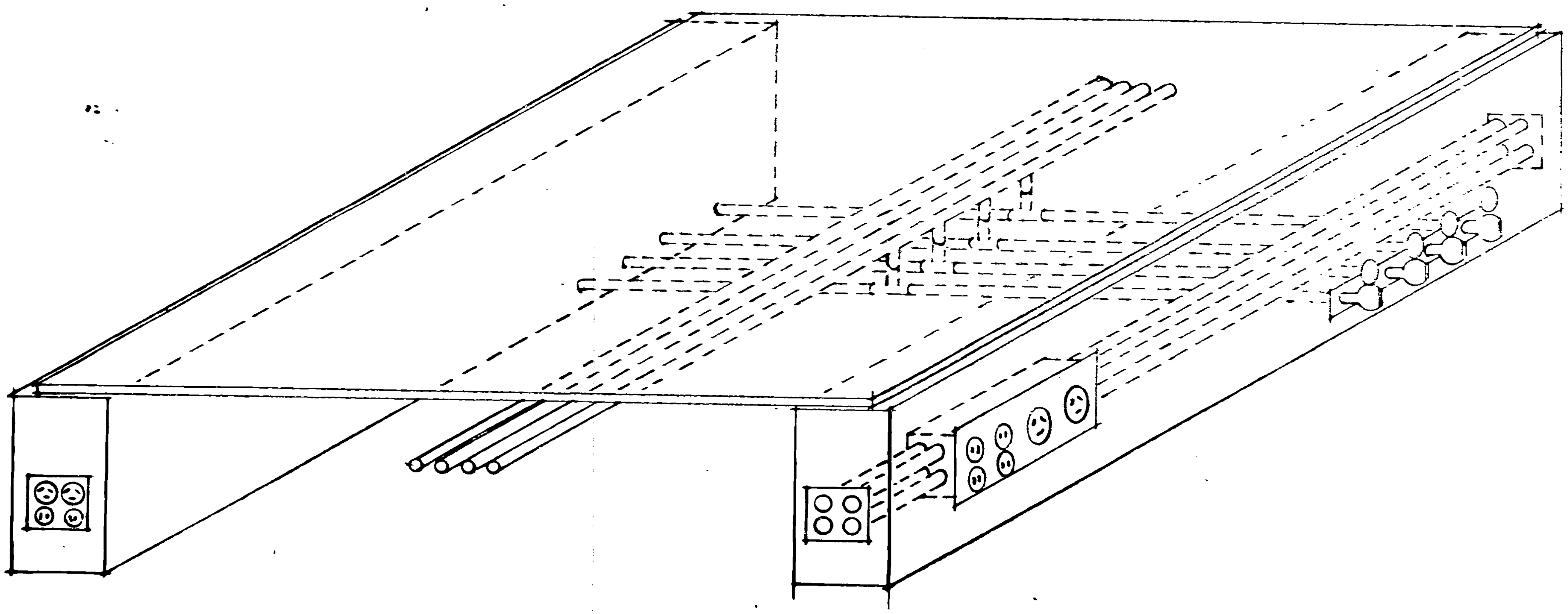
The decision as to the location of the source equipment would be based on the specific architectural considerations of the individual building and on the overall size of the system.

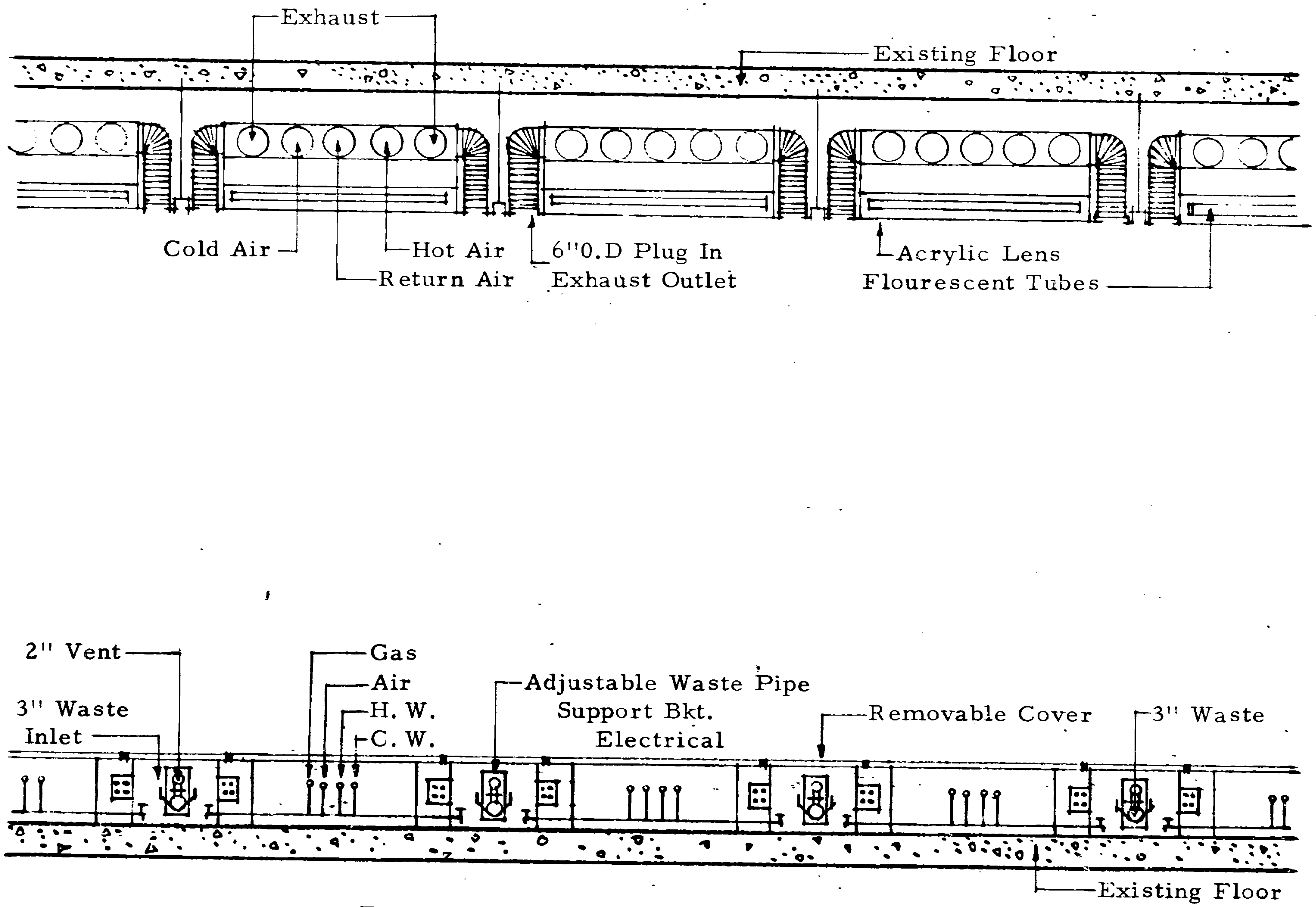
APPENDIX



Schematic Drawing of Mixing Box
in Ceiling Module

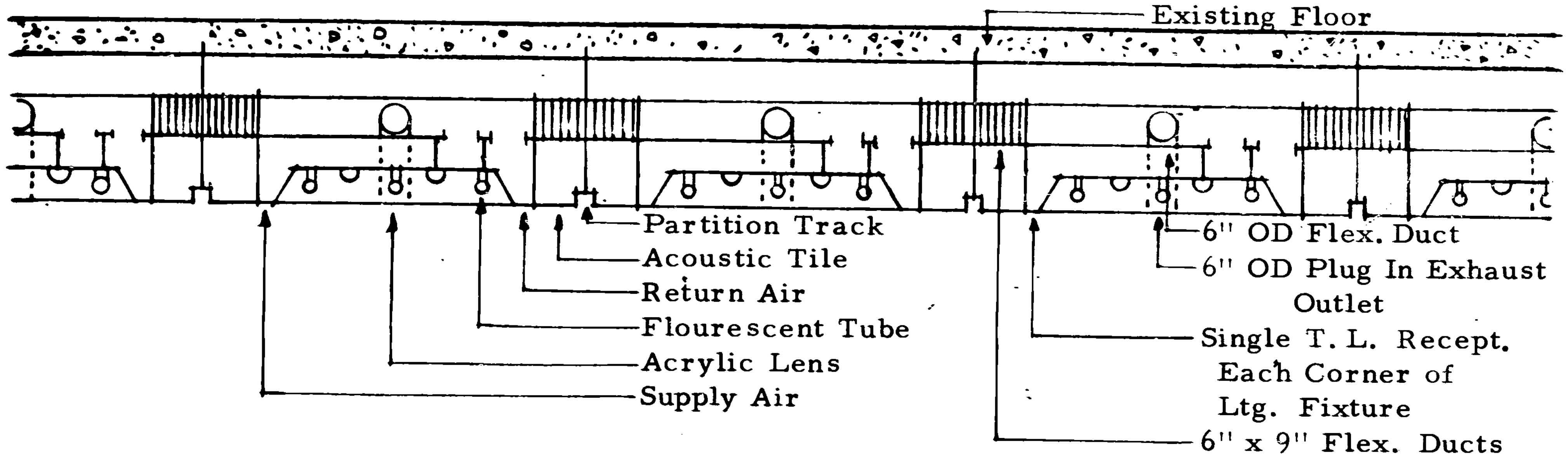
Schematic Drawing of Services in Floor Module

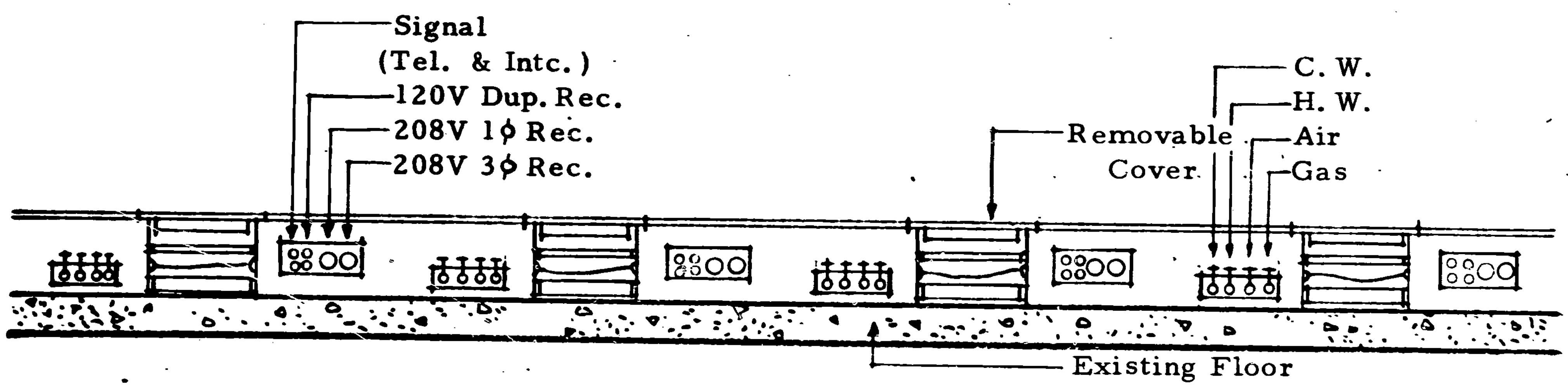




Transverse Section Through Installed Modules

Longitudinal Section Through Installed Modules





SPACE DETERMINATION

3

Prepared By the Research Team For a Comprehensive Concept For Vocational Education Facilities

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Preview of Unit Three, Space Determination

Creating flexible facilities does not relieve educators of the necessity of careful planning. Furthermore, existing space standards upon which facility planners now depend do not provide solutions to problems created by new developments in education. Some of the new developments are: dynamic relationships between different subject areas and resultant efforts to share subject material, space, and equipment; small, medium, and large group instruction; and new courses involving the use of new equipment types.

A nationwide survey of the space standards recommended by state departments of public instruction[1] revealed little relationship between space standards and new course activity patterns. The characteristics of acceptable existing rooms, as determined by past programs, are translated into individual state standards for new programs, regardless of the

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[1] See Unit Six, Appendix

introduction of new organizational techniques or the instruction in the use of new equipment and industrial processes. Accordingly, methods of planning facilities must be re-evaluated in light of present conditions.

This study recommends the use of a planning technique that does not require experimentation with live classes in temporary facilities. This technique is a computerized simulation of class activities. A class activity model can simulate classes of any size, using any instructional technique, for any period of time. By analyzing the results of computer simulations, educators will know more about equipment and space needs for instructional innovations and can plan facilities before students enter programs.

Since there is such a close relationship between course activities and equipment and space needs, a mathematical model has been developed to simulate activity patterns. Similar models are used to represent the flow of traffic in a city. In such a traffic model changing activities in a city, which generate varying flows of traffic through the street network of a city, are considered. An estimation may be made that if a certain activity takes place at a certain location and at a certain time of the day, it will generate a predictable increase or decrease in the volume of traffic on any particular street. Through the use of a similar technique, the relationship between educational activities and needs for space and equipment can be analyzed.

The purpose of the simulation model is to determine the effect on activity patterns of such factors as these: class composition, time duration of the course, time duration of individual activities, number of activities, number of equipment units for each activity, teaching technique, mobility of equipment, order of activities sequence, idle time of equipment, and idle time of students. To determine the relationship between these variables and resulting activity patterns, the variables are changed separately and in groups. Then, the model generates an estimate of equipment and space needs for each case. If values are set by educators in terms of costs of duplicate equipment and space versus costs of flexible activity scheduling and mobile equipment systems, such information can help determine desirable course activity patterns and facility needs.

Alternative methods of providing vocational facilities have been discussed in other sections of this report. The purpose of this section is to explain a technique that has been developed to evaluate alternative facility planning decisions.

Simulation Models

Many problems confronting modern industrial and economic planners are too complex to be solved by the use of standard analytical techniques. Situations that involve the interrelation of numerous variables, all changing simultaneously, demand powerful techniques for complete analysis. Such a complex situation confronted the researchers as they sought methods of designing vocational facilities by relating space and equipment needs to course activity patterns. One approach to this problem is through the use of computer simulation models.

A computer simulation model serves the same purpose for the economic or systems analyst as the laboratory does for the chemist or model oil refinery for the engineer. Both are designed to provide an experimental setting in which one may try various approaches to solving a problem and learn how the system under study responds to different stimuli.

In order to simulate, a set of equations must be written that describe the relationships of the variables involved. Once all these parameters and descriptive equations are established, the alternative plans may be tested, using a digital computer.

Simulation techniques have been used to experiment with complex systems in a wide variety of areas, including detailed economic systems, industry and firm behavior, and group behavior. It is a tool which, when properly used, can provide an insight into the operation of a system, prior to physical construction of the system. As such, simulation can be used to test new ideas and innovations in systems where the interrelationship between variables is too complex to be analyzed readily by hand calculations or by "trial and error."

Although the dynamic relationship between course activities and resulting needs for space and equipment is a complex system, apparently satisfactory vocational facilities have been planned and built without the aid of computer simulation. A number of usable standards, which provide recommendations for total space, total equipment, and even environment, are available for facility planning. However, these standards, many of which are recommended by state departments of public instruction, have qualities which tend to make them inflexible and out of date the minute that they are put down on paper. Some of these qualities are:

1. Standards are based on the apparent success of existing facilities to meet the needs of courses written in the past.
2. Recommendations are made for single courses conducted in single rooms.
3. Locations of perimeter walls are assumed to be permanent.
4. Sizes of classes are assumed to be unchanging.
5. The possibility of making new equipment arrangements is assumed not to exist.

As long as courses and organizational systems do not change, this type of standard, developed through the slow-moving process of trial and error, adequately will serve planners. When education and school organization change, such standards become far removed from the real needs of students and teachers.

Many educators feel that it is necessary to reorganize the educational process in order to teach students concepts and skills that will be useful in a world of fast-paced technological progress. A study of current literature on education reveals the changes which are occurring. Some of these are:

1. Combining subject material and instructional space for variable periods of time.
2. Scheduling large, medium, and small groups for the instruction of different phases of the same course.
3. Creating changeable arrangements of equipment to illustrate various aspects of technology,

industry, or business.[2]

4. Developing new courses or new combinations of old courses that represent more accurately aspects of modern technology and industry.

Educational processes are being changed and new activity patterns are being created that are not accounted for in existing standards. Plans for new facilities require careful analysis of these complex systems of activities. An analysis of activities can help to determine the needs for space, equipment, and environmental control that are created in the duration of one course or a cluster of courses. An accurate analysis of a course is dependent on a detailed listing of conditions that can be expected to occur. A partial list of potential variables follows:

1. Students complete tasks at different rates. Various mixtures of students with individual

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[2] One such rearrangement might include equipment brought together from several vocational courses and organized to teach production line theory.

attributes can be expected to influence utilization of equipment.

2. Every course has a particular planned sequence of activities requiring different quantities of equipment.

3. Each activity might be assigned a different predicted time of duration.

4. The instructor may or may not have the ability to plan a good sequence of activities. The instructor may take great liberties with a planned sequence, once the course is in operation.

5. The course may be in operation for a greater or lesser amount of time, depending on such things as school assemblies and testing periods.

6. Significant events may occur in periods of minutes, days, or weeks and must be related appropriately to time measurements of other activities.

7. Equipment breaks down with differing degrees of regularity and requires varying amounts of time for repair.

8. Attendance patterns differ for each student.

9. Class size may vary due to absence or combination of classes for special activities.

An evaluation of the facility requirements created by such complexities in activity patterns would consume an exorbitant amount of time, unless the technique of computer simulation was used. Probable reactions of teachers and students to situations that occur in the duration of a course can be stored in the memory banks of a computer and the effects of their response on space and equipment utilization estimated. It is the capacity to store many bits of information and to manipulate them so that interrelationships are revealed that makes the computer a useful tool for analyzing such complex problems.

Although there is practically no limit to the number of variables that can be manipulated in computer simulation, each variable must be accurately described, initially, or the computer may be simulating unreal conditions. At this time, observation of classes is being conducted to reveal significant variables and to determine the nature of each variable.

The researchers interviewed an instructor of an office machines course in order to facilitate development of the model. The information, provided by the interviews, cannot be expected to represent reality in as much detail as class observation will, but did provide a description of the course upon which model building could proceed. Although subsequent observation probably will create the need to modify the original model, an illustration of this technique can be provided in a simulation of the instructor's description of the course. This illustration is presented in the following section.

Description of A Simulated Course

A sample vocational course was developed and experiments were conducted on this course in order to clarify the problem and method used for its analysis. The course chosen was an office machines course somewhat similar to the one taught at Schenley High School in Pittsburgh.[3] This course is planned to familiarize students with the fifteen different office activities shown in Table 1. The righthand column in Table 1 indicates the amount of time, in weeks, that the instructor believes is required for average students to gain familiarity with the equipment.

A rotational sequence of this type commonly used in office machines courses is shown in Figure 2. During the length of the simulated class, students

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[3]In developing this course, consultations were held with Mr. T. J. Kirkpatrick at Schenley High School. For a detailed description of the course, see "Tentative Course of Study for Office Machines," Division of Curriculum Development and Research, The Board of Public Education, Pittsburgh, Pennsylvania, July, 1965.

Table 1

Office Machines

Office Activities and Time Schedules

Unit No.	No. of Machines	Name of Machine	Weeks
1	4	Electric Typewriter	2
2	4	Transcriber	2
3	4	IBM Selectric - Key Punch Simulator	2
4	2	IBM Card Punch and Verifier	2
5	1	Ditto Duplicator--Spirit	1
6	1	Stencil Duplicator	1
7	2	Full Keyboard Adding Listing Machine	1
8	1	Statistical Typewriter	1
9	2	Friden Rotary Calculator	2
	1	Marchant Rotary Calculator	
	1	Monroe Rotary Calculator	
10	2	Burroughs 10-Key Multiplier	2
	2	National 10-Key Adding Listing	
	1	Monroe Adding Listing	
11	1	A. B. Dick Offset Duplicator	2
12	1	Teacher Helper	1
13	1	Olivetti Print Calculator	2
	1	Victor Print Calculator	
14	4	Comptometer--Key Driven	2
15	1	Check Protector	1

Figure 2

Week

Students	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	1	2	2	3	3	4	4	5	6	7	8	9	9	10	10	11	11	15	*	13	13	14	14
2	1	1	2	2	3	3	4	4	6	5	8	7	9	9	10	10	11	11	15	*	13	13	14	14
3	2	2	3	3	4	4	5	6	7	8	9	9	10	10	11	11	15	*	13	13	14	14	1	1
4	2	2	3	3	4	4	6	5	8	7	9	9	10	10	11	11	15	*	13	13	14	14	1	1
5	3	3	4	4	5	6	7	8	9	9	10	10	11	11	15	*	13	13	14	14	1	1	2	2
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13	9	9	10	10	11	11	15	*	13	13	14	14	1	1	2	2	3	3	4	4	5	6	7	8
14	9	9	10	10	11	11	15	*	13	13	14	14	1	1	2	2	3	3	4	4	6	5	8	7
15	10	10	11	11	15	*	13	13	14	14	1	1	2	2	3	3	4	4	5	6	7	8	9	9
16	10	10	11	11	15	*	13	13	14	14	1	1	2	2	3	3	4	4	6	5	8	7	9	9
17	11	11	15	*	13	13	14	14	1	1	2	2	3	3	4	4	5	6	7	8	9	9	10	10
18	11	11	15	*	13	13	14	14	1	1	2	2	3	3	4	4	6	5	8	7	9	9	10	10
19	15	*	13	13	14	14	1	1	2	2	3	3	4	4	5	6	7	8	9	9	10	10	11	11
20	15	*	13	13	14	14	1	1	2	2	3	3	4	4	6	5	8	7	9	9	10	10	11	11
21	13	13	14	14	1	1	2	2	3	3	4	4	5	6	7	8	9	9	10	10	11	11	15	*
22	13	13	14	14	1	1	2	2	3	3	4	4	6	5	8	7	9	9	10	10	11	11	15	*
23	14	14	1	1	2	2	3	3	4	4	5	6	7	8	9	9	10	10	11	11	15	*	13	13
24	14	14	1	1	2	2	3	3	4	4	6	5	8	7	9	9	10	10	11	11	15	*	13	13

*Available for teacher help.

move from one equipment unit to another, according to this sequence. The model logic[4] for this office machines course is based on the assumption that each student will be scheduled on the next machine in his sequence whenever he finishes work on the previous machine. A student may return to an activity that he has not completed only if the equipment necessary for the next activity in the sequence is in use, the student has completed an activity ahead of time, or the student has free time at the end of the course. The student can skip ahead in the sequence only if the student has completed all past activities, the equipment necessary for makeup work is unavailable, the equipment used in the next activity has broken down, or the student has finished an assignment early. The original sequence is realigned constantly as student absences, machine breakdowns, and the

---

[4]See "Model Description" in <u>Appendix</u>.

learning speed of students have their effect on activity patterns.

Many experimental simulations are still being run and the results checked in the process of refining this activities simulation model. As might be expected, the most difficult part of this task has been not in creating the model, but in collecting data that accurately represents the activities that go on in this class. Conclusive experiments that will lead to the creation of a useful planning tool must await further data collection and experiments.

However, at this time it is possible to describe some of the information that is generated during the simulation and to demonstrate how this information can be used to plan a suitable mix of equipment for a particular sequence of activities. The best number of equipment units for each of the fifteen activities taught in this office machines laboratory is sought in this experiment, given the conditions previously described, such as student absence and machine breakdown.

The following five factors from the total computer output are charted in Figure 3, "Laboratory Analysis." These were selected by the author to demonstrate the value of simulation to the decision-making process.

Upper Graph

1. Number of Machines

The number of machines of each type are indicated in the appropriate columns. For easy identification, these points are connected with a solid line. The number of equipment units of each machine type represents the total equipment mix to be tested in this experiment.

2. Mean Daily Requests

A point in each machine type column indicates the number of students who required each machine on an average day. These points are connected with a dashed line. Mean daily requests were derived from daily

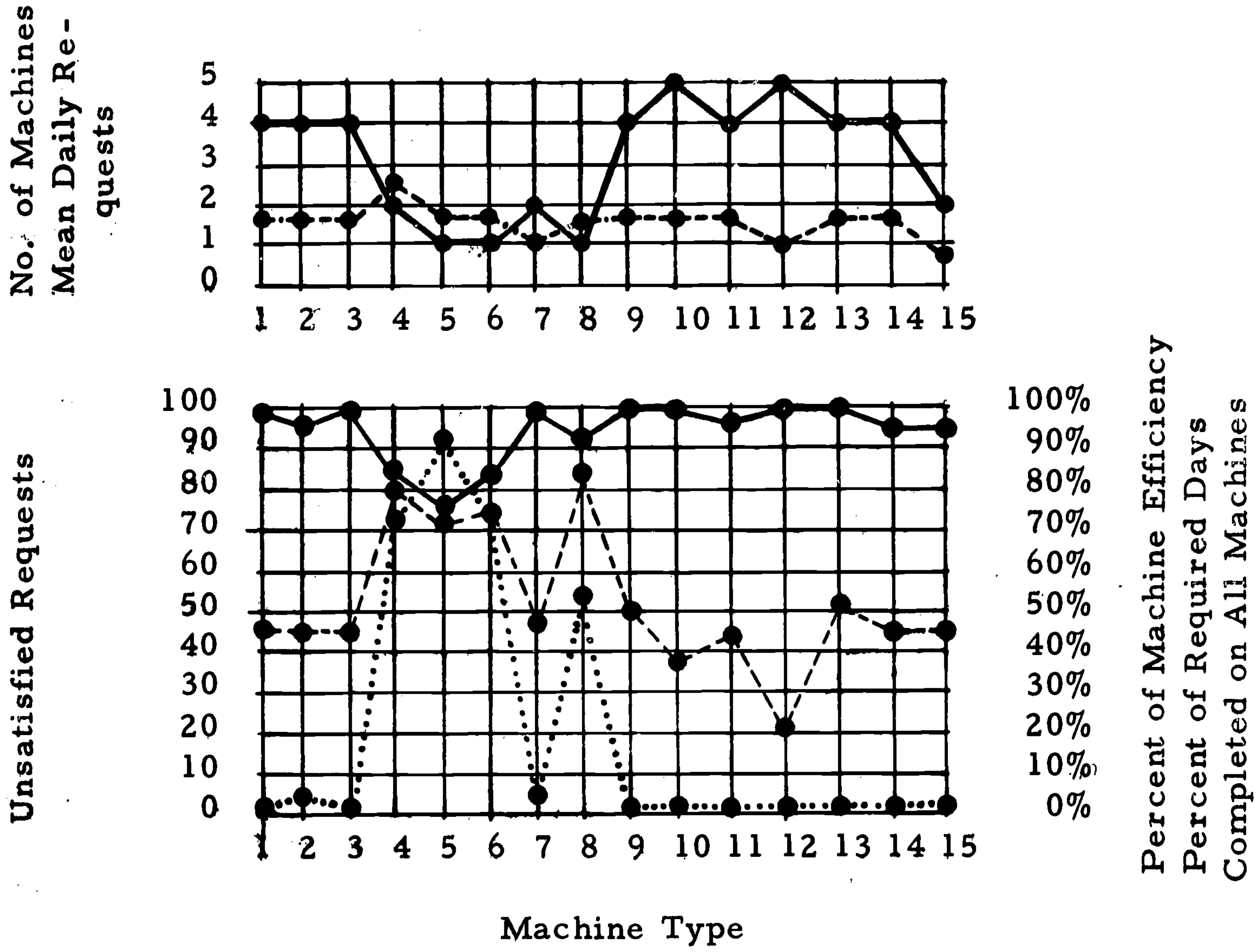
FIGURE 3

LABORATORY ANALYSIS

By: Machine Mix
Mean Daily Requests

Completed Machine Days
Machine Efficiency
Unsatisfied Requests

Run #2



Upper Graph

●———● number of machines
●- - - -● mean daily requests

Lower Graph

●———● percent of days completed on all machines (read to right)
●- - - -● percent of machine efficiency (read to right)
●........● unsatisfied requests (read to left)

requests recorded throughout the entire duration of the class.

Lower Graph

3. Percent of Days Completed on all Machines

The points indicating the percent of completion on each machine type are connected with a solid line. The equipment in each machine type will be in operation a maximum number of days, if all students are to complete the required time on all machines; therefore, the percent of days completed is an indication of the success that students met in completing the course.

4. Percent of Machine Efficiency

A point in each machine type column indicates the percent of total days in the course that each machine type was used by students. The points, connected with a dashed line, indicate the extent to which machines were used in the laboratory. This can be contrasted with the percent of days that students complete on all machines, since high machine use efficiency indicates that there may not be enough units of a particular machine type and that student time on the machine type has been sacrificed.

5. Unsatisifed Requests

Points connected with a dotted line indicate the number of unsatisfied requests that students have made for a particular machine type. Unsatisfied requests are another measure of whether or not there is a sufficient number of machines available for student use. Typically, any rise in unsatisfied requests corresponds with an increase in machine efficiency and a decrease in the percent of required days that students complete on the machines.

This information can be used to identify a "bottleneck" and analyze its effect on laboratory performance. In this case, a "bottleneck" is a point in the activity sequence where there is an insufficient number of machines to satisfy all requests. In the upper graph, bottlenecks are shown where the mean daily request line rises above the line representing numbers of available machines. This occurs for machines types four, five, six, and eight. As seen in the lower graph, the results of these "bottlenecks" are dramatic! The days completed on these machines drops from above ninety percent to below eighty percent. As would be expected, percent of machine efficiency and the number of unsatisfied requests climb drastically for these same machine types.

If this analysis were being performed to plan a machine mix for a real office machines laboratory, the planner would know that at least one more unit of equipment was needed in machine types four, five, six, and eight. Also, there may be too many units of equipment for machine types one through three, and nine through fourteen, as indicated by the extent to which the number of machines exceeds the mean daily requests. Then, the planner could simulate the class, again, using the new machine mix consisting of less equipment units for some machine types and more equipment units for other types. He could analyze similar graphs for the new machine mix to determine its suitability.

By using such a tool, the educational facilities planner would have useful information to help make decisions about when new equipment should be ordered, the effects of change in a rotational sequence and what changes would have to be made in the laboratory to accommodate new organizational procedures, such as team teaching. This could be done without the necessity of expending money and time for experimentation with live classes.

Conclusions and Recommendations

The results of performing a limited set of experiments demonstrate that the model would be useful in evaluating alternative facility planning decisions under a varying range of circumstances. It is possible to evaluate alternative sequences, student capacity of classrooms, the number and type of machines required in different laboratories and the effects of different teaching and administrative techniques on space and equipment needs. Another use could be coordinating the use of facilities for several courses that require certain common facilities, so as to minimize the total facility requirement for a school or school system.

The development of the model described in this report can have a significant impact on the planning of new courses and facilities. With the distinct possibility of new large secondary schools in Pittsburgh and a renewed emphasis on vocational education nationally, analytic tools are essential in order to aid the planning process.

Since the intent of this phase of the study was to develop the feasibility of an analytic method, it is obvious that a great deal of work remains to be done for this method to achieve its maximum benefit. Some recommendations can be presented:

1. Further development of model.

At present, the model does not encompass all of the variables that could cause variations in activity time. Additional research and consultation with education consultants is needed to improve the realism of the model. Further development of output reports is necessary so that the task of analyzing results is easier. This would include plotting routines for automatic graphing of results.

2. Data collection and model validation.

In order to test the validity and, consequently, the usefulness of such a model, it will be necessary to collect data on actual courses and compare model predictions with actual results. Any significant variation will indicate areas where the model logic needs improvement.

3. Extension of model.

Undoubtedly there are several directions in which the model can be extended. One is to develop a model that will examine more than one course of instruction at one time, thereby making it possible to coordinate facility utilization for two or more courses.

4. Development of a sequencing algorithm.

A sequencing algorithm, a computational formula used to arrive at a solution to a problem, is needed as part of the model so that efficient sequences can be developed quickly, given machine and student configurations.

5. Technique to optimize facility requirements.

The model, presented in this report, does not develop optimum facility requirements. Its purpose is to predict the result of a range of alternative course activity patterns. However, it should be possible either to apply some existing optimizing techniques (i. e., linear programming or queueing theory) or to develop an optimizing technique that would predict the best allocation of facilities. The simulation model would be used then to test the results of the optimizing model in order to determine how realistic the results were.

It will be necessary to assign values to student time and machine time in order to develop optimizing techniques. This will require a significant amount of research and data collection.

APPENDIX

Model Description

This classroom simulation is an event-type model, in which each event normally occurs once during each school day. These events, which will be discussed in greater detail in the following pages are as follows:

Event No. 1	EABSNC	Figure No. 4
Event No. 2	EAVAIL	Figure No. 5
Event No. 3	EDELAY	Figure No. 6
Event No. 4	ESCHDL	Figure No. 7
Event No. 5	EREPRT	Figure No. 8
Event No. 6	EDLAY2	Figure No. 9

A general flow diagram of the logical activities performed within each of these events is exhibited at the end of this outline in the figure notated to the right of the event name.

The simulation is initiated by reading into computer storage areas certain required data. This is done in subroutine DATAIN shown in Figure No. 4. This data may be real in nature (drawn from historical classroom records), or it may be fabricated by the planner in order to determine the relative changes to the system brought about by certain parameter changes. The required input to the model is as follows (see Figure No. 12, "GLOSSARY OF KEY VARIABLE NAMES"):

1. Number of students in the class;
2. Number of different and distinct machine types;
3. Total number of machines, and the distribution of these machines among the various distinct types;
4. Total number of different and distinct sequences to which a student may be assigned;
5. The actual sequences themselves, and the expected number of days required for an average student to gain average proficiency on each machine type within the sequences;
6. The particular sequence to which each student is assigned, and the student's starting point in the

sequence;

7. Amount of time that faster or slower students can deviate from predicted average time.

8. Delay parameters for each machine to be used in the classroom.

All other values illustrated in Figure No. 12 will either be determined or calculated within the simulation model, itself.

Following the completion of a simulated school year a detailed summary (see Figure No. 11) of all relevant data and statistics collected during the school year is printed out by the computer. It is from this summary that the planner can analyze the effects of various parameter changes.

Events

EABSBC--Event No. 1

This event essentially represents the taking of role in the classroom. Each of the machine requests for the current day is filed in a waiting list. The absences (if there are to be any) are then generated randomly. The machine requests of all absent students are then stored in a temporary waiting list. The exact nature of each student absence is determined, and the information is stored so that it will be available for the daily report of student status. The event then reschedules itself for the next day.

EAVAIL--Event No. 2

This daily event examines all current machine delays to determine if any current delays are to end prior to the class period. For each delay which is to end, the particular machine status is changed from "delayed for repair" to "tentatively available." The event then reschedules itself for the next day.

EDELAY--Event No. 3

This event makes a probabilistic determination of which machines (if any) are to break down during this day. For each machine which is to break down, the duration of the delay is then drawn from a distribution of delay durations for the particular machine. The status of the machine is changed from "tentatively available" to "delayed for repair," and the time that the delay will end is stored for later printout in the daily report of machine status. The status of all machines which are not delayed is now considered to be "available." The event then reschedules itself for the next day.

This event does not comprehend minor delays of only a few minutes. As used here, the term, "delay" means non-availability of a machine for at least one day or longer. Also, it is assumed that all breakdowns occur at the beginning of a class period, thus making the machine unavailable for the entire period.

ESCHDL--Event No. 4

This event comprehends the actual assignment of machines to students during the class period. First, each student's primary request is processed. If the request can be satisfied, the student's status is changed to "active," and the machine's status is also changed to "active." At this time, the student's primary request for the next day is determined and filed. If the student has not yet completed work on this type of machine, he will request the same machine type for the next day. If work has been completed on the given machine type, the student will request the next machine type in sequence. At this time, all necessary bookkeeping regarding this student, including his status and progress, is filed for subsequent reporting.

After all primary requests have been processed, unsatisfied requests, if any, are examined. The first alternative is to provide the student with makeup work on some machine type in his sequence on which he had previously worked, but had not completed the required number of days. If this alternative fails, either because the student had completed all previous assignments, or because the desired machines are not available, the nature of his unsatisfied request is examined. If the student is being held up by a machine delay, he may go on to the next machine type in his sequence.

Finally, the status of all students who have completed their sequences without having completed all work within their sequences is examined. An attempt is made to find makeup work for such students. If no such makeup work is available, the student must remain idle for the day.

The event is then rescheduled for the next day.

ERDPRT--Event No. 5

This event produces the daily activity reports. The status of each student (absent, present but idle, present and active, present but idled by a machine delay) is reported. The status of each machine, idle, active, or delayed, is reported. If the machine is active, the student using it is reported. If the machine is delayed, the day that the delay is to end is reported. Finally, the total number of requests for each machine type during this day is reported. The logic goes on to perform certain initializations required for the next day's activity, and then reschedules itself for the next day.

EDLAY2--Event No. 6

This event is not self-scheduling, and it occurs only as often as the simulator wishes it to occur. It provides the simulator with the ability to step in and remove a particular machine from the classroom at any point in the simulation, and keep it out of service for any specified period of time.

SUMMARY

The final summary at the end of the simulation provides a total recap of all the daily reports. In addition, it provides the simulator with other pertinent data and statistics that will be valuable in analyzing the final results.

Constraints

Presently, the simulation has certain constraints built into it. Any of these may be changed; but, at present, they are as follows:

1. There can be no more than five separate and distinct machine sequences;
2. The maximum class size is thirty students;
3. The maximum number of machine types is twenty;
4. The maximum number of machines is fifty.

Figure 4

SUBROUTINE DATAIN

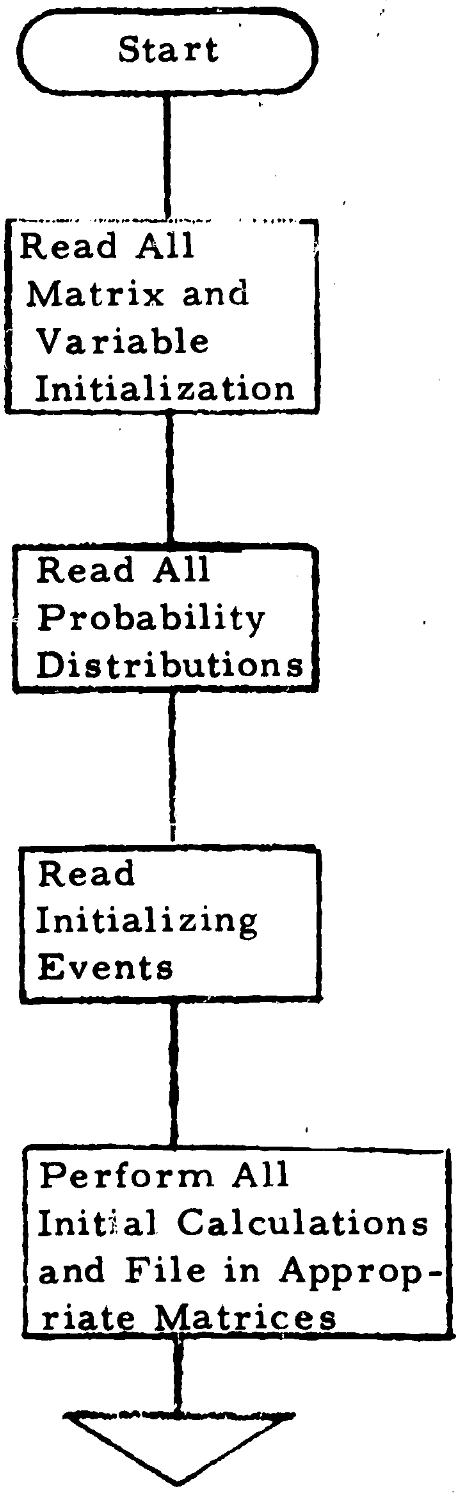


Figure 5

SUBROUTINE EABSNC   EVENT NO. 1

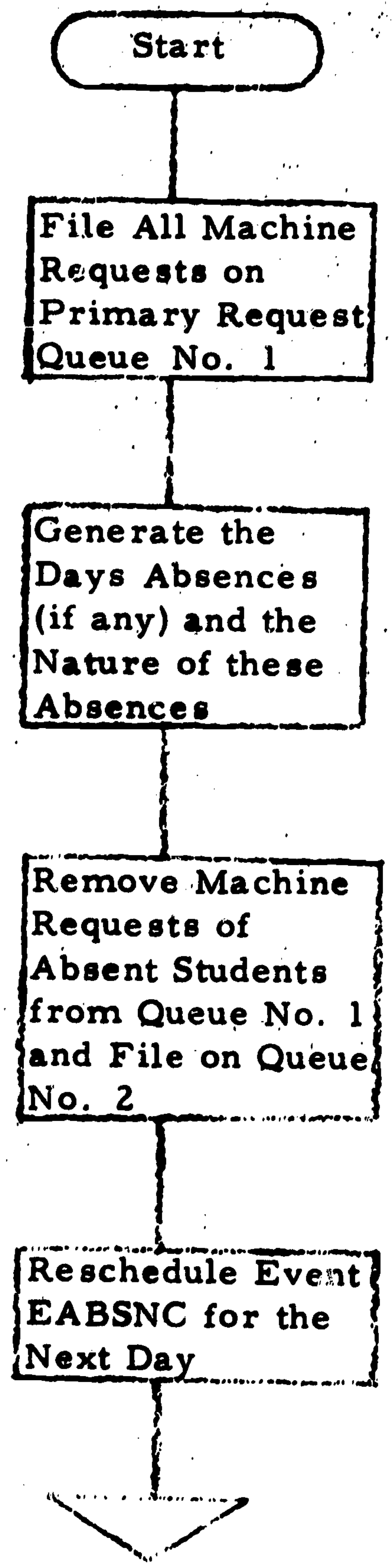


Figure 6

<u>SUBROUTINE EAVAIL</u> EVENT NO. 2

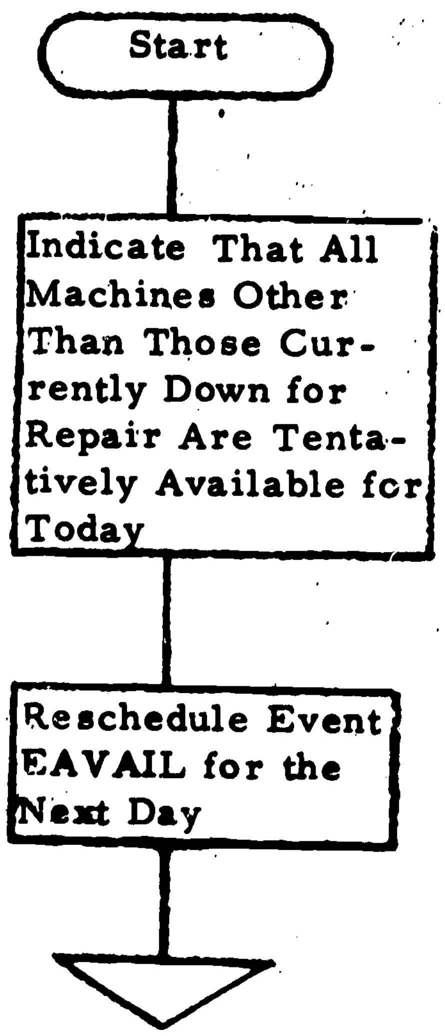


Figure 7

SUBROUTINE EDELAY   EVENT NO. 3

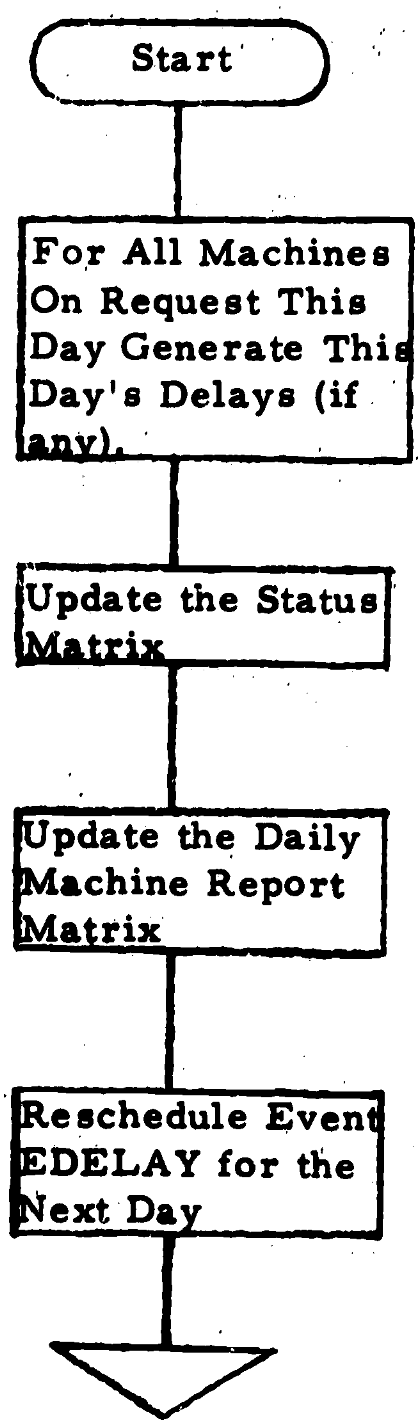


Figure 8

SUBROUTINE ESCHDL EVENT NO. 4

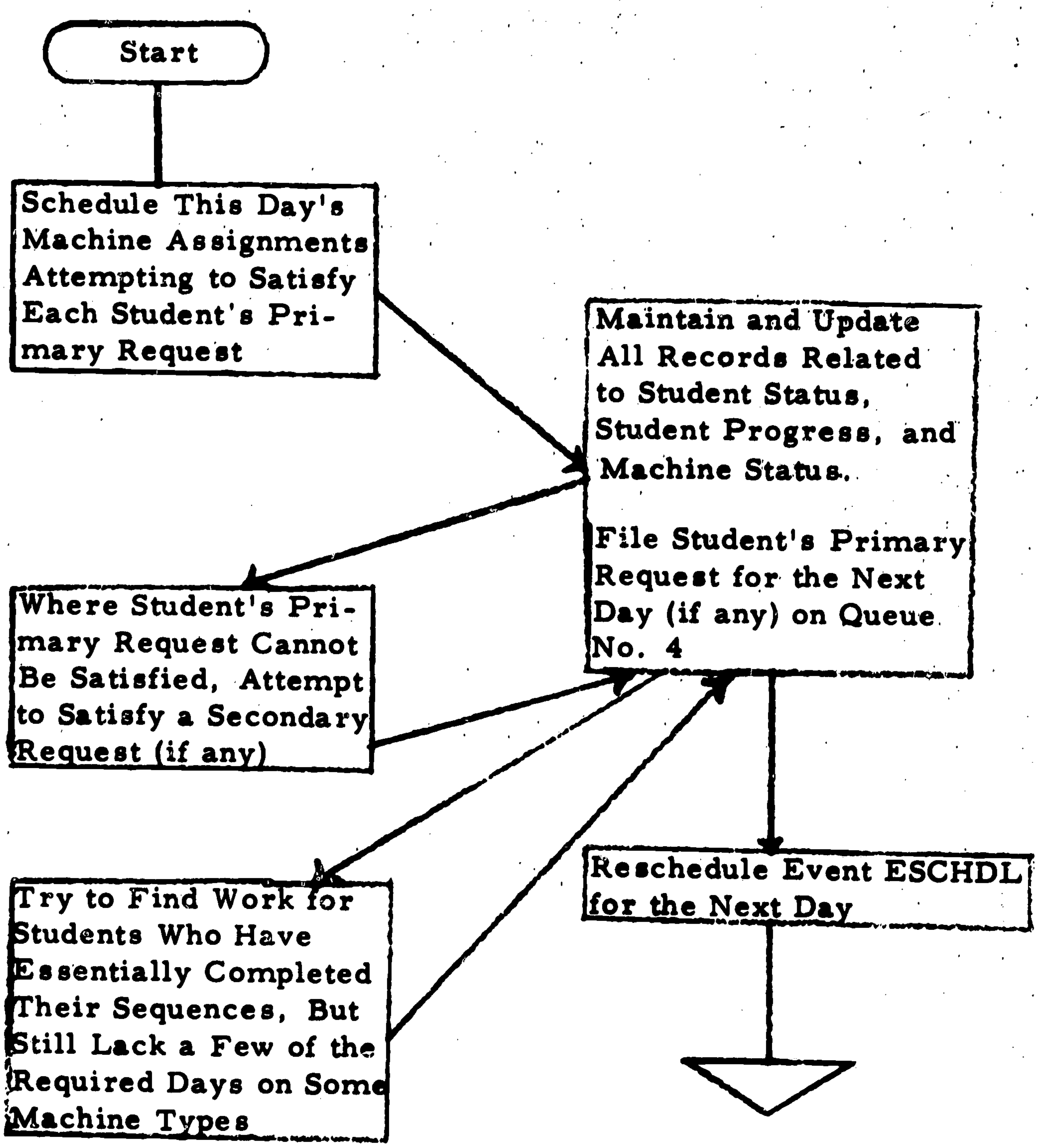


Figure 9

SUBROUTINE EREPRT   EVENT NO. 5

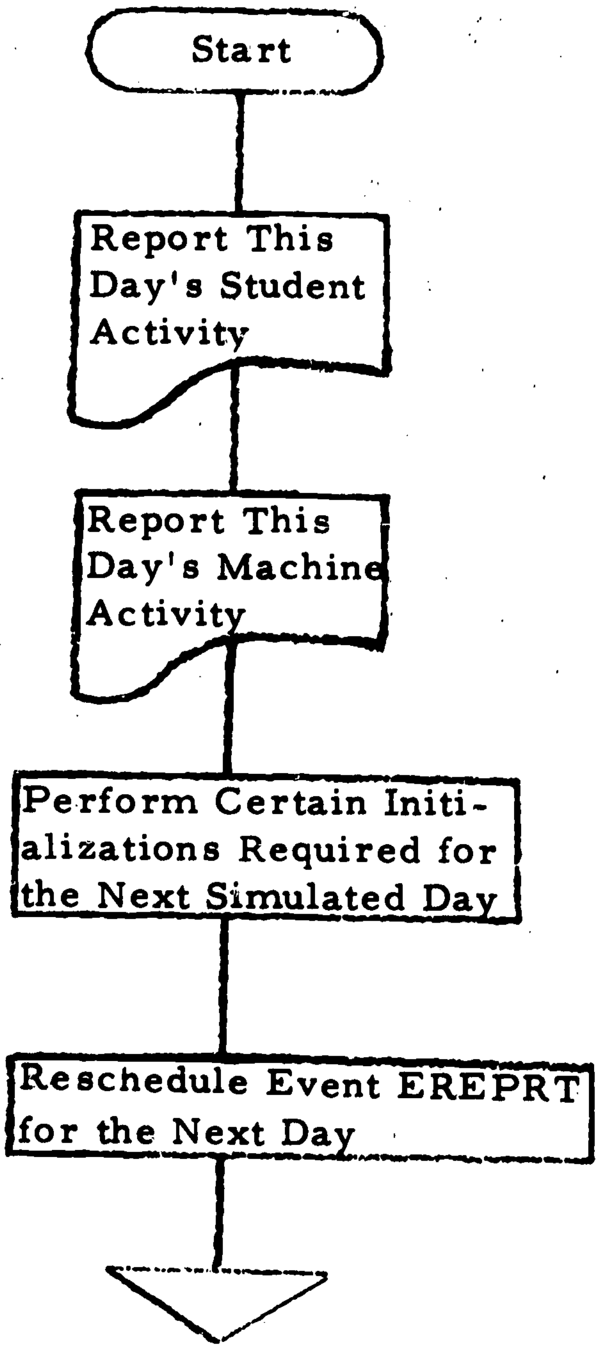
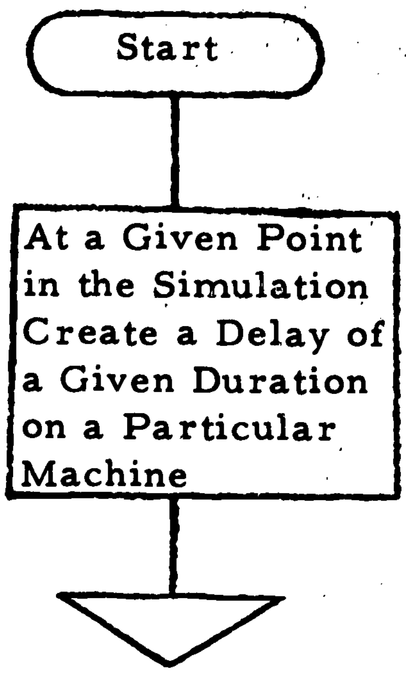


Figure 10

SUBROUTINE EDLAY2 EVENT NO. 6



NOTE:

If this event is to be used, it must be read in as an initial event.

Figure 11

SUBROUTINE SUMMARY

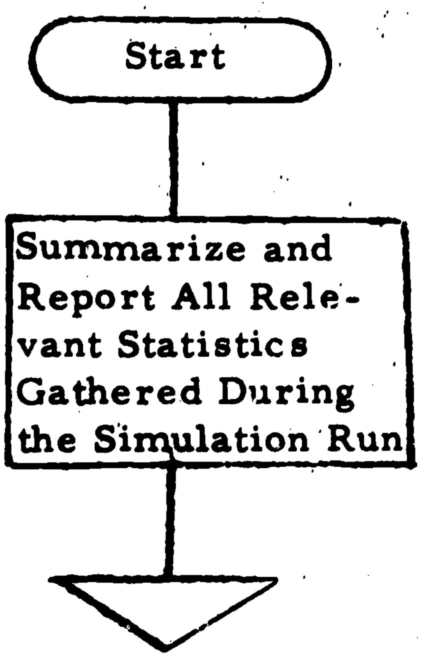


Figure 12

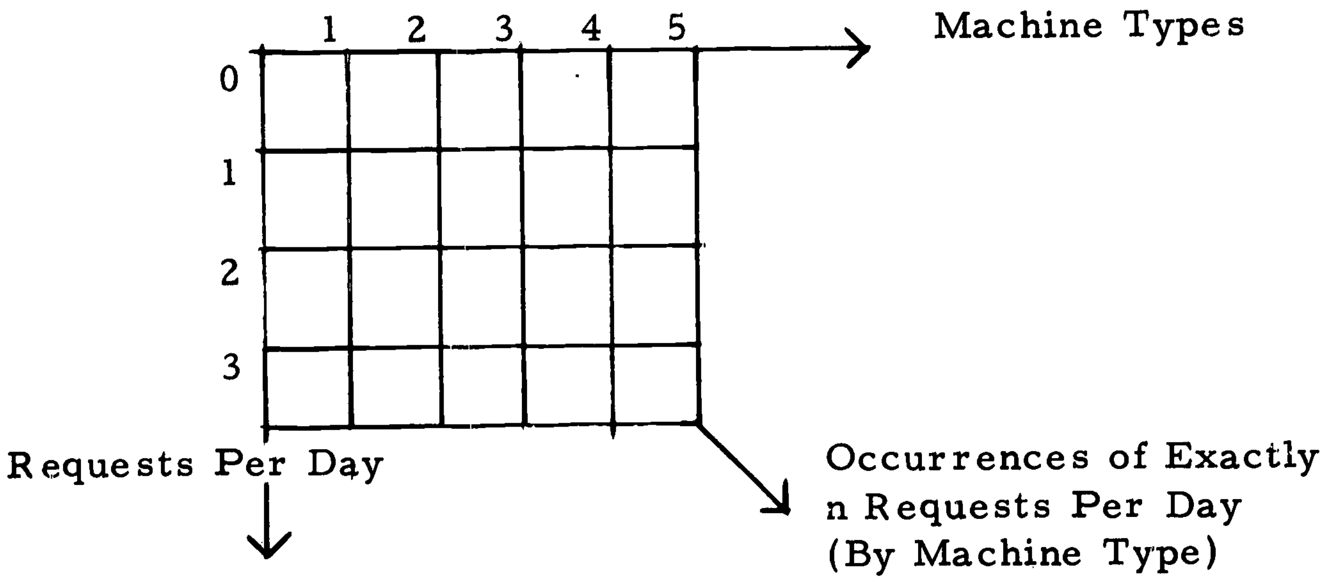
GLOSSARY OF KEY VARIABLE NAMES

A. One Word Variables:

NMACH - Total Number of Machines
NSEQ - Total Number of Sequences
NSTDNT - Total Number of Students
NTYPE - Total Number of Distinct Machine Types

B. Double-Dimensioned Variables:

IREQ (30,20) - (30 Rows, 20 Columns) - Frequency Distribution of Number of Requests Per Day By Machine Type



JMACH (3,20) - Machine Distribution Matrix

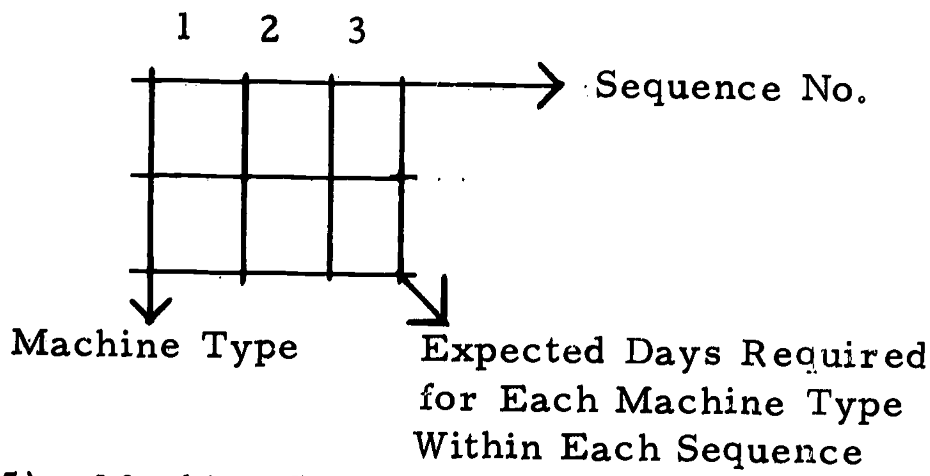
Machine Type →	1	2	3
Total Machines Preceding This Type			
Machines of This Type			
Required Student Attributes (packed) - Max. of 4 Digits			

(Figure 12 continued)

JREQ (2, 20) - Daily Machine Type Request Matrix

	1	2	3	→ Machine Type
Requests for This Machine Type Today				
Total Requests for This Machine Type To Date				

JSEQ (20, 5) - Expected Days Required for Each Machine Type Within a Given Sequence



JSEQ2 (20, 5) - Machine Sequence Matrix

	1	2	3	Sequence No. →
Total Machine Types (Entries in this Sequence)				
First Machine Type In This Sequence				
Second Machine Type In This Sequence				
Third Machine Type In This Sequence				
Fourth Machine Type In This Sequence				

nth Machine Type
In this Sequence
↓

(Figure 12 continued)

JSTDNT (7, 30) - Student Attribute Matrix

	1	2	3	4	→ Student No.
Speed					
Speed					
Speed					
Speed					
Sequence No.					
Starting Location in Sequence					
Current Location in Sequence					

Student Attributes are Rated:

1 - Very Fast
2 - Fast
3 - Average
4 - Slow
5 - Very Slow

Speed is drawn from a normal distribution

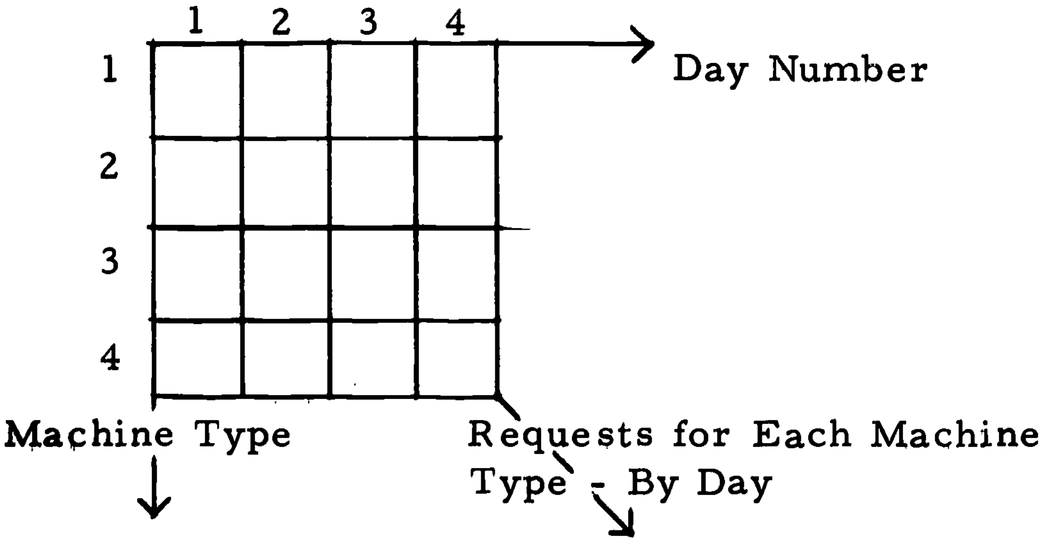
KMACH (4, 50) - Daily Machine Report Matrix

	1	2	3
Machine Status			
Student Using Machine (if any)			
Days Idle to Date			
Days Delayed to Date			

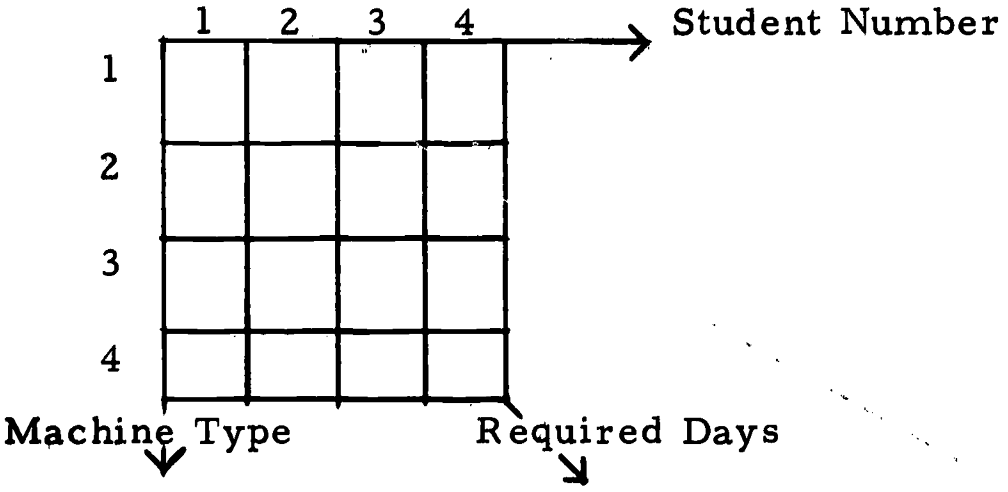
Machine Status: 0 - Idle
1 - Delayed
2 - Active

(Figure 12 continued)

KREQ (20, 130) - Log of Daily Machine Type Requests



KSEQ (20, 30) - Required Days for Each Machine Type By Student, Based on Individial Student Attributes

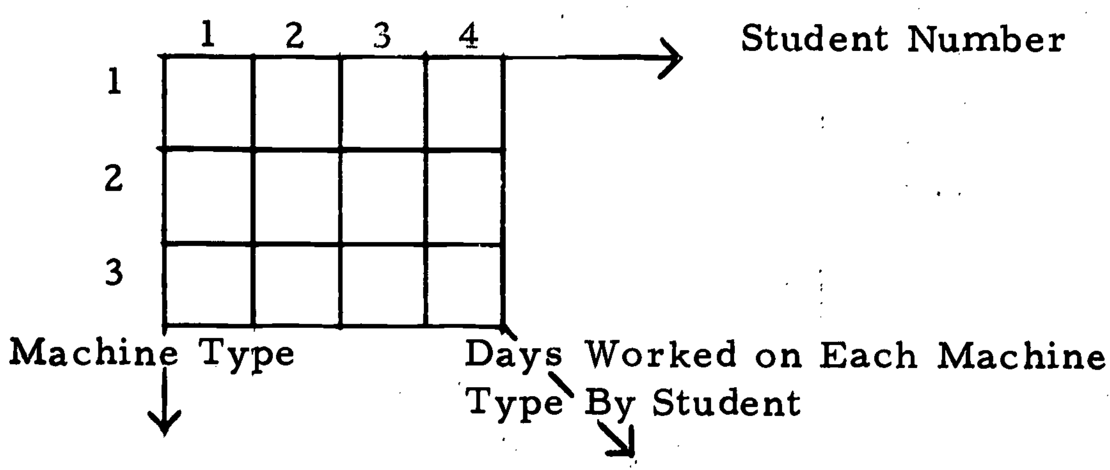


KSTDNT (3, 30) - Daily Student Report Matrix

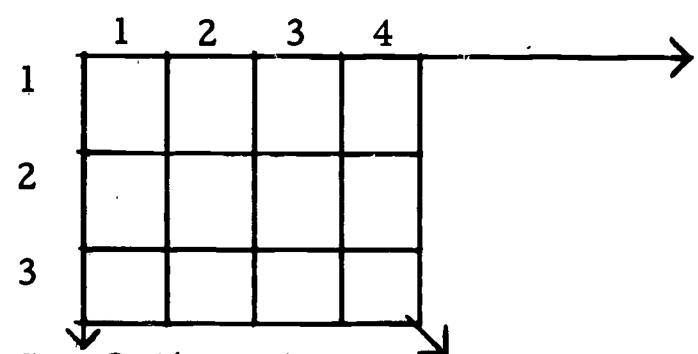
	1	2	3	4
Student Status				
Days Absent to Date				
Days Idle to Date				

Student Status:
- 0 - Present, But Idle
- 1 - Absent, School Business
- 2 - Absent, Illness, etc.
- 3 - Present, and Active
- 4 - Present, Idled by a Machine Delay

LSEQ (20, 30) - Actual Days Spent By Each Student On Each Machine Type



MSEQ (20, 30) - Anticipated Day When Each Student Should Begin Work On Each Machine Type in his Sequence



SREQ (60, 20) - Time a Machine Request was First Initiated vs. Time First Satisfied By Student, By Machine Type

Student 1	1	Time Request Initiated					Machine Type
	2	Time Request Satisfied					
Student 2	3	Time Request Initiated					
	4	Time Request Satisfied					
Student 3	5	Time Request Initiated					
	6	Time Request Satisfied					

2x Students

STATUS (3, 50) - Machine Delay Status Matrix

	1	2	3	4	
Day No. When Machine Will Next Be Available					Machine Number
Probability Machine Will Suffer A Delay On Any Given Day					
Distribution Number for Drawing Delay Duration For This Machine					

Part 4 of 8

SCHEMATIC MODERNIZATION

4

Prepared By The Research Team For A Comprehensive Concept For Vocational Education Facilities

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Preview of Unit Four, Schematic Modernization

All educational facilities are expected to provide environments which satisfy the specific needs of the many activities that occur in modern school buildings. Each environment that adequately serves a distinct activity may be described in terms of space, light, condition of the air, noise level, and mechanical services to the equipment used for that activity. It is only recently, however, that educators have begun to ask that facilities also provide flexibility. In other words, any environment that serves a particular activity must be capable of being changed quickly and inexpensively to accommodate the needs of another activity.

Naturally, educators expect to have a high quality yet flexible environment in any new school building. They are also beginning to evaluate existing school buildings in terms of the quality and flexibility of their spaces. However, because it often is expedient to occupy space in non-educational structures for short or long periods of time, the question of whether a suitable educational environment can be created in warehouses, office buildings, movie theaters, and so forth, is now being asked. This report suggests that a mechanical service system, designed specifically around the needs of educational activities, can be installed with relative ease in new schools, existing schools, and non-educational buildings that are temporarily used for schools.

The central theory of this concept suggests that an educational environment is more dependent on a mechanical service system and related furniture and equipment than it is on a building's structural system. The theory further suggests that the components of what might be called an "environmental system" should be separated from basic structure and be left accessible for future change. If this were done, a high quality environment with a capability for flexibility and portability could be provided in many kinds of buildings.

Such a system could be installed in new schools to provide future flexibility. Also, it could be installed temporarily in a non-educational building to provide a high quality environment which could be moved and reinstalled in another building with relative ease. It might have its most important application, however, in the modernization of an existing school building that is considered to be inflexible and out of date. Therefore, the environmental system described in this report should provide not only a high quality environment serving all needs of educational activities, and the flexibility necessary for future change, but also the independence from any one structural system to enable installation into the different buildings that may be used for education.

The Modern Educational Facility: High Quality Environment with Flexibility

Any educational activity, whether it be planing wood cabinet parts or reading poetry, should be facilitated by an appropriate environment. An environment which is suitable for one activity is different, in many ways, from an environment which is suitable for another activity. Some of the changing environmental elements are space, light, condition of the air, noise level, and services to equipment. The wood planing activity requires more space and greater circulation of air than does the poetry reading activity. The noise of the wood planer should be contained near the planer and away from the reading area. There are no equipment services required for reading, while the planer needs power and exhaust services. The ideal facility, then, has the capability to create an environment suitable for each activity that may occur within its area.

Fewer and fewer activities remain stable and unchanging over long periods of time. Large, medium, and small group instruction requires that spaces be changed, sometimes instantaneously. In a short period of time, a class can move from formal presentation through laboratory activity to informal discussion, thus requiring different light levels, air conditioning, and acoustics. The advent of activities such as televised lectures, and tape recorded language lessons require new services to a wide range of new equipment. From these few representative examples, it can be seen that facilities must provide not only a high quality environment but also a high degree of flexibility. This flexibility is required in terms of space, mechanical services, furniture, and equipment. In other words, total environmental flexibility is required.

Flexible Environment: Independence from the Limitations of a Structural Frame

Another problem further complicates the demands made for good educational facilities. Unlike requirements for high quality environment and flexibility, which grow out of educational theory, this problem simply is born of necessity. A new school is an expensive structure. Hence, a school system often operates in a conglomeration of different buildings. There may be a few new schools, a large number of aging schools, and a few buildings in the community that are being used temporarily for schools. The addition of a new structure to a school system's inventory of buildings often necessitates the moving of certain activities and their facilities from one building to another. Ideally, every facility should provide a high quality, flexible environment no matter whether it is housed in an old, new, or temporary school building. The problem lies in providing such facilities in the many different types of building used for education.

It is a suggestion of this study that those elements of a building which directly create an environment be considered as independent of those elements which seem to have less to do with environment. In other words, mechanical equipment and services, non-bearing partitions, furniture, and instructional equipment, which are all subject to change, should be freed of the limitations of structural systems which are not easily changed. Considering the history of buildings, this is an unusual approach to take.

Two functions of any building are to provide shelter and environment. Man's first huts provided shelter from wind, rain, and snow. Later, increased sophistication of man's activities required that spaces within shelters provide suitable environments for those activities. Living rooms needed light and warmth. Kitchens needed sources of heat and water for cooking. The laboratory of today requires a vastly more complex array of services including compressed air, vacuum lines, gas, and so forth. To generalize, it can be said that the structural frame performs the sheltering function while mechanical equipment, interior partitions, and furniture perform the environmental function.

Most buildings have performed these functions with one inseparable shelter and environmental system. For example, hot air was circulated through the cellular floors, or hypocausts, of Roman baths. Many older school buildings have "breathing walls" which circulate air and also serve to divide classrooms from corridors. Even new school buildings are served by air, water, and electric power lines fixed in concrete floors, concrete block walls, or plenum spaces above plaster ceilings. Schools that are built in this manner offer many obstacles to future change. This example was given by the Director of Facilities for the Pittsburgh Board of Public Education:

> . . . old, warm air heating systems with their large ducts and breather walls seriously hamper the freedom needed to design alteration work to comply with new educational philosophies.[1]

A number of factors point to the separation of a building's shelter and environmental systems. One factor that necessitates separation can be found again in the words of Pittsburgh's Director of Facilities:

> Imbalance as to durability of the various building components means that the building itself may be built to last seventy-five years, but its mechanical and electrical systems have a life of but twenty-five to thirty-five years. This necessitates the

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[1] Thompson, J. H., "Educators on School Design," A Survey of Professional Opinion, Producers' Council, Inc.

difficult replacement of integral systems several times over the life of the building.[2]

A factor which enables the development of independent environmental systems comes from mankind's increasing reliance on environmental technology. Formerly, light was supplied through windows or skylights which were dependent for their location on the structural frame. Today, the exact needs for different lighting levels in schools are more easily satisfied by electrical lighting systems which are not so dependent on structural systems. It is safe to say that improvements in environmental technology will produce many new systems for providing light, power, and so forth. These improvements may happen faster than school systems will want to demolish their existing buildings.

The combination of these two factors, along with the growing need for flexibility in educational facilities

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[2]Ibid

and the increased changing of the functions of school buildings, seems to support the suggestions contained in this study for an independent, flexible, and portable environmental system. A detailed description of the mechanics of such a system is presented in Unit Two of this report. The purpose of this book is to illustrate how the installation of a flexible environmental system might improve different buildings.

Applications of an Environmental System

The environmental system, described in Unit Two, Flexibility Through Modularity, performs these three basic functions: mechanical service, equipment service, and space division. Mechanical services include air conditioning, water, lighting, and sound control. Equipment services include electrical power, compressed air, gas, and exhaust. Space division is accomplished with a multi-directional switching system of operable partitions. Conceivably, the system could well include furniture and instructional equipment.

The services of the system would be distributed from floors or ceilings, as was most efficient. All elements of the system would be "snapped" into place with special connectors for floors or ceilings. Similarly, connections in service lines would be made with "snap-on," "plug-in," or threaded couplings. Each element would be sufficiently independent to provide for replacement or modification.

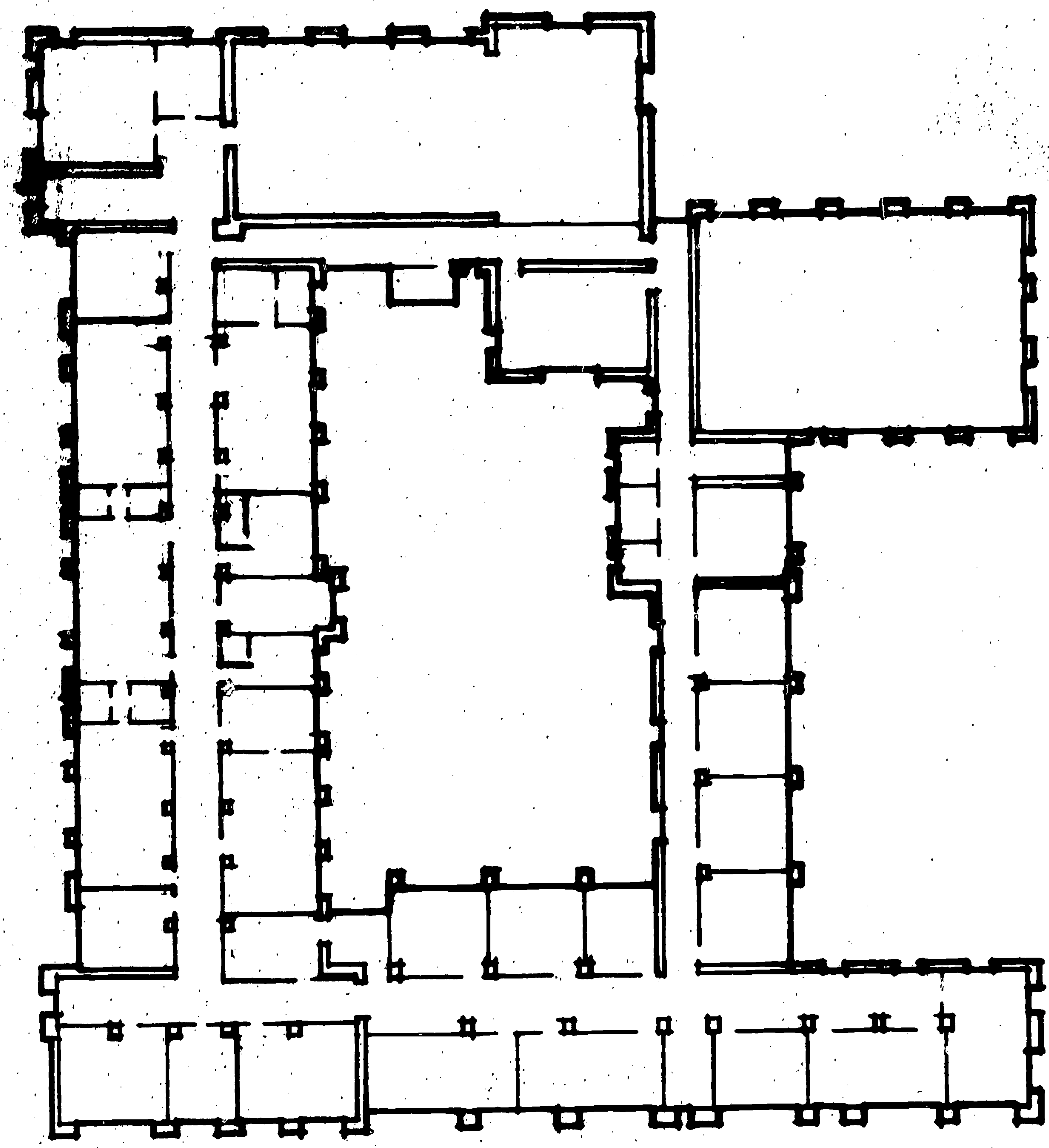
Installation of the system into new construction would not differ greatly from standard methods. Also, it would not make a great deal of difference whether the structural frame were steel or concrete. The system itself could be installed in pieces or in pre-assembled modules. If there were trade jurisdictional problems in the area in which the buildings were to be constructed, the elements of each component of the system could be shipped to the appropriate sub-contractor who would make the installation. However, if there were no jurisdictional problems, complete modules could be assembled in factories and shipped to the job site, ready for installation. The latter method could save money in reducing field work.

Existing buildings would have to be prepared in order to accept the system. Non-bearing partitions and outdated mechanical systems would be removed in portions of buildings to be modernized. In many buildings this would be a necessary operation since the inflexibility of existing spaces is not appropriate for modern educational practices. In addition, mechanical systems have begun to deteriorate by the time most buildings are scheduled for modernization. When this "gutting" process was completed, the building or a portion of it would be an anonymous shell, ready for the installation of the educational environmental system. From that point, the process would be similar to the one described for new construction.

To further illustrate the application of this environmental system, a set of schematic drawings have been prepared which show the system installed in an existing school building in Pittsburgh. An existing Pittsburgh school was selected for illustrative purposes because accurate working drawings were available from the Facilities Department. However, the selection of this particular school does not reflect, in any way, the current plans of the Pittsburgh Board of Education.

The school itself was chosen because its present and predicted enrollments are representative of the general problem faced by many existing schools. At present there are 1,923 students attending classes daily in this building. Its rated capacity is 1,500 students. This means that the occupancy at present is 128.2 percent of the rated capacity. The present enrollment consists of both high school and junior high school students; however, in the future, this school is scheduled to become entirely a middle school. As a middle school, its enrollment is not planned to exceed 1,200 to 1,500 with students in grades six, seven, and eight.

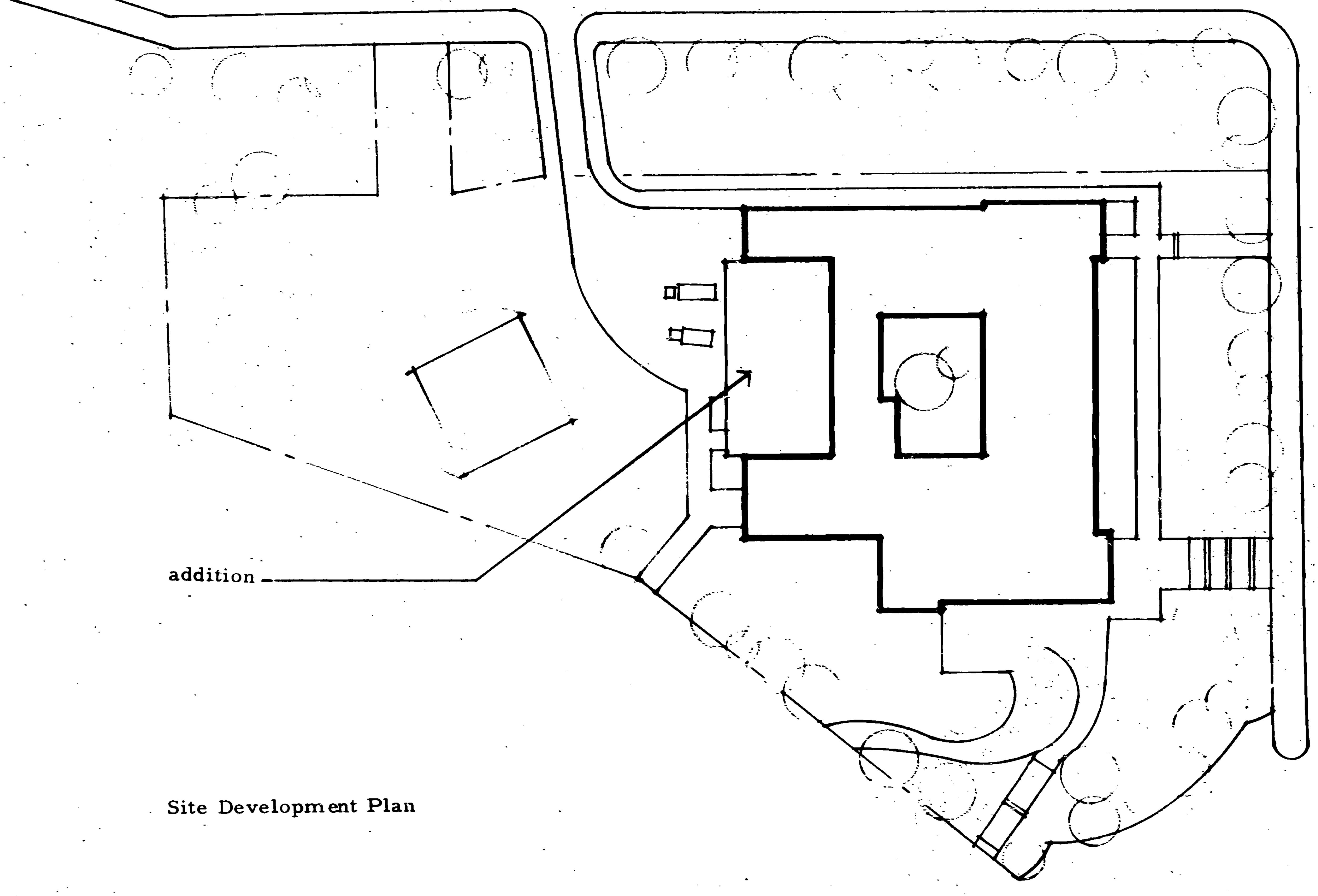
Also, this building was chosen because it resembles many existing Pittsburgh school buildings in its physical problems. Because it is both a junior and senior high school, this school houses exploratory vocational programs for younger students and job-centered programs for older students. These programs are housed in the "egg-crate" classrooms which typify school buildings of this type. An examination of the "Existing Second Floor Plan" will reveal many



Existing Second Floor Plan

non-bearing masonry walls which cut up the space of this building into many small, inflexible classrooms. Home Economics and Business Education programs are located in such spaces and scattered throughout the building. The trade and industrial shops are located in the basement, across the hall from the cafeteria. Materials and equipment can be brought into the shops only from a small service apron, up a flight of stairs, and down a long corridor. The service apron and its approach are insufficient for any large truck.

Any effort at modernization which would improve these situations must be tempered by the fact that the school will soon be converted to house only middle school programs. This means that all of the senior high school, job-centered vocational programs which are presently located in this building will soon be moved to a new structure. Although modernization must provide a high quality environment which meets the needs of all activities.



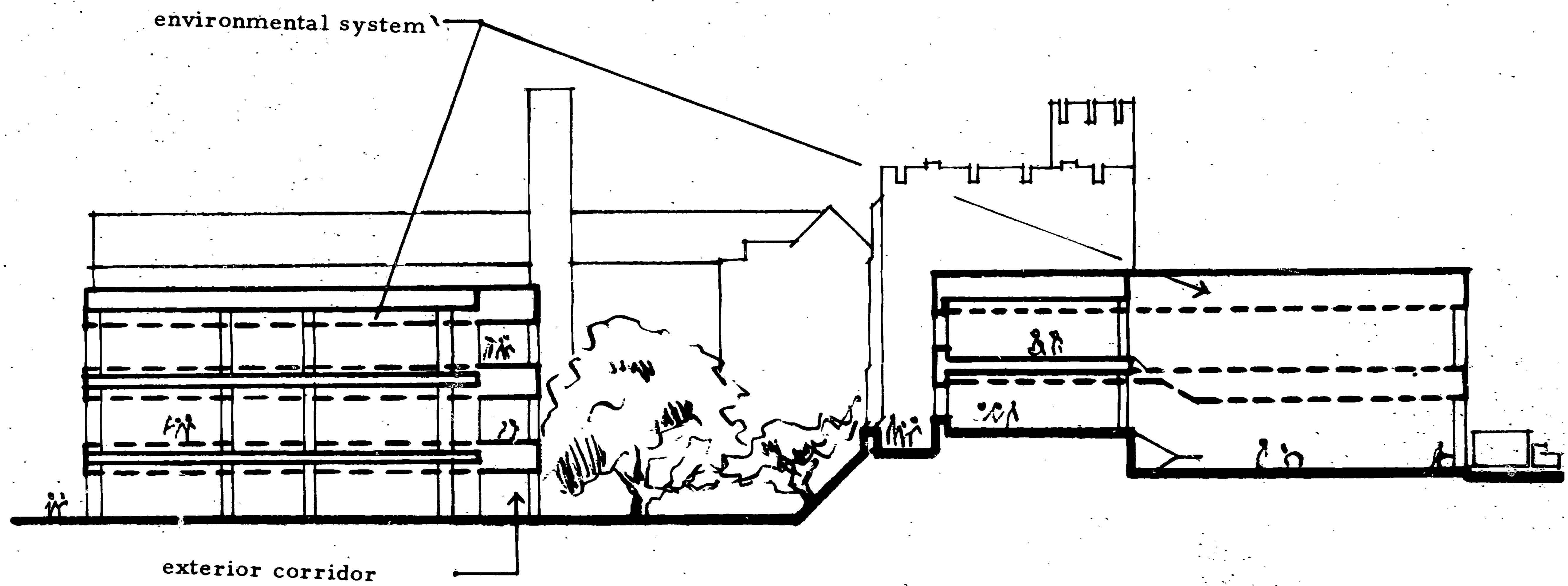
Site Development Plan

it must not provide an environment which is not easily convertible to middle school programs.

For this same reason, there must not be a heavy investment in more space. Additional space which would make the building more usable for the present 1,923 middle and high school students would be unnecessary for the planned 1,200 to 1,500 middle school students when the building is converted. Therefore, the additional space proposed in this study does not increase the total space of the building over 100,000 square feet. The space that has been added is intended for Technical and Industrial programs that need higher ceilings than are provided anywhere in the existing building. (See Site Development Plan)

It is entirely possible that even with this additional space, the school building will not house adequately its present middle and high school enrollment. If this were so, a satellite facility could be either purchased or rented. The environmental system presented in this study would be equally applicable to such a temporary satellite facility.

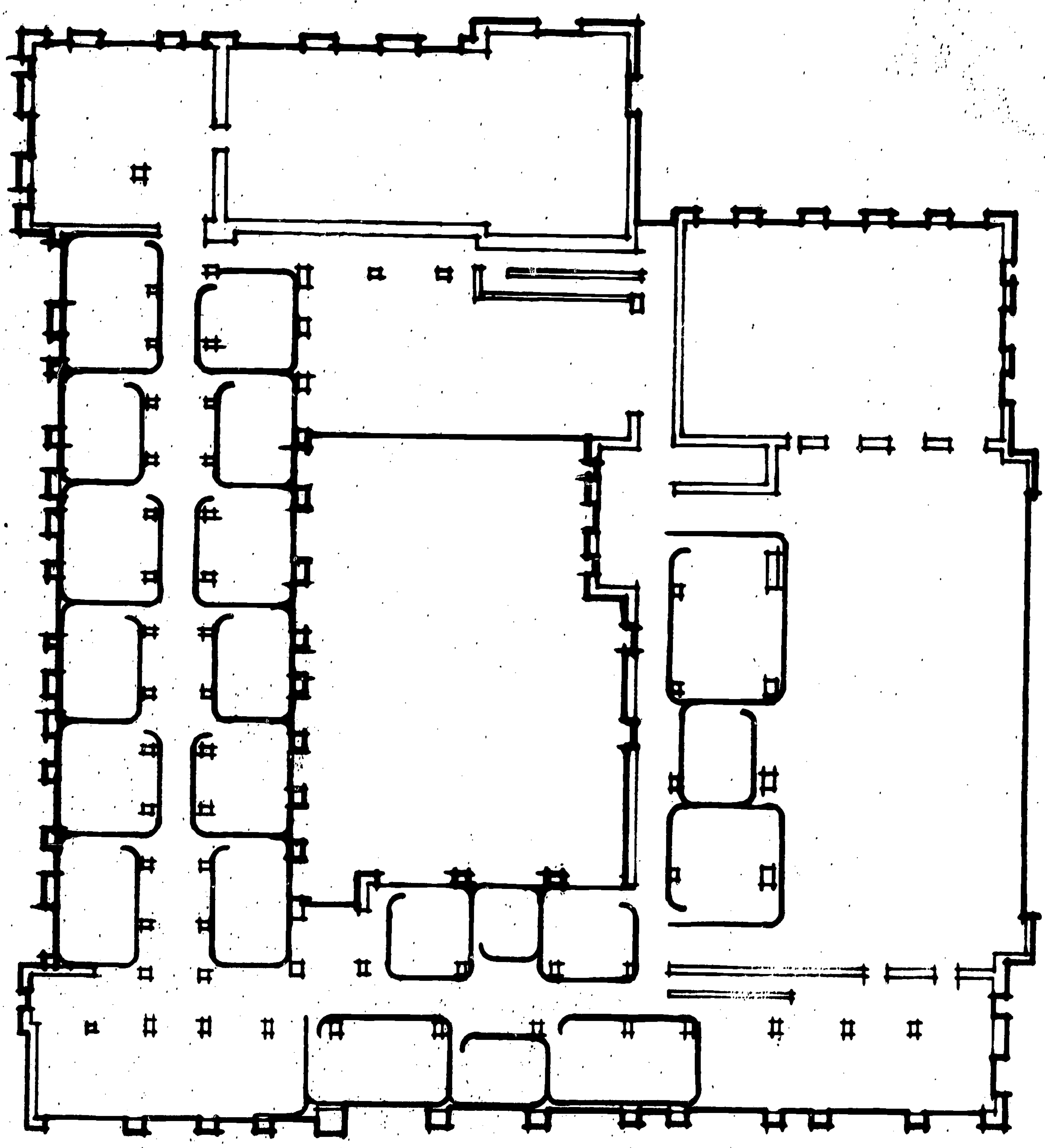
A survey of the building's architectural drawings revealed that floor to ceiling heights were sufficient for installation of the system. It was also seen that with few exceptions all partitions were non-bearing and, therefore, removable. Although no survey of the condition of mechanical services was done, it was assumed, for the purposes of this study, that a new mechanical system could feasibly replace the old. The location of the environmental system elements is shown by the dotted lines on the "Building Section" drawing. The section drawing also indicates that the main distribution lines of the system could be housed in the floors and ceilings of an exterior corridor added to the building. The exterior corridor would allow for larger class areas within the building.



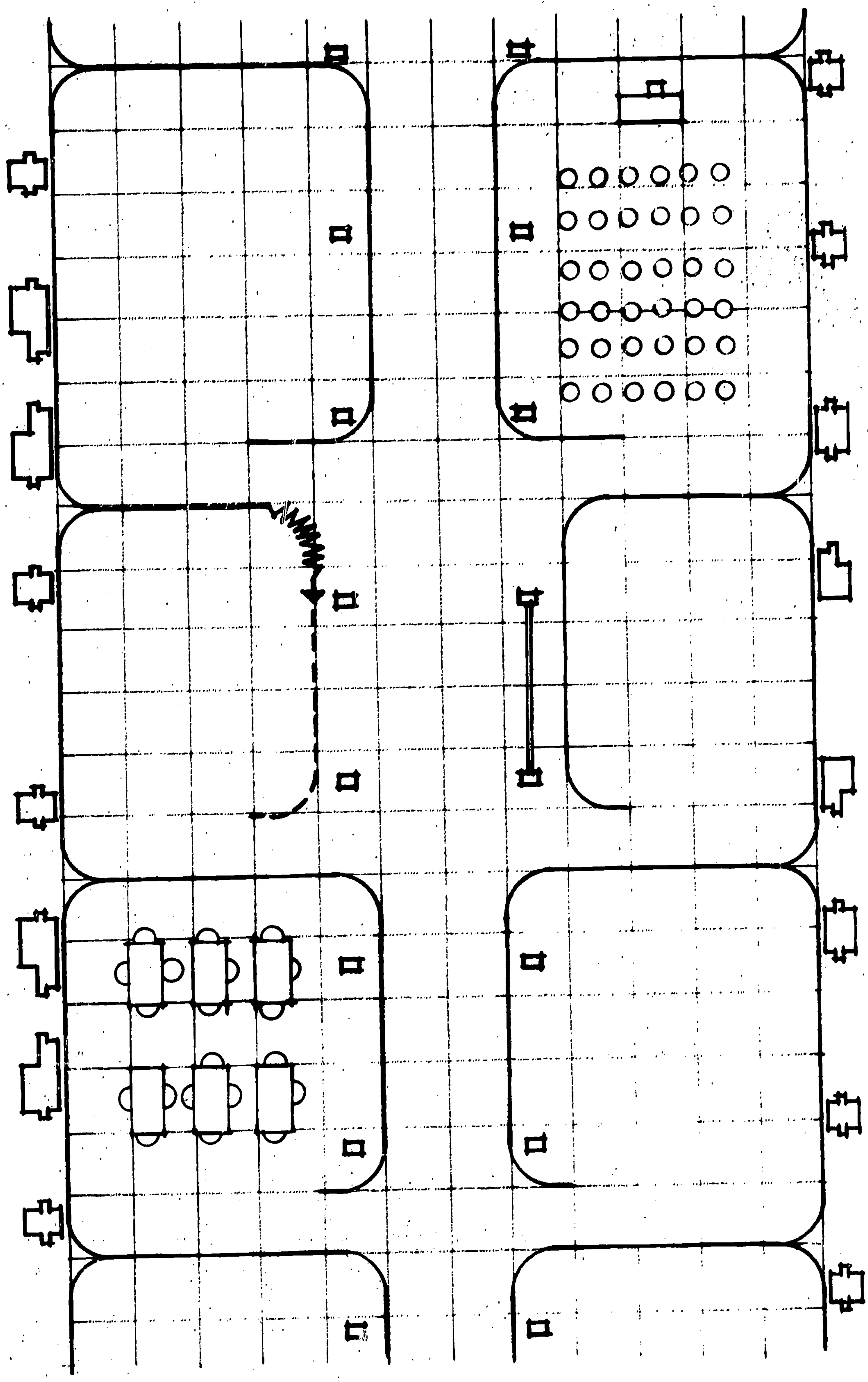
Building Section

First Application

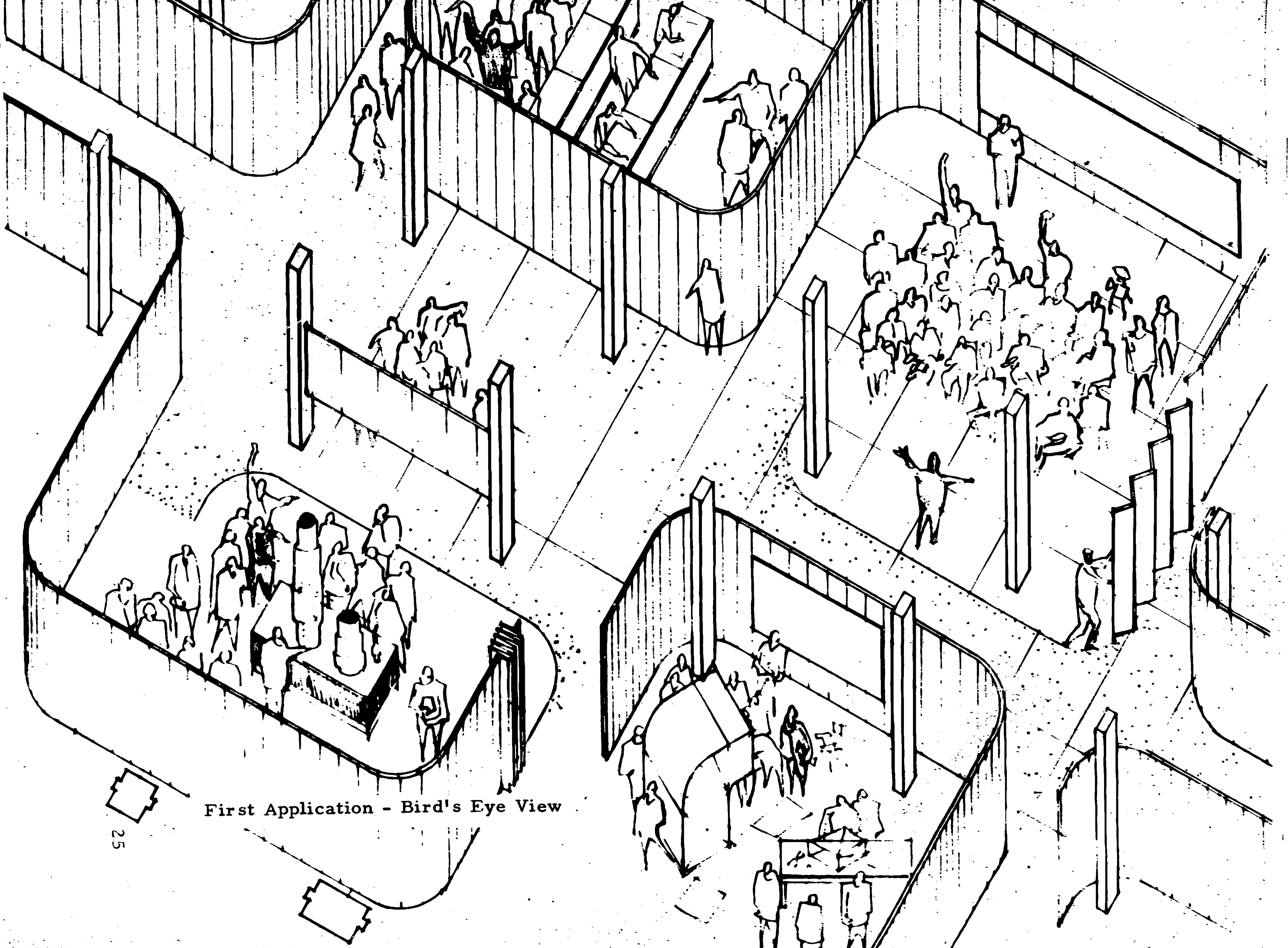
These modifications of the building would allow for a number of different space arrangements. The first of these is presented in the following four drawings. A space system, very similar to the one that had previously existed, was developed. In other words, central circulation was retained between the double row of columns and class areas were divided into small rooms. It would then be possible to conduct classes in much the same manner as they are now; however, since operable partitions were used, the spaces could be combined at will.



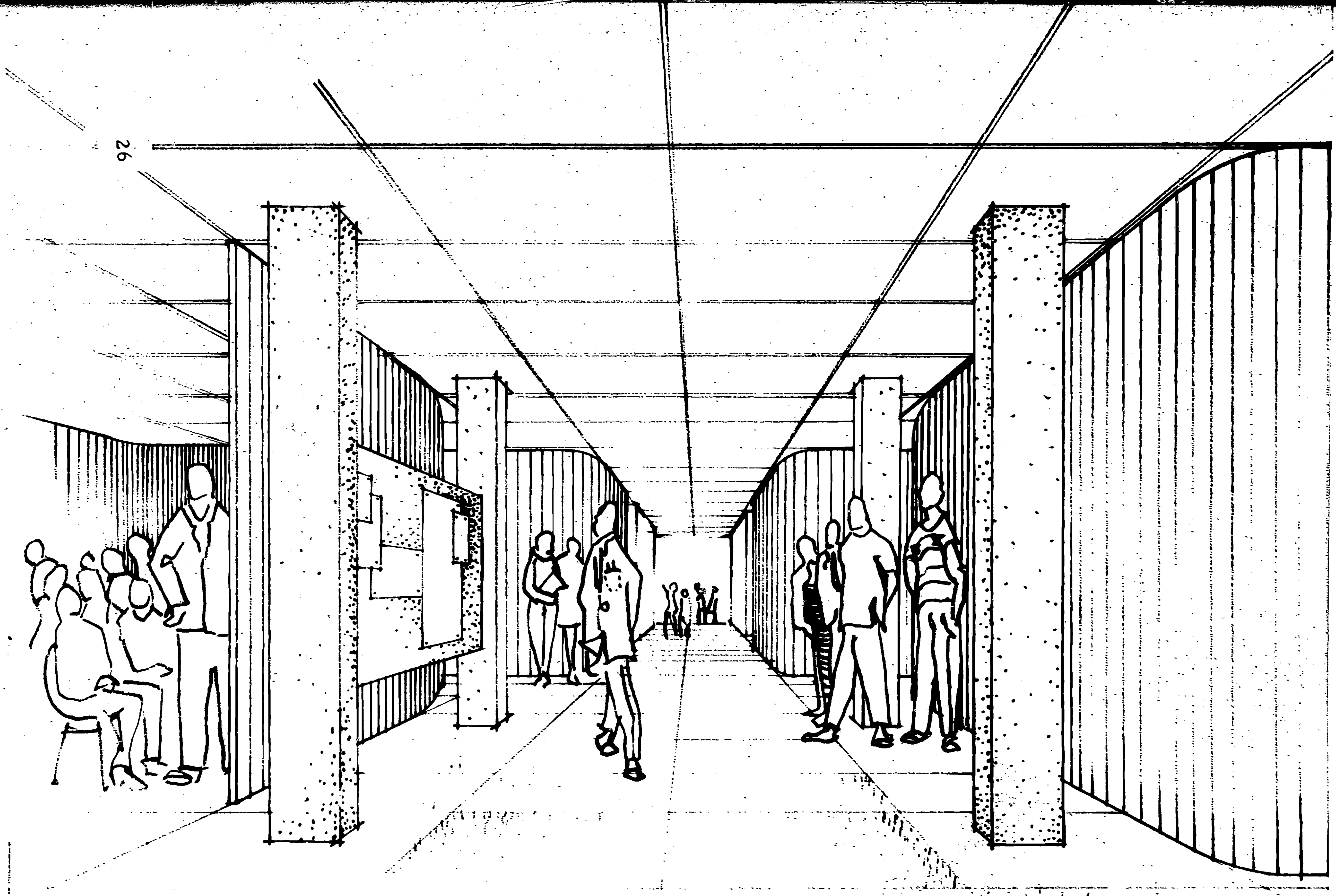
First Application - Second Floor Plan



First Application - Detail Plan



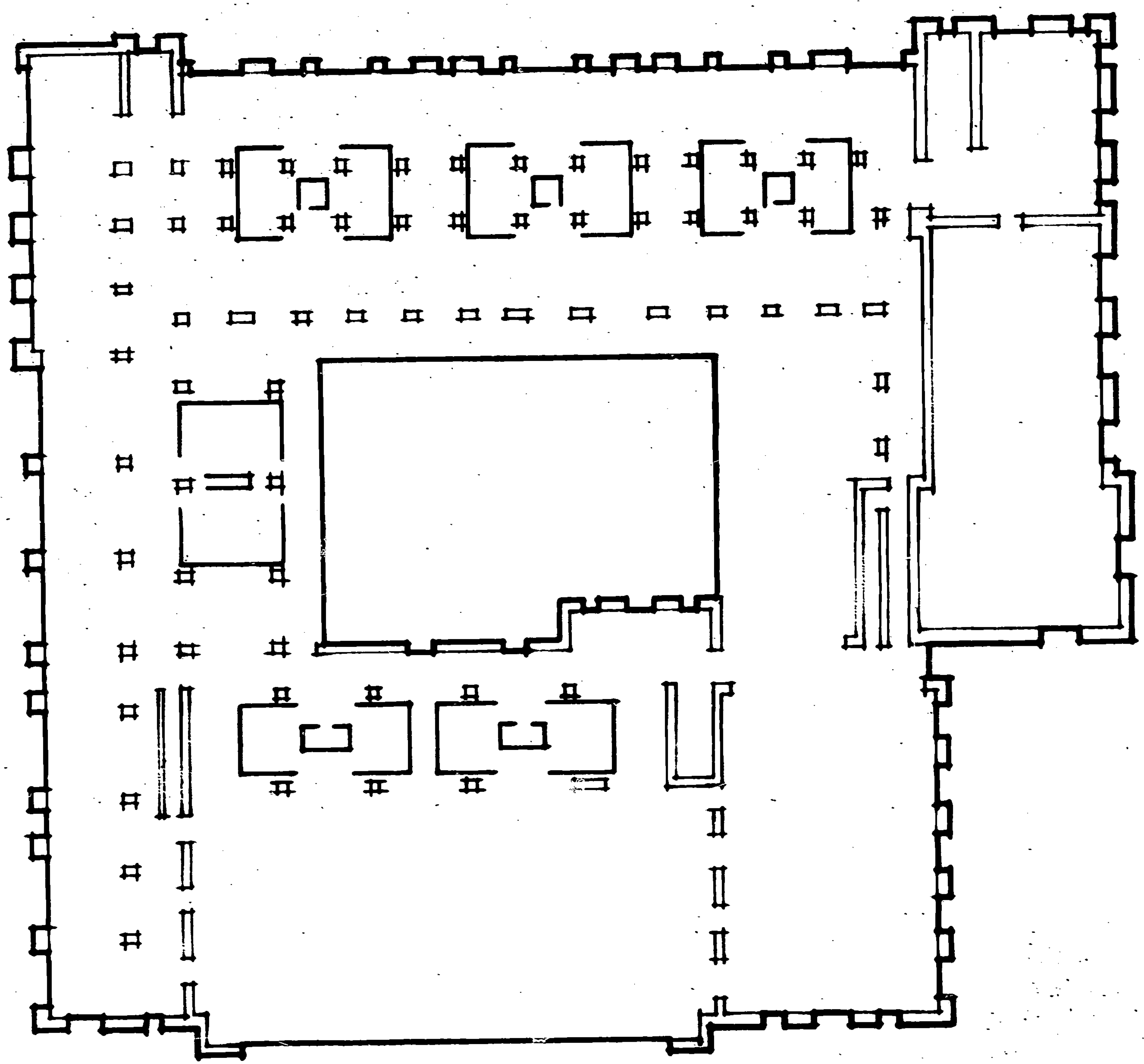
First Application - Bird's Eye View



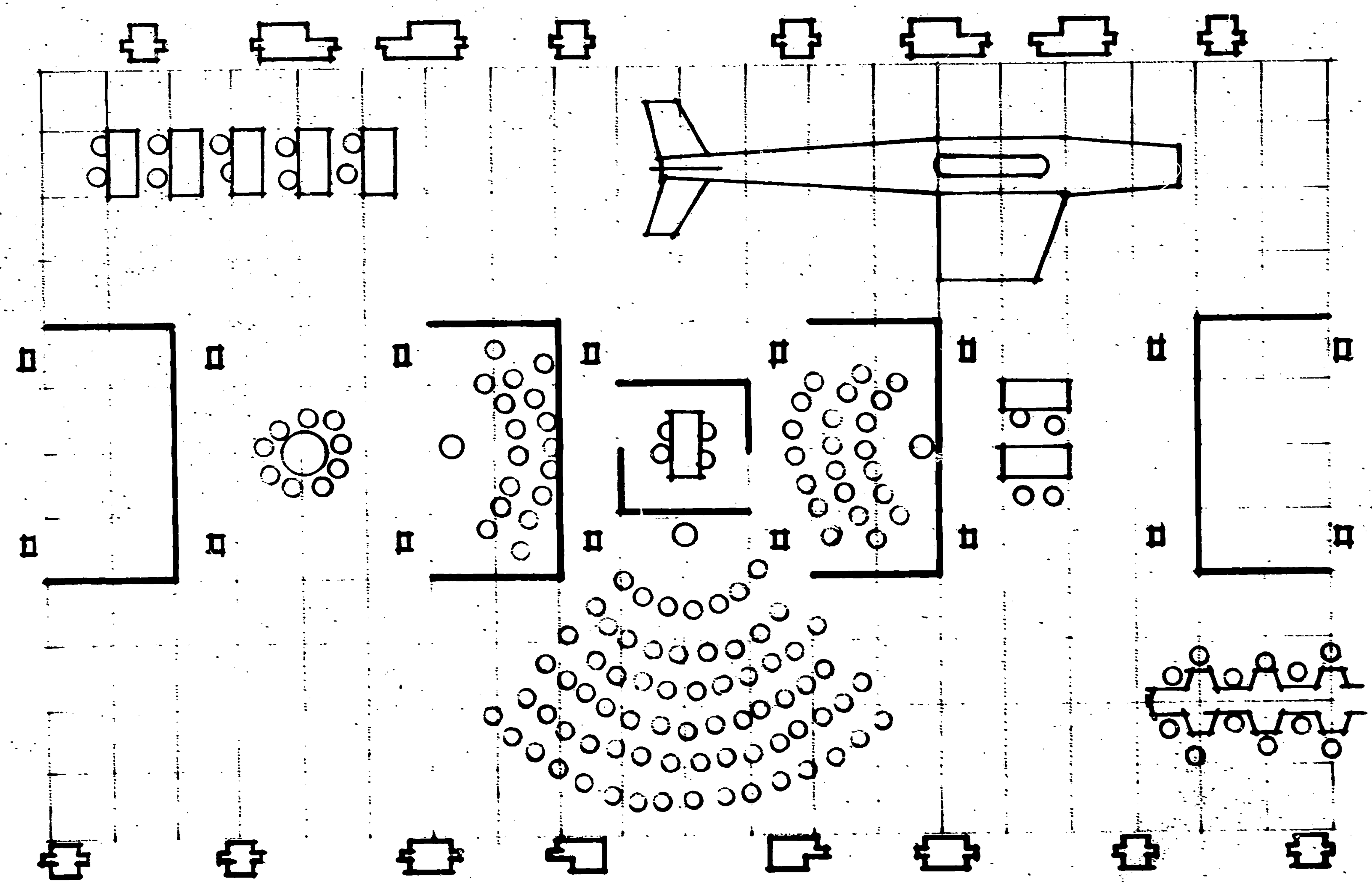
First Application - Interior View

Second Application

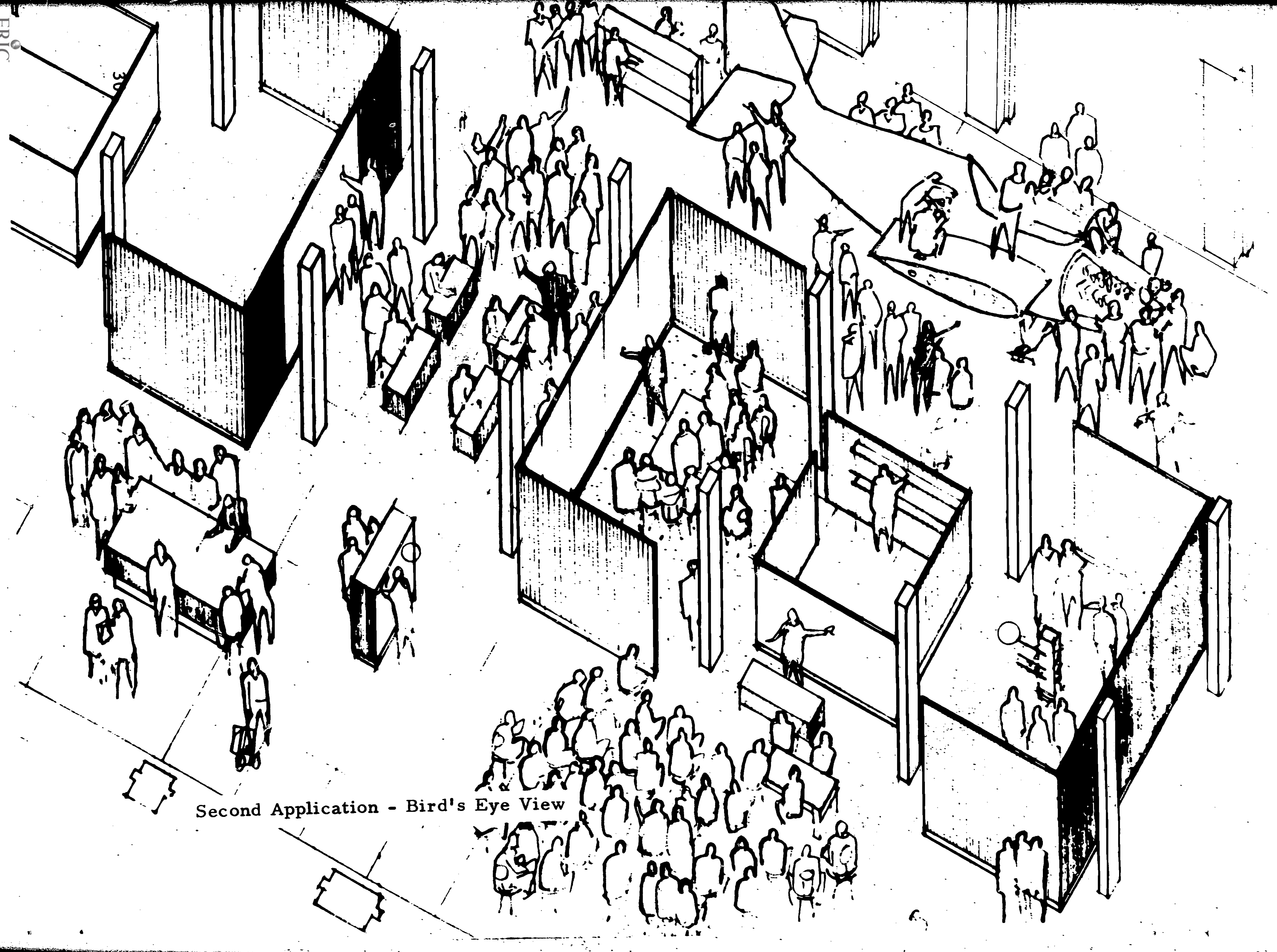
In the second arrangement, a much more open system of space was designed. It should be noted at this point that the one limitation of this school building, which prevents it from providing the total flexibility of new construction, is the physical presence of a double row of columns in the center of the space. These columns were of architectural concern since they did not relate to the exterior piers. Therefore, a division of space was sought which utilized the strongly defined areas where the former corridor had been. In a sense, the space was turned inside out. Storage areas, small discussion rooms, teachers' offices, and so forth, were provided as special islands in a sea of otherwise open space. Circulation, in this case, was located within a newly constructed exterior corridor.



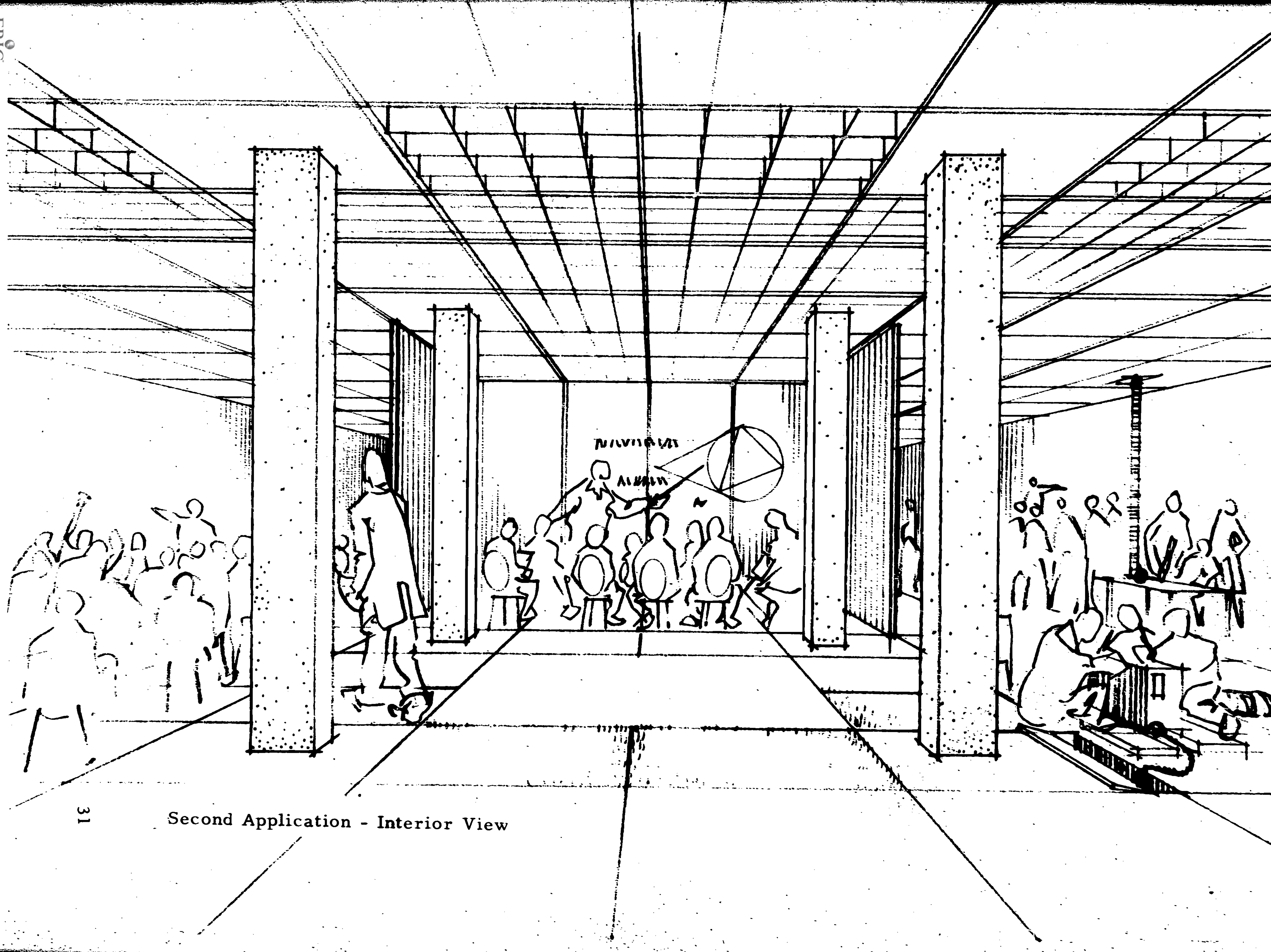
Second Application - Second Floor Plan



Second Application - Detail Plan



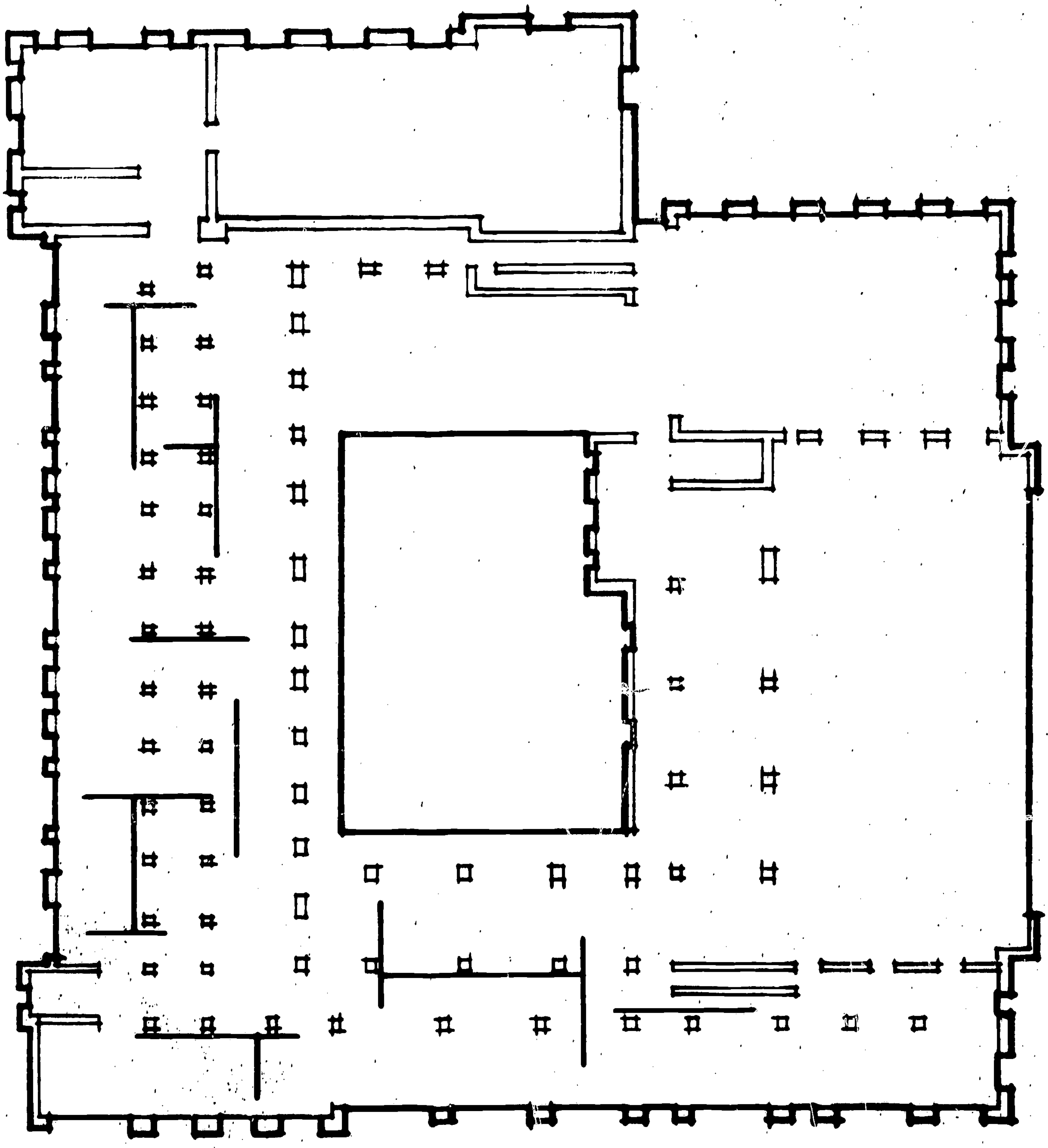
Second Application - Bird's Eye View



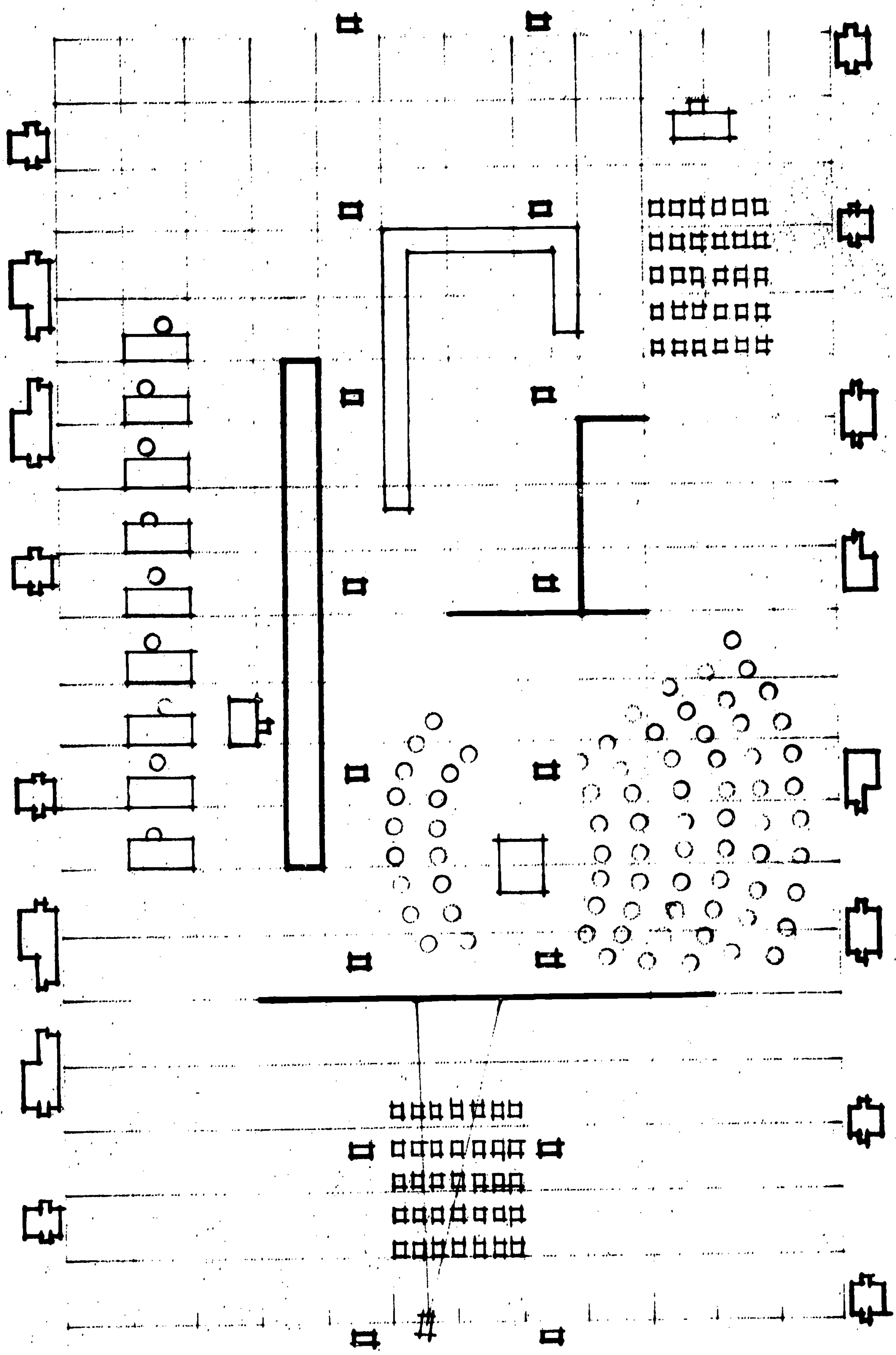
Second Application - Interior View

Third Application

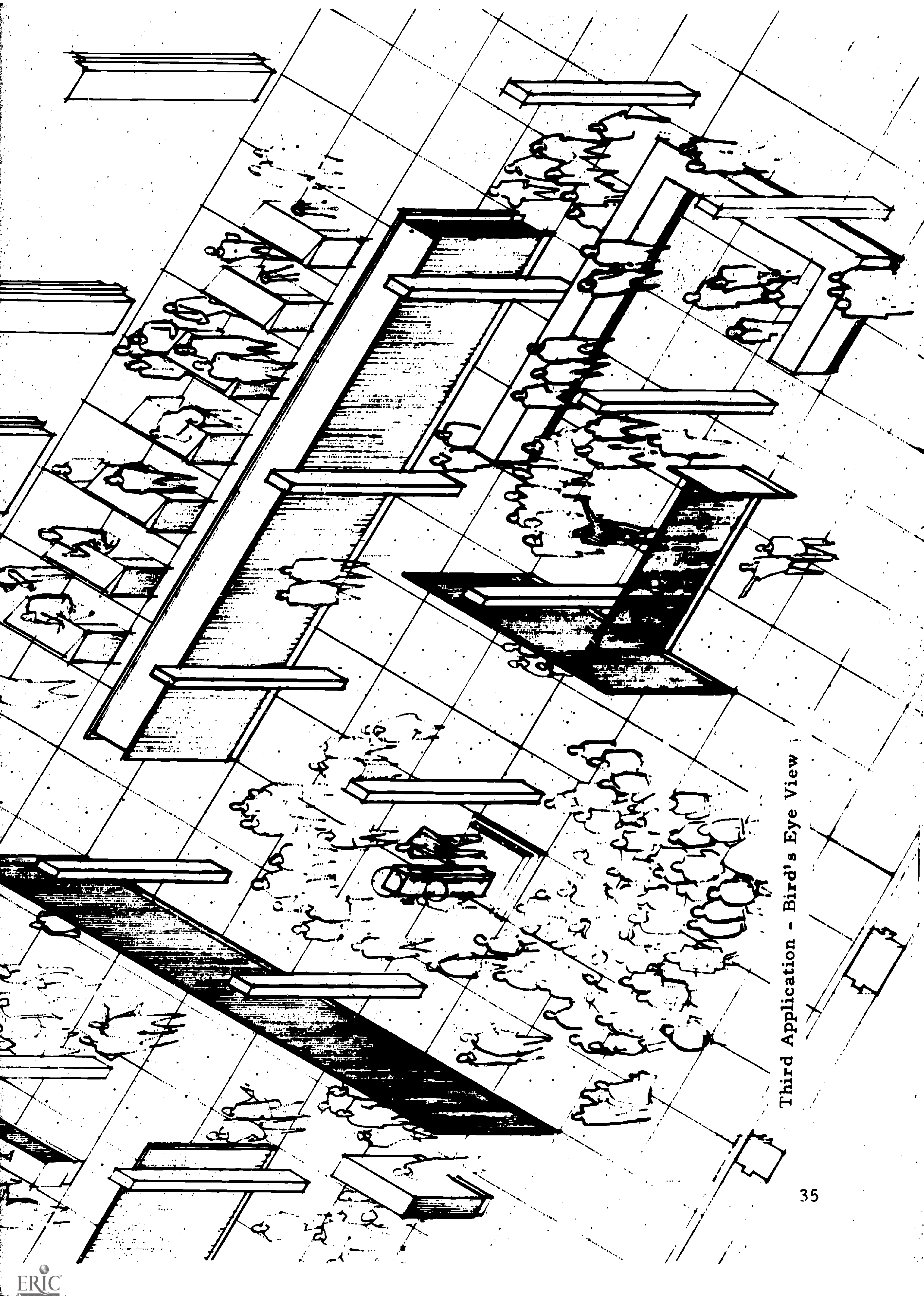
In the third scheme, a space system was attempted which was not so obvious in its recognition of the interior columns. Operable partitions were arranged in long intersecting planes to provide for visual definition of space only. Activity areas flowed around these partitions. With this kind of partition arrangement, spaces were rather amorphous and tended to interlock. There began to be an integration between the various class activities. As in the second arrangement, circulation was provided through exterior corridors ringing the court.



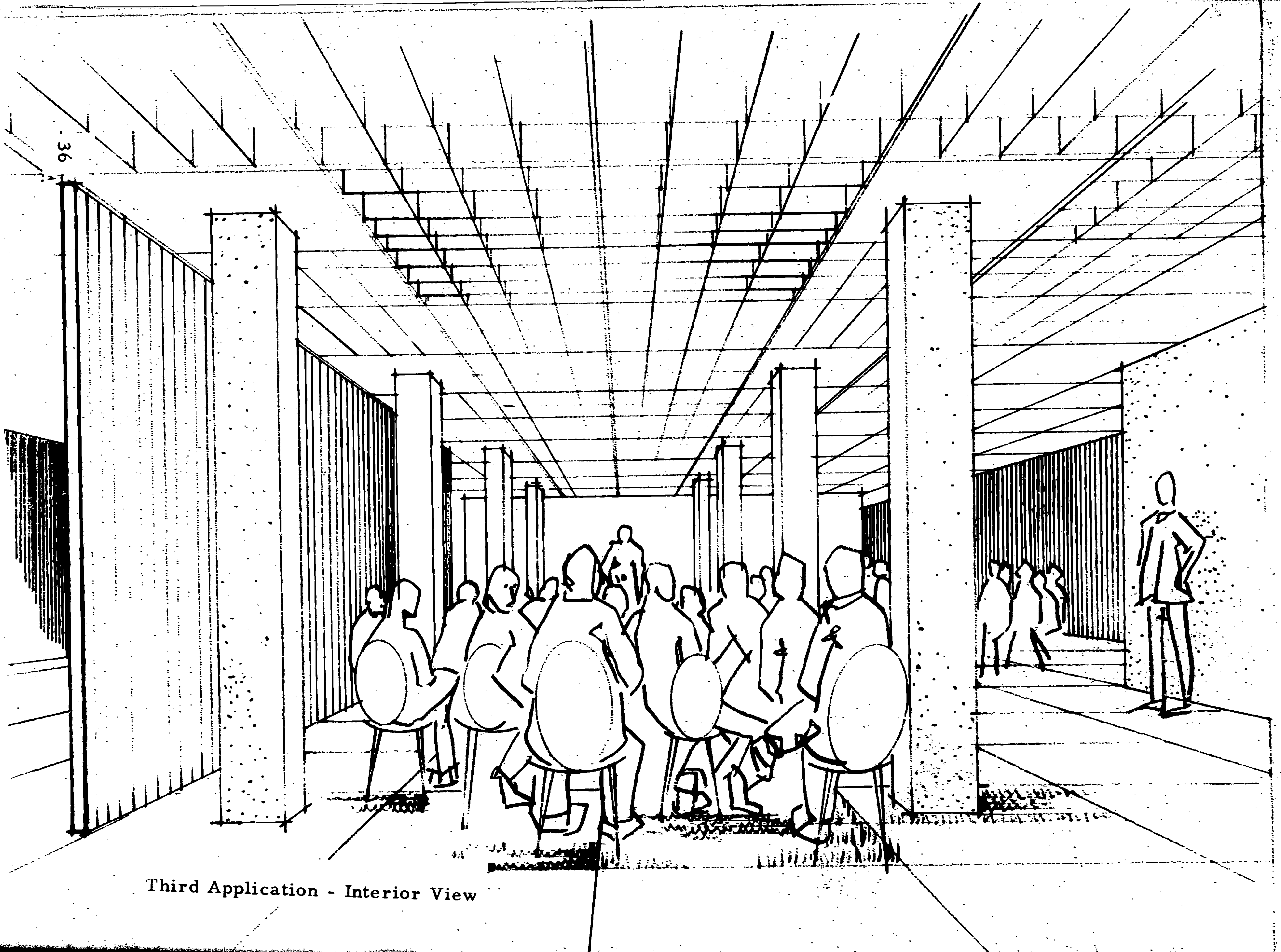
Third Application - Second Floor Plan



Third Application - Detail Plan



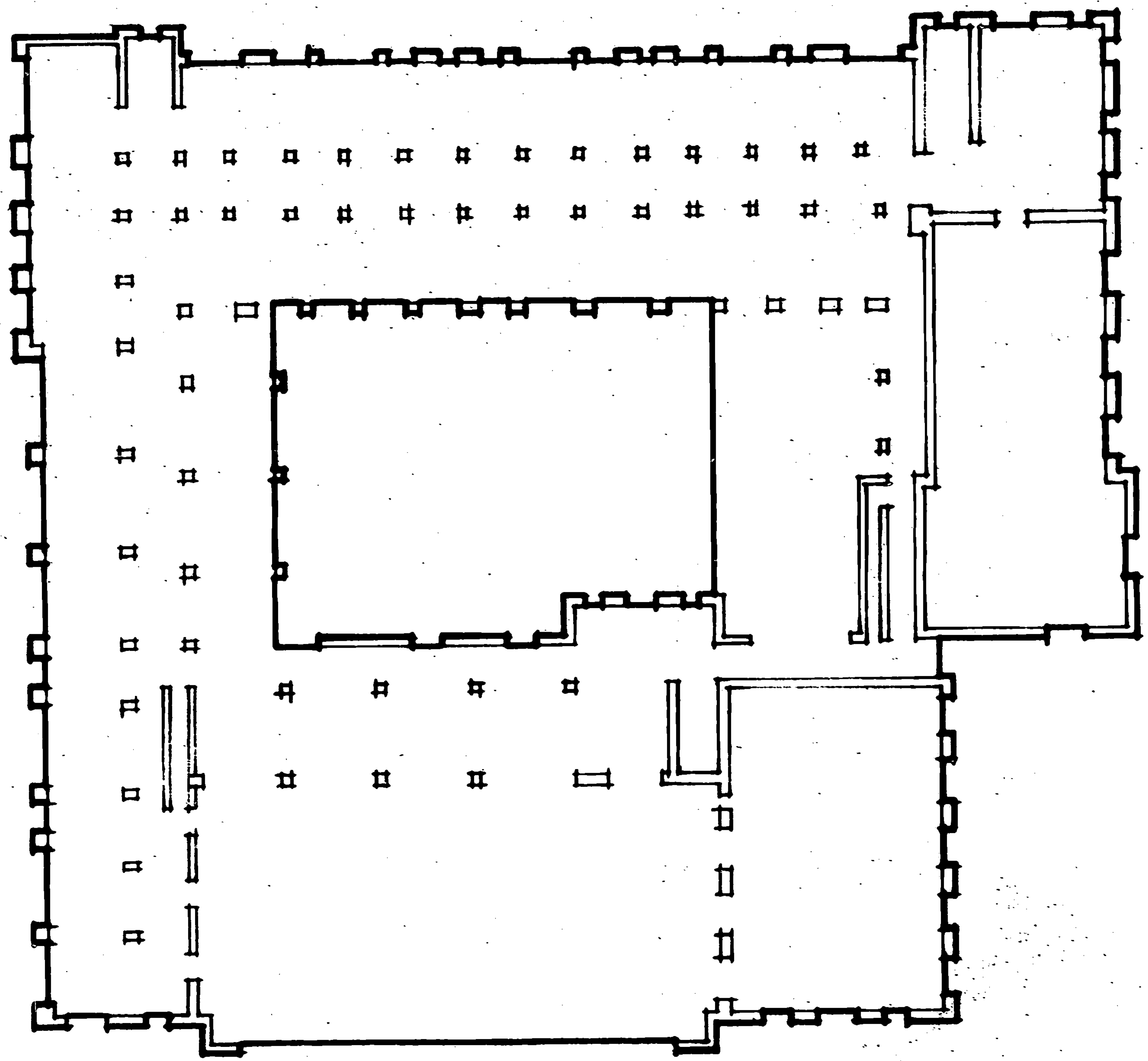
Third Application - Bird's Eye View



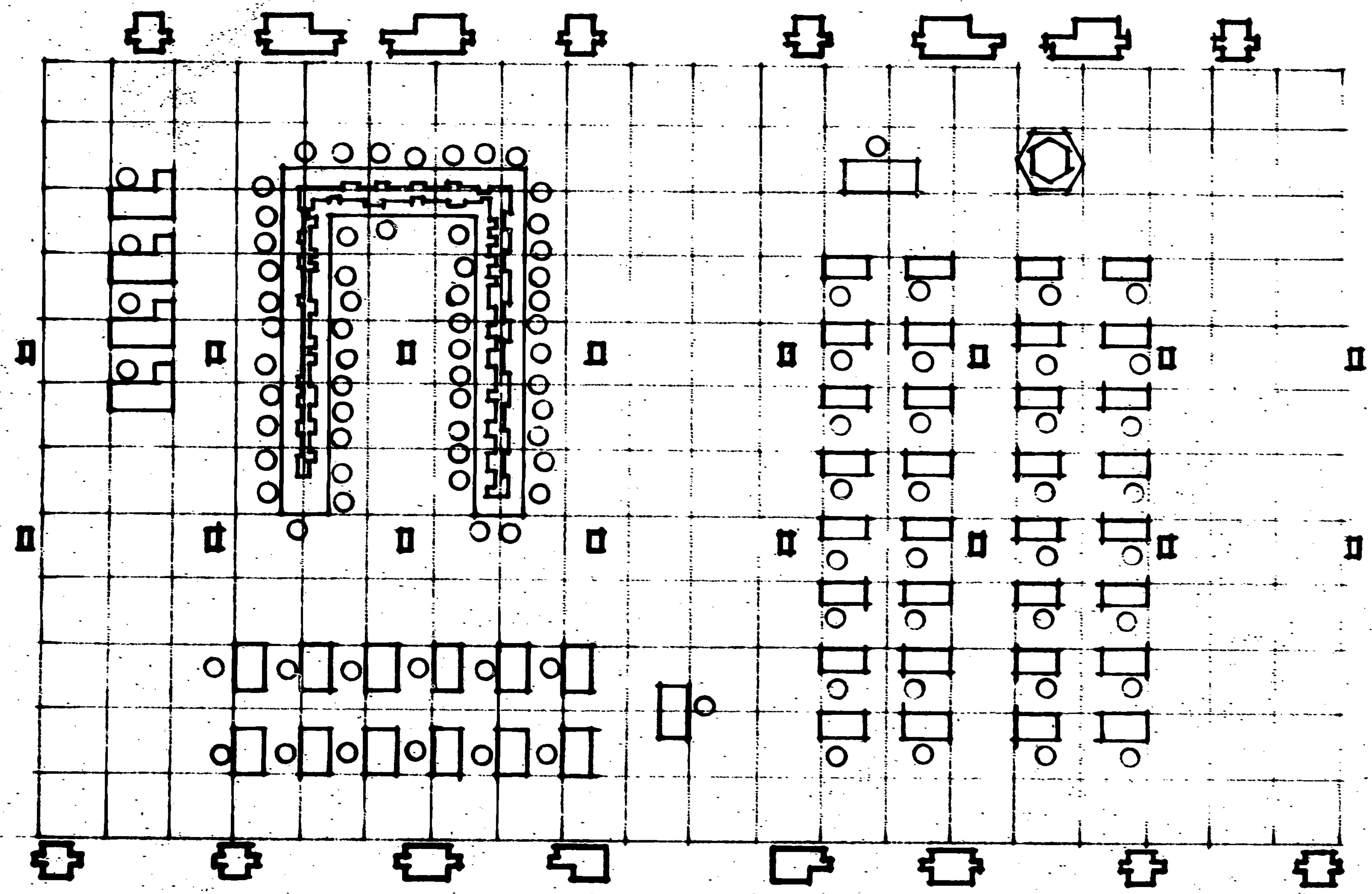
Third Application - Interior View

Fourth Application

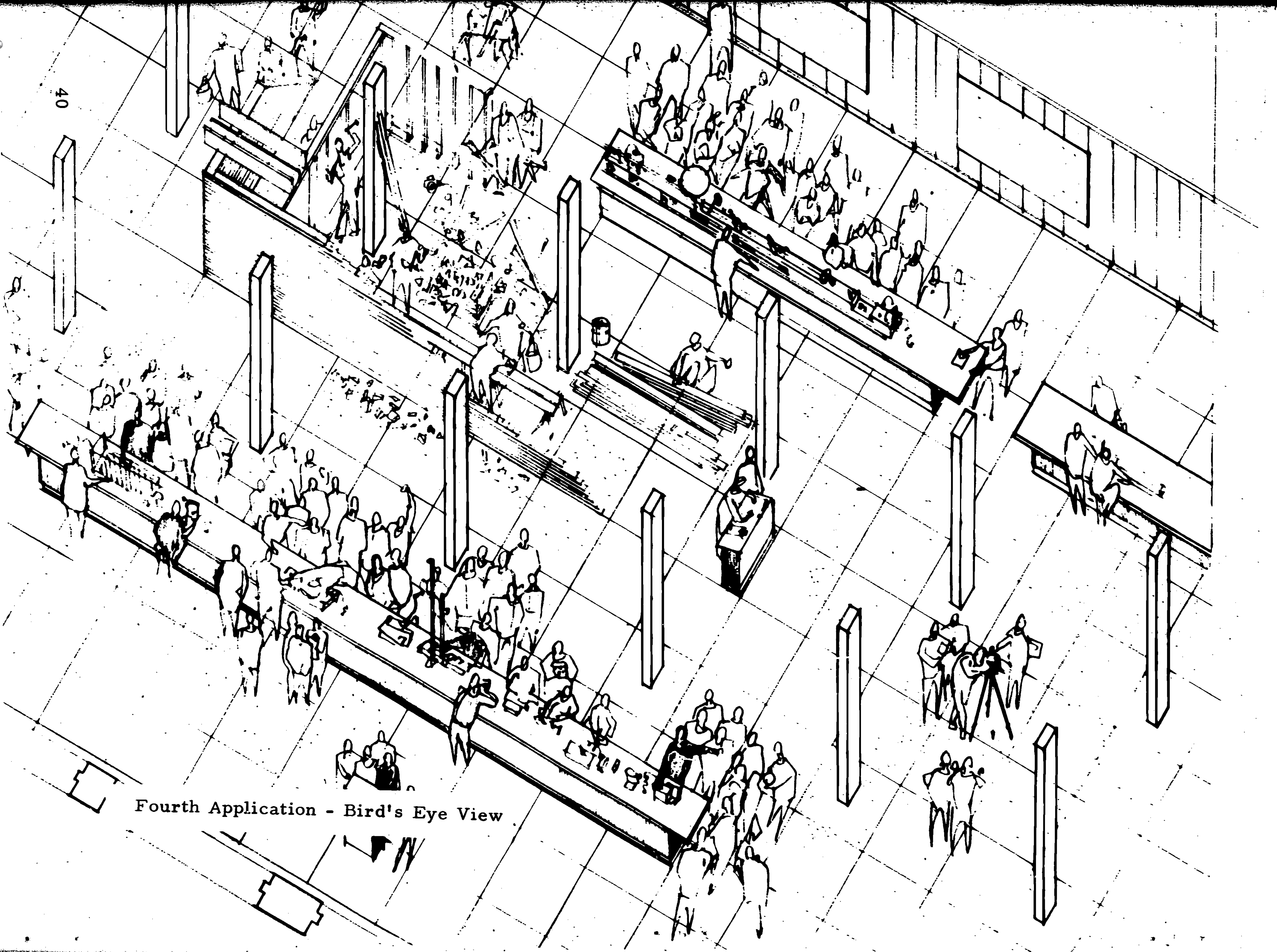
The final scheme shows a completely open space. In this type of space, activity definition can be achieved through the particular sets of equipment which have been pulled together temporarily for various student projects. In other words, definition no longer need be by class area. Student projects can spring up anywhere. Because this space is totally open, circulation can be considered to filter through the different activity areas; therefore, there may be no need to provide exterior or interior space specifically limited to corridor use.



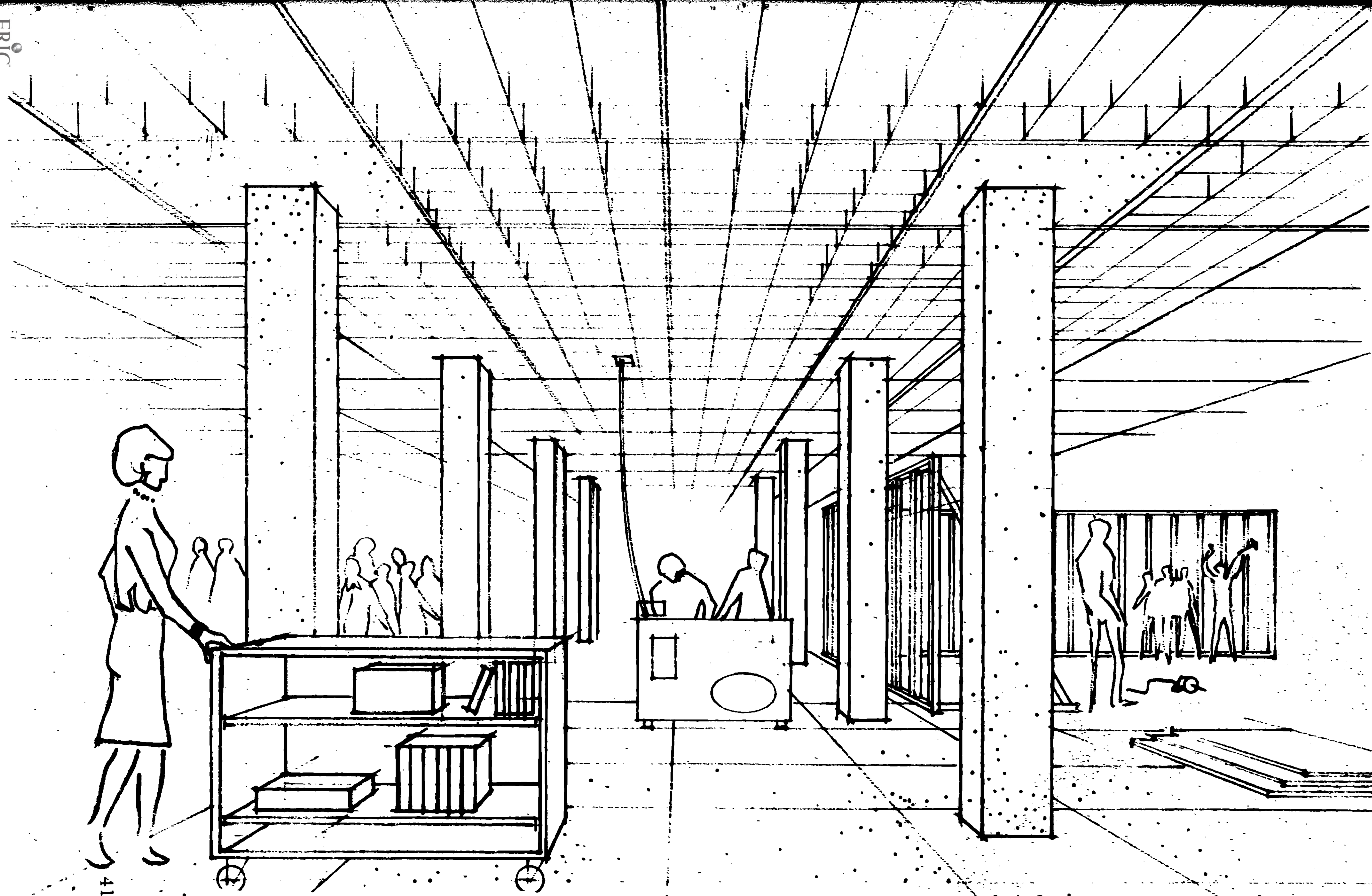
Fourth Application - Second Floor Plan



Fourth Application - Detail Plan



Fourth Application - Bird's Eye View



Fourth Application - Interior View

Advantages of an Environmental System

The environmental system that has been discussed and illustrated can provide a number of advantages to school systems such as Pittsburgh's. A high quality environment, which can satisfy the specific needs associated with any activity and yet not limit that activity as it changes or as it relates to any other activity, can be provided in most buildings that are available for educational use. Therefore, the system meets many of the requirements of education in a world of change.

The system provides every service required by educational activities today. These services can be supplied to the exact location of each activity and in the proper balance that best meets environmental needs associated with that activity. The services are supplied through standardized elements which can be produced in great quantity. Since the system utilizes mass production, every dollar spent for facilities brings a greater return in the quality of the system's components.

Each component of the system is independent of any other component and independent of the structural frame in which the system is placed. The environment is flexible because it can be modified almost at will. Also, it is possible to replace worn out or out-of-date components with a minimum of effort. This means that the system can be modified continually to take advantage of progress in environmental technology.

Because the system is independent of any structural frame, it can be installed in many different types of buildings. This means that both existing school buildings and buildings that are used temporarily for schools can be provided partially or totally with an environment that is nearer to the ideal that can be provided in a new school building. Independence of the environmental system from the structural frame also means that the system has a certain degree of portability.

This system provides a changeable environment for educators who must equip today's students with useful skills and knowledge for tomorrow's world. The word "change" probably characterizes the present age better than any other word. Knowledge about the world changes; skills that are necessary for gainful employment change; and subjects that are taught in schools change. It follows that educational facilities must be dynamic if educators are not to be hampered in their efforts to keep up with an evolving world.

A SCHOOL PLANNER'S GUIDE TO THE PITTSBURGH BUILDING CODE

5

Prepared By The Research Team
For A Comprehensive Concept
For Vocational Education
Facilities

CREDITS

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Preview to Unit Five, A School Planner's Guide to the Pittsburgh Building Code

Recommendations have been made in this study for vocational facilities that are open and flexible. Proposals for such space in vocational laboratories cannot be made without regard for restrictions set forth in local or national building codes. It is the purpose of this unit to report on a preliminary investigation of the Pittsburgh Building Code that was conducted in order to find potential conflicts between the recommendations of this study and the requirements of the Code. Although a study of the Code has to be specific to Pittsburgh, it may still be of interest to educators outside this area. In many ways, the Pittsburgh Building Code is similar to such nationally used Codes as the National Building Code, as recommended by the National Board of Fire Underwriters, and the Department of Labor and Industry's, Building Regulations for Protection from Fire and Panic.

In other units of this report, it is proposed that many vocational laboratories can be built without permanent walls. There are a number of limitations that most Codes place on the extent to which space in a school can be open and flexible. Among these limitations are: areas housing large amounts of combustible materials must be separated from other spaces with a minimum of two-hour fireproof construction; hazardous machinery must be isolated in some approved manner from students engaged in non-hazardous activities; there must be a sufficient number of visible exits from any area housing school students; and occasionally, there are limits to the size of open classroom space. These potential conflicts were discussed in preliminary interviews with officials of the Bureau of Building Inspection in Pittsburgh.

In general, it was found that there were no basic conflicts between the recommendations set forth in this study and requirements of the Pittsburgh Building Code. Large quantities of combustible materials can be stored in isolated warehouse areas to reduce the danger of fire in vocational laboratories. Hazardous activities and machinery can be separated from non-hazardous activities with wire-glass partitions. Since it is possible to assemble large groups of students in open laboratory space, careful attention must be paid to exit requirements of the Code and exits be provided on the basis of exit requirements for large assembly areas. Finally, it was found that although building codes in cities such as New York and Chicago limit the size of open classroom space, no such limitations appear in the Pittsburgh Building Code. On the basis of these preliminary interviews, it is possible to say that the proposals set forth in this study do not in any serious way conflict with the requirements of the Code.

This discussion cannot be regarded as the final statement about recommendations of this project and Code requirements. The officials of the Bureau of Building Inspection cannot be expected to commit themselves on the basis of preliminary discussions. Only as architectural and engineering drawings are prepared for specific projects can officials be called upon to deliver their final judgements.

Since plans for new facilities are still being formulated, it is believed that it would be useful to present the sections of the Pittsburgh Building Code that relate to school construction in a way that would emphasize the more pertinent requirements to school administrators and planners. This will provide educators with the opportunity to read and understand the Code quickly and to relate its requirements to new facility concepts as they are developed.

It should be emphasized from the beginning that the following material forms a guide to the Pittsburgh Building Code and in no way can be used in lieu of the Code. Because of its general application, this guide does not attempt to be responsible for every construction detail that appears in the Code. Although the order of topics has been set by their importance to school planning and does not follow the original order, section numbers have been retained for easy reference back to the Code.

City of Pittsburgh

Pennsylvania

DEPARTMENT OF PUBLIC SAFETY
BUREAU OF BUILDING INSPECTION
OFFICE OF THE SUPERINTENDENT

May 11, 1966

Mr. Don Carter
Pittsburgh Board of Education
% O.V.T. Center
635 Ridge Avenue
Pittsburgh, Pa. 15212

Dear Mr. Carter:

We have reviewed your assembly of data in the Pittsburgh Building Code, entitled "A School Planners Guide to the Pittsburgh Building Code".

It appears to have assembled the data necessary regarding schools and eliminate the necessity of searching through our Code to locate the data needed.

We have not proof read the various sections and would advise that when construction plans are made reference should be made from the Guide to the Code.

However, for the purposes of planning, this appears to be an excellent document.

Very truly yours,

J. Clyde Taylor

J. CLYDE TAYLOR,
Superintendent

JCT/s.

Table 5-A-Occupancy Separations

TABLE 5-A

REQUIRED OCCUPANCY SEPARATIONS IN BUILDINGS

LEGEND: 1—1-Hour Occupancy Separation.
2—2-Hour Occupancy Separation.
4—4-Hour Occupancy Separation.

OCCUPANCY GROUP:	A-2	A-3	A-4	A-5	A-6	B	C-1	C-2	D-1	D-2	D-3	D-3a	D-4	E	F	G
A-1 Assembly	2	2	2	2	2	2	2	2	4	4	2	2	2	2		4
A-2 Assembly		2	2	2	2	2	2	2	4	4	2	2	2	2		4
A-3 Assembly			2	2	2	2	2	2	4	4	2	2	2	2		4
A-4 Assembly				2	2	2	2	2	4	4	2	2	2	2		4
A-5 Assembly					2	2	2	2	4	4	2	2	2	2		4
A-6 Assembly						2	2	2	4	4	2	2	2	2		4
B School							2	2	4	4	2	2	2	2		4
D Commercial, Industrial and Office																
D-1 (Extra Hazardous)										4	4	4	4	4		4
D-2 (Hazardous)											4	4	4	4		4
D-3 (Light Hazard)											*	2	2	2		4
D-3A (Sub-Light Hazard)														1		4
D-4 (Non-Hazardous)											*			1		4

*Every room containing a central heating plant shall be separated from the remainder of the building by a "2-hour occupancy separation" as defined in Sec. 508.

NOTES

1. Not more than two (2) openings, protected by self-closing, Underwriters' "A" Label, or 3-hour fire-resistive doors, kept normally closed, permissible between public storage garages and Occupancies of Groups "A", "B", "C" and "D-4". No single opening shall exceed twenty-one (21) square feet in area.

2. Fire-resistive vestibules with a least dimension of eight (8) feet, and of not less than 4-hour fire-resistive construction, and with all openings protected on both sides of the wall with an Underwriters' "B" Label, or a 1½-hour fire-resistive automatic or self-closing door, will be permitted.

OCCUPANCY CLASSIFICATION

Sec. 501. (b) Every building whether existing or hereafter erected shall be classified by the Superintendent according to its use or the character of the occupancy as one of the Occupancy Groups "A" to "G", inclusive, as defined in Chapters 6 to 12, inclusive, respectively, and as follows:

OCCUPANCY CLASSIFICATION

A. ASSEMBLY—Primary and intended use for assembly of persons for the purpose of amusement, entertainment, education, instruction, worship, transportation, recreation, sports, dining or similar purposes, with admission either public or restricted.

A-1 Capacity 1,001 or more.
A-2 Capacity 751-1000.
A-3 Capacity 501-750.
A-4 Capacity 251-500.
A-5 Capacity 76-250.
A-6 Capacity 75 or less.

(A room having a capacity of not more than 75 persons shall not be construed as being within an "A" Occupancy Classification if the assembly of persons therein is incidental or accessory to another occupancy classification.)

B. SCHOOL—Primary and intended use for instruction, recreation and education.

D. COMMERCIAL, INDUSTRIAL AND OFFICE

D-1. EXTRA HAZARDOUS—Occupancy involving the handling, manufacture, processing or use of highly flammable, explosive or unstable materials.

D-2. HAZARDOUS—Occupancy involving the handling, processing, manufacture, use or storage of flammable or explosive materials.

D-3. LIGHT HAZARD—Occupancy involving Class 1 garages or the handling, processing, manufacturing, use of storage of combustible but not highly flammable or explosive materials.

D-3A. SUB-LIGHT HAZARD — Occupancy of Class 2 garages

D-4. NON-HAZARDOUS—All other occupancies under this section involving lesser hazards than those stated under "D-1", "D-2" and "D-3".

F. ACCESSORY, INCIDENTAL OR MISCELLANEOUS OCCUPANCY—Accessory occupancy in connection with any of the other defined occupancies, but housed in a separate structure not exceeding the ground area of the building of primary use, and incidental and miscellaneous occupancy in connection with the use of land.

G. WORKING STAGES—In connection with Group "A" Occupancy. (Special Requirements.)

Occupancy Separations

Sec. 506. When portions of a building or structure containing more than one classification of occupancy have each classification of occupancy separated from all other classifications by unpierced occupancy separations, as shown in Table 5-A, each portion thus separated shall be considered as a separate building or structure, and limitations given for separate buildings shall govern. Buildings and structures not so separated shall be deemed as containing joint or mixed occupancy and governed by the most restrictive of the various limitations of the occupancies.

Kinds of Occupancy Separations

Sec. 507. Occupancy separations shall be vertical, horizontal, or both, or where necessary, of such other form as may be deemed necessary by the Superintendent to afford complete separation between the various occupancy areas in the building or structure.

Types of Occupancy Separations

Sec. 508. Occupancy Separations shall be classified as "4-hour", "2-hour" and "1-hour", defined as follows:

(1) A "4-HOUR" occupancy separation shall be of not less than 4-hour fire-resistive construction, and all materials of such construction shall be incombustible. 4-hour separations shall have no openings therein except where noted as allowable in the footnotes for Table 5-A.

(2) A "2-HOUR" occupancy separation shall be of not less than 2-hour fire-resistive construction and all materials of such construction shall be incombustible. All openings in walls forming 2-hour separations shall be protected on one side of the wall by Underwriters' "B" Label, or 1½-hour fire-resistive doors. Such doors shall be self-closing doors kept normally closed, or automatic fire doors.
The total width of all openings in any one story of a 2-hour separation wall shall not exceed 20 per cent of the length of the wall and no single opening shall have an area greater than 100 square feet.
All openings in floors forming a part of a 2-hour separation shall be protected by vertical enclosures extending above and below such opening. Walls of such enclosures shall be of not less than 2-hour fire-resistive construction, and all openings in such walls shall be protected on one side thereof by Underwriters' "B" Label, or 1½ hour fire-resistive doors, self-closing and kept normally closed, or automatic fire doors.

(3) A "1-HOUR" occupancy separation shall be of not less than 1-hour fire-resistive construction. All openings in such 1-hour separations shall be protected by self-closing, Underwriters' "C" Label, or equivalent fire-resistive doors kept normally closed, or automatic fire doors.

Table 5-B-Occupancy Height and Structural Limitations

TABLE 5-B

HEIGHT AND STRUCTURAL LIMITATIONS FOR THE VARIOUS TYPES OF OCCUPANCY
(Maximum Total Number of Stories for a Building in Which Any Occupancy Is Permitted)

Chapter	OCCUPANCY CLASSIFICATION		TYPE I Fireproof CHAPTER 15	TYPE II Fire-Resistive CHAPTER 16	TYPE III Protected or Heavy Timber CHAP. 17	TYPE IV Incombustible CHAP. 18
6	GROUP A-1	ASSEMBLY	No Limit	No Limit	1 Story	Not Allowed
	GROUP A-2	ASSEMBLY	No Limit	No Limit	2 Stories**	Not Allowed
	GROUP A-3	ASSEMBLY	No Limit	No Limit	2 Stories**	1 Story
	GROUP A-4	ASSEMBLY	No Limit	No Limit	2 Stories**	1 Story
	GROUP A-5	ASSEMBLY	No Limit	No Limit	2 Stories**	1 Story
	GROUP A-6	ASSEMBLY	No Limit	No Limit	3 Stories	3 Stories
7	GROUP B	SCHOOL	No Limit	No Limit	2 Stories	2 Stories
9	GROUP D	COMMERCIAL, INDUSTRIAL AND OFFICE				
	GROUP D-1	(Extra Hazardous)	(See Sec. 902(a)	(See Sec. 902(a)	Not Allowed	Not Allowed
	GROUP D-2	(Hazardous)	5 Stories (See Sec. 902(b)	3 Stories (See Sec. 902(b)	Not Allowed	Not Allowed
	GROUP D-3	(Light Hazard)	No Limit	5 Stories	3 Stories(9)	1 Story ***
	GROUP D-3a	(Sub-Light Hazard)	No Limit	No Limit	5 Levels above grade**	5 Levels above grade (10)
	GROUP D-4	(Non-Hazardous)	No Limit	No Limit	5 Stories	3 Stories

NOTES TO TABLE 5-B

1. Whenever height limitations of the Zoning Ordinance are more restrictive than the limitations set forth in the above table, the more restrictive limitations shall govern.

4. In Occupancy Groups "A", each balcony shall be considered as one story.

Occupancy Separations

Sec. 506. When portions of a building or structure containing more than one classification of occupancy have each classification of occupancy separated from all other classifications by unpierced occupancy separations, as shown in Table 5-A, each portion thus separated shall be considered as a separate building or structure, and limitations given for separate buildings shall govern. Buildings and structures not so separated shall be deemed as containing joint or mixed occupancy and governed by the most restrictive of the various limitations of the occupancies.

Note:

Classrooms shall be considered Group B occupancy and vocational shops will be considered Type D-3 occupancy.

Table 28-B-Occupancy by Square Feet Per Person

TABLE 28-B

MAXIMUM NUMBER OF OCCUPANTS BASED ON THE NET FLOOR AREA

TYPE OF OCCUPANCY	Square Feet Per Person
Theaters, sports arenas and similar places of amusement	6
Dance halls, lodge halls, lecture rooms and similar occupancies	7
Main exercise rooms of gymnasiums	15
Bowling Alleys (exclusive of the area occupied by the alleys)	10
Dining areas	12
Vocational shops and similar occupancies in schools	100
Court rooms and other public rooms in public buildings (exclusive of seating)	40
Offices up to 400 square feet in area	100
Offices more than 400 square feet in area	60
Drafting or engineering rooms	60
Class rooms	20
Laboratories	100
Libraries and reading rooms	30
Standing room areas for any class of occupancy	3
Factories for light manufacturing, Occupancy Classification D-2, D-3, D-4	80
Factories for heavy manufacturing, garages, except Class 2 garages, warehouses, etc., and first floor of Class 2 garages	300
Power houses, boiler rooms, etc.	500

NOTES

1. Theaters, churches and other assembly rooms having fixed seats shall be computed upon the actual number of seats plus all standing room areas, or areas which could be used as standing room under the provisions of this Code.
2. Churches and other assembly rooms having pews or benches shall be computed on the basis of eighteen (18) inches of pew or bench per person.
3. "Net floor area" shall be taken to mean all usable floor, including all areas occupied by equipment or furnishings, but not including corridors, toilet rooms and such other accessory rooms as may be provided.

Table 28-A-Occupancy Exitway
Limitations

TABLE 28-A

MAXIMUM NUMBER OF OCCUPANTS PERMITTED FOR EACH UNIT WIDTH OF EXITWAY *

Values shown are for doorways and stairs. Required units of width may be decreased: 20% for corridors and ramps up to 10% slope; 10% for ramps having 10% to 16-2/3% slope.

OCCUPANCY CLASS		CONSTRUCTION TYPES Type I	Type II	Type III	Type IV	Type V	Type VI	Type of Stairs	Maximum Distance to Exitway
A-1	Theater	62	62					A	100 ft.
	Non-Theater	67	67					A	100 ft.
A-2	Theater	57	57					A	100 ft.
	Non-Theater	67	57	50				A	100 ft.
A-3	Theater	50	50		50			A	100 ft.
	Non-Theater	60	60	50	50			A	100 ft.
A-4	Theater	40	40		40			A	100 ft.
	Non-Theater	50	50	40	40	40		A	100 ft.
A-5	Theater	40	40		33			A	100 ft.
	Non-Theater	50	50	33	33	33	33	A	100 ft.
B	First Floor	80	80	70	70	60	50	A	100 ft.
	Other Floors	60	60	50	50			A	100 ft.
D-1**									
D-2	Protected	80	80					C	125 ft.
	Unprotected	40	40					C	75 ft.
D-3 and	Protected	100	100	80	80	80		C	150 ft.
D-3a	Unprotected	60	60	60	50	50		C	100 ft.
D-4	Protected	150	150	100	150	100		C	150 ft.
	Unprotected	150	150		150			C	150 ft.
	Unprotected			60		40		C	100 ft.
E -	(No Limit)								
F -	(No Limit)								
G		33							

*Exits for Assembly Room above third floor shall require the approval of the Board of Standards and Appeals.

**As may be required by the Board of Standards and Appeals.

NOTES

1. Theater in this table means an Assembly Room with fixed seats, customarily darkened during performances. Theaters shall have not less than three (3) exits as remote from each other as practicable.

2. "Protected" indicates that materials which are combustible are properly protected by a sprinkler system, or such other automatic types of system or systems as may be necessary by reason of the type of hazard.

3. Add 25% of the second floor and 85% of each balcony to the full capacity of the first floor to determine the required number of units of exitway at grade, where such floors are permitted to exit through common first floor exitways.

4. Where the occupancy is mixed, the more stringent requirements shall govern.

Minimum Exitway Requirements

Sec. 2803. The minimum number of exitways to be provided from each Occupancy Classification shall be as follows:

1. OCCUPANCY CLASSIFICATIONS GROUP "A"— Two (2) exitways accessible from each story or mezzanine as remote from each other as possible, the location of all exitways to be subject to the approval of the Superintendent.

Group B Occupancies (School)

Group "B" Occupancies (School)

Group "B" Occupancies Defined

Sec. 701. Group "B" Occupancies shall be the primary and intended use of any building or structure or any part thereof for the purpose of education, instruction or recreation.

Construction and Height

Sec. 702. The Allowable Types of Construction and Limits of Height for Buildings and Structures of Group "B" Occupancies are set forth in Table 5-B.

Basis of Exit Requirements

Sec. 703. For the determination of exit facility requirements, rooms in Group "B" Occupancies shall be classified as follows:

1. Lecture Rooms .... 7 sq. ft. per person
2. Main Exercise Rooms of Gymnasiums .... 15 sq. ft. per person
3. General Classrooms and Recreation Rooms .... 20 sq. ft. per person
4. Museums, Libraries, etc. .... 30 sq. ft. per person
5. Shops, Vocational, etc. ....100 sq. ft. per person

(Room capacity shall be determined by dividing the room areas by the appropriate capacity unit.)

Places of Assembly for schools shall not be placed above the first floor level nor below the grade level unless approved by the Board of Standards and Appeals.

Light and Ventilation

Sec. 704. All portions of Group "B" Occupancies shall be provided with light and ventilation, either natural or artificial, as required in Chapters 42 and 43 of this Code.

Heating Plant Separation

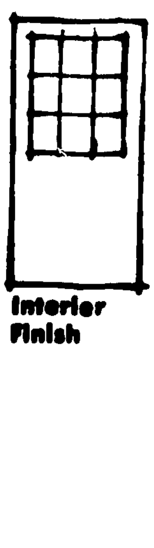
Sec. 705. Every room containing a central heating plant shall be separated from the remainder of the building by a "2-hour Occupancy Separation," as defined in Sec. 508.

Flammable or Explosive Materials

Sec. 706. No highly flammable or explosive materials, excepting only such as are normally used in school laboratories, shall be stored in any Group "B" Occupancy. The use and handling of fuel oil shall comply with recognized safe practice. The recommendations of the National Board of Fire Underwriters shall be considered as a guide to safe practice.

Enclosure of Vertical Openings

Sec. 707. Elevator shafts, vent shafts and other vertical openings which permit the passage of fire or smoke through more than one floor shall be enclosed in buildings of Types I, II or III Construction, as defined in Chapters 15, 16 and 17 of this Code, with the following exception:



Stair towers may have wire glass panes in Class "B" fire doors not to exceed one hundred (100) square inches and not more than twelve (12) inches in one direction. The total area of all panes shall not exceed seven hundred fifty (750) square inches. All parts of the frame supporting the wire glass shall be of incombustible material.

Interior Finish

Sec. 708. In Group "B" Occupancies interior finish shall be of noncombustible or noninflammable materials which shall not develop toxic or noxious gases when exposed to heat or flames.

2. OCCUPANCY CLASSIFICATIONS "B," "C-1," AND "G"—Two (2) exitways accessible from each story or mezzanine as remote from each other as possible.

Group A Occupancies (Assembly)

Group "A" Occupancies (Assembly)

Group "A" Occupancies Defined

Sec. 601. (a) Group "A" Occupancies shall be the primary and intended use of any building or structure for the purpose of assembly of persons for amusement, entertainment, education, instruction, worship, transportation, recreation, sports, dining or similar purposes, with admission either public or restricted.

Sec. 601. (b) For the purpose of defining structural and height limitations, Group "A" is divided into the following divisions:

A-1	Capacity	1,001 or more
A-2	Capacity	751-1,000
A-3	Capacity	501-750
A-4	Capacity	251-500
A-5	Capacity	76-250
A-6	Capacity	75 or less

(A room having a capacity of not more than 75 persons shall not be construed as being within an "A" Occupancy Classification if the assembly of persons therein is incidental or accessory to another occupancy classification.)

Any classroom with an occupancy of 50-75 students shall be considered Group A-6 occupancy.

Sec. 601. (c) CONSTRUCTION BELOW GRADE. A place of assembly in a building of non-fire-resistive construction may not have any part of its floor more than 12 feet below grade, and if in a fire-resistive building may not have any part of its floor more than 20 feet below grade.

Construction and Height

Sec. 602. The Allowable Types of Construction and Limits of Height for Buildings and Structures of Group "A" Occupancies are set forth in Table 5-B.

Working Stages

Sec. 603. For definitions, specific limitations and requirements for Working Stages, see Chapter 12, Occupancy Group "G".

Interior Finish

Sec. 604. Interior Finish of Group "A" Occupancies shall be of non-combustible or non-flammable materials which shall not develop toxic or noxious gases when exposed to heat or flame. Combustible material may be used for decorative purposes if rendered flame-proof. Non-permanent flame-proofing shall be tested each year and renewed whenever necessary.
EXCEPTION: Wood wearing surface for floors shall be permitted. Wood panelling on walls shall be permitted, provided that when the applicable area in any room exceeds 5,000 square feet the wood shall be treated to render it fire-retardant.

Light and Ventilation

Sec. 605. All portions of Group "A" Occupancies shall be provided with light and ventilation, either natural or artificial, as required in Chapters 42 and 43 of this Code.

Enclosure of Vertical Openings

Sec. 606. Elevator shafts, vent shafts and other vertical openings which permit the passage of fire or smoke through more than one floor shall be enclosed in buildings of Types I, II and III Construction, as defined in Chapters 15, 16 and 17 of this Code.

Group A-6 Occupancies

Sec. 607. Group A-6 Occupancies shall comply with the requirements of this Code for D-4 Occupancies and shall be exempt from all of the provisions of this and other chapters which apply to assembly occupancies except that each A-6 occupancy shall comply with the requirements set forth in Tables 5-A and 5-B and shall be provided with at least two means of egress.

Group D Occupancies (Commercial, Industrial, and Office

Group "D" Occupancies (Commercial, Industrial and Office)

Group "D" Occupancies Defined

Sec. 901. (a) COMMERCIAL, INDUSTRIAL AND OFFICE. Group "D" Occupancies shall be the primary and intended use of any building or structure or any part thereof for commercial, industrial, office or like purpose.

"D-3" and "D-3a"

Sec. 901. (d) Division "D-3" (Light Hazard) shall include occupancies involving the manufacture, assembling, warehousing, use, sale or storage of combustible but not highly flammable products and materials. The Board of Standards and Appeals shall have authority to reclassify under Occupancy Group D-3 any building to be used for the storage, warehousing, manufacturing, processing, use or sale of hay, straw, broom-corn, hemp, tow, jute, sisal, excelsior, kapok, hair, oakum, artificial flowers, matches, mattresses, rubber, cork, brooms, carpet linings, paper, pasteboard, feathers or cotton or to be occupied as a woodworking plant, a planing mill, drying rooms or for an occupancy of equal fire and life hazard, if such building is equipped with an approved automatic sprinkler system.

"D-4"

Sec. 901. (e) Division "D-4" (Non-Hazardous) shall include occupancies not included under Divisions "D-1", "D-2" "D-3" or "D-3a" and involving lesser hazards than those stated therefor.

"D-3", "D-3a" and "D-4" —Construction and Height

Sec. 902. (c) The allowable types of construction and the limits of height for buildings of Divisions D-3, D-3a and D-4 shall be as set forth in Table 5-B.

Light and Ventilation

Sec. 905. All buildings, structures and parts thereof of Group "D" Occupancy customarily used by human beings shall be provided with adequate light and ventilation by means of windows or skylights or shall be provided with adequate artificial light and a mechanically operated ventilation system as required by Chapters 42 and 43. "D-1" and "D-2" Occupancies shall have such forced ventilation as may be necessary or required by the special hazard in each case and as determined by the Board of Standards and Appeals.

Enclosure of Vertical Openings

Sec. 906. Elevator shafts, vent shafts and other vertical openings which will permit the passage of fire or smoke through more than one floor shall, in buildings of Types I, II and III Construction, be enclosed as provided in Chapters 15, 16, 17 and 25 of this Code.

EXCEPTION: Escalators (not required means of exit) in fully sprinklered buildings of Types I and II Construction with D-3, D-3a or D-4 Occupancy need not be fully enclosed under the following conditions:

(a) When substantial non-combustible curtain boards or draft stops are provided below each ceiling pierced and extend at least 24 inches below the ceiling; and

(b) A line of sprinklers, supplied by a riser not supplying any other sprinklers, is arranged outside of curtain board or draft stop to provide an effective water curtain completely around the under side of each floor opening.

4. OCCUPANCY CLASSIFICATIONS "D-2," "D-3" AND "D-4"—Every story that exceeds 3,000 square feet of Types I, II or IV Construction, or occupied by more than seventy-five (75) persons, or of Types III or V Construction, or occupied by fifty (50) or more persons, shall have two (2) exitways accessible from each story or mezzanine.

Every basement or cellar, or story below grade, larger than six hundred (600) square feet in area, shall have at least two (2) means of egress, both of which shall be accessible from any portion of said basement or cellar, and one of which may be located and constructed in accordance with requirements which may be set by the Superintendent if an exit complying with all of the requirements of this Chapter cannot be provided.

TECHNICAL APPENDIX

Definitions of Certain Terms

Stairs and Exits

Enclosure of Vertical Openings

Special Requirements for Group "A" Occupancies

Table 14-A Fire Resistive Requirement for Construction Types

Construction Types

Fire Zoning Regulations

Definitions of Certain Terms

Definitions of Certain Terms

Sec. 401. As used in this Code, certain terms shall be defined as follows:

ALTERATION—Any change, rearrangement, addition or modification in construction.

BASEMENT—A story partly below ground of which one-half or more of the height is above the average level of the adjoining ground.

BUILDING—A structure which encloses space. Any portion of a building separated from any other portion by an unpierced fire-resistant wall extending from the lowest floor to the underside of the roof shall be construed as being a separate building. EXISTING BUILDING—A building in existence at the time any official action of the Bureau of Building Inspection in relation thereto is necessary.

CELLAR—A story of which more than one-half the height is below the average level of the adjoining ground.

COMBUSTIBLE—Capable of igniting and continuing to burn or glow at or below a temperature of 1200 degrees F.

COURT—An open, unoccupied space bounded on two or more sides by the walls of a building. INNER COURT—A court which does not extend to a thoroughfare, to a side yard having a width of three feet or more or to a front or rear yard. OUTER COURT—A court which extends to a thoroughfare, to a side yard having a width of three feet or more or to a front or rear yard. (See, also, definition of court, as applied to exitways, in Sec. 2801.)

CUBIC CONTENT, CUBE OR CUBAGE—The actual cubic space enclosed within the outer surfaces of the outside or enclosing walls and contained between the outer surfaces of the roof and 6″ below the finished surfaces of the lowest floors. (The standard cubic contents does not include the cube of courts or light shafts open at the top or the cube of outside steps, cornices, parapets, open porches or loggias.)

DEAD LOAD—The weight of the structure.

EXISTING BUILDING—See Building.

FIRE RESISTIVE—Ability to resist fire and to prevent its spread, in accordance with Sec. 302(a) 5(b).

FLAMEPROOF MATERIAL—Any non-structural or decorative material, such as fabrics, composition boards, cardboard and paper products, or any other material which, in its untreated form, is readily combustible, shall be considered flameproof only if after suitable treatment it is found not to burst into flame or support combustion when subjected to the flame of a gasoline torch applied to the edge of said material for thirty seconds. Any wood which meets the requirements of Sec. 302(a) 5(c) shall be considered flameproof.

FLAMMABLE—Same as COMBUSTIBLE.

FLOOR AREA—The area included within surrounding walls of a building exclusive of vent shafts and courts.

GARAGES—Class 1 garages are bus or truck garages and other garages, except Class 2 and Class 3, in which more than three motor vehicles are housed or kept and or in which repairs involving open flames, spark emitting devices or highly heated parts are made. Class 2 garages are open air parking garages without basements for parking of passenger cars only, with parking lanes not less than 8′0″ wide and with vehicular entrances and exits not to exceed seven (7) feet in height. Class 3 garages are all other type passenger car garages not included in Class 1 or Class 2 garages and shall have a floor area not in excess of three car capacity. They shall be classed as Group F for occupancy use.

INCOMBUSTIBLE—Same as NON-COMBUSTIBLE.

INFLAMMABLE—Same as FLAMMABLE.

LIVE LOAD—Any load imposed or capable of being imposed on a structure other than the loads of the structure itself.

MEMBERS, PRIMARY AND SECONDARY—In the main structural framework of buildings, primary members shall be construed to include any steel member used as a column, a grillage beam or to support masonry walls or masonry partitions, including trusses, isolated lintels spanning an opening of eight (8) feet or more, and any member required to brace a column, or a truss, or to support two hundred (200) or more square feet of floor or roof area. Secondary members shall be construed to include all other steel members, including filling-in beams of floor and roof system, which individually support less than 200 square feet of floor or roof area.

NON-COMBUSTIBLE—Incapable of igniting and continuing to burn or glow at or below a temperature of 1200 degrees F.

NON-CONFORMING—Not in compliance with one or more of the provisions of this Code but in existence since prior to the enactment thereof.

NON-FLAMMABLE—Same as NON-COMBUSTIBLE.

OCCUPANCY—The purpose for which a building or part thereof is used or intended to be used. Change of occupancy shall mean a change from one occupancy classification to another and shall not be construed as meaning a change of user or occupant. Mixed Occupancy shall mean the use of a building for more than one occupancy classification.

PENTHOUSE—A structure built above a roof, limited in use to the housing of machinery, mechanical equipment and stairways. A penthouse shall not be construed as a story.

REPAIR—The reconstruction or renewal of any part of an existing building for the purpose of its maintenance.

STORY—That portion of a building between the floor and the ceiling of any occupied level having a minimum height of six (6′) feet and eight (8″) inches. For the purpose of height regulation, any basement, cellar, attic or penthouse not intended for use as part of the primary occupancy of the building or for any other primary occupancy shall not be classified as a story.

STRUCTURE—Any piece of work which is built or constructed.

THOROUGHFARE—A street, road, alley, way or other space customarily used for travel.

VENEER—A facing of brick, stone, concrete, tile, metal, wood, glass or the like attached to a wall. Veneer shall not be calculated as contributing to the strength of a wall.

Stairs and Exits

Stairs and Exits

General— Sec. 2801. All buildings hereafter erected except buildings of Groups "E" and "F" Occupancies shall have exitways as herein provided for.

Definitions EXITWAY shall mean any required means of direct egress in either a horizontal or vertical direction leading to a thoroughfare.

CORRIDOR wherever used in this Chapter shall be synonymous with passageway, hallway and similar designations for horizontal travel from or through subdivided areas. For fire protection see Footnote (16) to Table 14-A.

HORIZONTAL EXITWAY shall mean one or more protected openings through or around a fire wall or fire partition, or one or more bridges connecting two buildings. Where horizontal exits are employed, provisions shall be made to eventually reach grade level.

COURT, as applied to exitways, shall mean a space open to the sky, or a properly enclosed corridor. Exit courts shall lead directly to a thoroughfare. (See Sec. 2818 (e).

UNIT OF WIDTH shall mean the required width of a path of travel either horizontally or vertically, for one person or a single line of persons to exit from a building or from any of its parts. All units of width shall be unobstructed by railings or by doors when in an open position.

ENCLOSURES—The construction of enclosing walls for the various types of buildings in which they occur is regulated by Part V of this Code.

RAMPS—Wherever stairs are mentioned, ramps may be substituted. Except as stated in Sec. 2815, ramps shall comply with all of the requirements for stairs.

Exitway Capacity Sec. 2802. Exitway capacity shall be based upon the number of persons to be accommodated, the type of occupancy, and the probable hazard due to fire or panic by reason of the type and method of construction of the structure.

Units of exitway shall be provided in accordance with Table 28-A. When the number of persons to be accommodated is not fixed in a manner satisfactory to the Superintendent, the Superintendent shall require exitways to be provided based upon the character of the occupancy and the number of occupants per square foot of net floor area devoted to a particular purpose as set forth in Table 28-B. Such action by the Superintendent shall not be construed as relaxing in any manner whatsoever the requirements of Table 28-A and the total number of occupants permitted in any structure or any of its parts at any one time shall be the maximum number that can be accommodated by the exitway capacity as shown in Table 28-A.

Unit of Width

Sec. 2805. The unit of width shall be 20 inches, except that in exitways less than 2½ units wide the width of units and half units shall be as shown in the following Table 28-C. Credit as exitway width shall not be given for any fractional part of a unit other than one-half.

"TABLE 28-C"

	Doorways and Stairs	Corridors
1 Unit	24 inches	30 inches
1½ Units	32 inches	36 inches
2 Units	40 inches	44 inches
2½ Units	50 inches	50 inches

More than 2½ Units—Add ten (10) inches for each ½ unit.

General Requirements for Stairways

Sec. 2808. The requirements for stairs apply to all stairways except inter-communicating and similar stairways which do not constitute exitways, and which are so located and arranged as not to be subject to use as exitways. No provision of this section shall be construed as waiving the requirements for enclosures to prevent the spread of fire and smoke. For multistory buildings, stairway requirements are non-cumulative.

All new stairways (including platforms, landings, etc., used in connection therewith) in buildings three (3) stories or more in height, and in all buildings of fire-resistive construction shall be of not less than Type IV, incombustible construction, throughout. Handrails are exempted from this requirement. Treads of stairs, risers and landing floors shall be unpierced. Wood stairs, permitted in Types III and V Construction, shall have the soffits protected by 1-hour fire-resistive ceiling construction. The space beneath the bottom run of stairs of combustible construction shall not be used for closets or like purposes.

There shall be no variation in width of treads and the height of risers in any flight. Variation in height of risers in adjacent flights shall not exceed 3/16 inch. All treads less than 10 inches, as measured horizontally from the faces of risers, shall have a nosing or an effective projection of approximately 1-inch beyond the faces of the risers below.

Where, in the judgment of the Superintendent, material of stair treads and landings is such as to involve danger of slipping, non-slip material shall be provided.

No arrangement of treads known as winders shall be permitted in new stairways.

Stairways and their intermediate landings shall continue with no decrease in width along the direction of exit travel, except that existing stairs with decrease in width may be accepted, subject to the provision that the narrowest point shall determine the rated width for all floors above that point, or, in the case of basements, below that point.

For classes of stairways and their requirements see Table 28-D.

Stair Arrangement and Access

Sec. **2809**. In buildings of non-fire-resistive construction, more than three (3) stories in height with roofs having a slope of less than one foot in four, at least one stairway shall extend through the roof. In buildings more than four (4) stories high, having three (3) or more required stairways, at least two (2) shall extend through the roof or shall be connected by a corridor in the top story.

Where roofs are used for roof gardens or similar occupancies, stairways shall be provided in compliance with requirements of other parts of the building. Class "C" stairs may be used for access to unoccupied roofs.

Unless otherwise permitted by the requirements for individual occupancies, all stairways shall lead to a thoroughfare directly or by way of a court, not less than 2½ units in width or at least equal to the aggregate widths of all the exits discharging through it, except that where two or more exits discharge through such court, the required court width to serve such exits may be reduced ½ unit for each twenty (20) feet of distance between such exits.

Where stairways discharge through fire-resistive passages, such passages shall be not less than eight (8) feet in height. Where there is communication between the passage and the street floor, all such openings shall be protected by not less than Class "B" fire doors.

All exits to stairways shall be so located that they are readily accessible and visible. All stairways which may be used for exit purposes shall be so arranged as to make clear the direction of egress to a thoroughfare.

Handrails and Railings

Sec. **2810**. All stairways shall have well secured handrails as required by Table 28-D. The clear distance between handrail and wall or other obstruction shall be not less than two (2) inches. Stair wells exceeding fifteen (15) inches in width shall be protected by well balustrades or guards not less than four (4) feet high when measured vertically from the face of the riser. Wide stairways shall be provided with one or more continuous intermediate handrails substantially supported; the number and positions of intermediate handrails to be such that there will be not more than 2½ units of width between adjacent handrails. Upon approval by the Superintendent, this distance between intermediate handrails may be increased, but no exitway credit shall be allowed for such increase in width.

TABLE 28-D

CLASSES OF STAIRWAYS

CLASS	Minimum Clear Width in Inches	Sum of 1 Riser and 1 Tread in Inches	Angle of Stairs in Degrees	Comparable Slope in Inches per Foot	Required Handrails	Maximum Vertical Distance Between Landings
A	2 Units (40")	17½ to 18	30 to 33	6-15/16 to 7-25/32	Both sides	8 feet
B	2 Units (40")	17½	33 to 38	7-25/32 to 9-3/8	Both sides	12 feet

NOTES

1. Intermediate landings on straight run stairs shall have a minimum width of 42 inches in the direction of run.
2. No flight with less than three (3) risers shall be used except as may be permitted for theater balconies.
3. For Class "A" stairways the walls at the outer corners of landings shall be curved on a radius of at least two (2) feet or shall have a 45 degree splay not less than twenty (20) inches wide.
4. Swinging doors only shall be permitted on Class "A", "B", "C", and "D" stairways.
5. Only Class A stairways are permitted in schools.

Horizontal Exits Sec. 2811. Horizontal exits consisting of one or more protected openings through or around a fire wall or a fire partition or one or more bridges connecting two buildings may constitute fifty (50) per cent of the exitway capacity. Fire partitions used to provide a horizontal exitway shall be at least equivalent in fire resistance to the type of stairway enclosure required for the building, and in any case, at least equivalent to 2-hour fire-resistive construction. Every fire section for which credit is allowed in connection with a horizontal exit shall also have at least one other exitway.

Construction and arrangement shall be such that the exitway from each possible area of refuge cannot be obstructed by the same smoke or fire which may involve the area from which refuge is taken. Every horizontal exit for which credit is given shall be so arranged that there are continuously available paths of travel leading from each side of the horizontal exits to exitways leading to the street.

Doors leading to horizontal exits shall be kept unlocked and unobstructed whenever premises are occupied on either side of the exit.

Except as permitted for door sills at bridges, no stairs or steps shall be used in a horizontal exit in a new building. Ramps are permitted where a difference exists in levels between connected floor areas.

New bridges and balconies shall have a minimum width of two (2) units. Completely enclosed bridges shall be level with the floor. When a bridge or balcony is not completely enclosed, the level of the bridge floor shall be one step (approximately 7½ inches) below the building floor.

All wall openings, in both of the connected buildings, any part of which is within ten (10) feet of any bridge as measured horizontally or below shall be protected by standard fire doors or metal framed wired glass windows; provided, however, that where bridges have solid sides not less than six (6) feet in height, such protection of wall openings may be omitted.

Bridges which are not fully enclosed shall be provided with sides not less than five (5) feet high, which may be solid, slatted, grilled or screened construction, but no openings shall be greater than four (4) inches in one dimension.

Balconies leading around fire walls or fire exit partitions shall have an unobstructed length and width of not less than the required exit width of the exit doors which they serve.

All bridges and balconies shall be of incombustible construction, and all floors shall be solid.

Doors Sec. 2812. All doors used in connection with exitways shall be substantially constructed and installed in a workmanlike manner, be fitted with reliable hardware, and shall swing with the exit travel. Doors from individual rooms to corridors need not swing with the exit travel except: (a) where a room is used for purpose of assembly; (b) where a room is occupied by fifty (50) or more persons or (c) where a room contains any hazardous occupancy.

Doors which lead into the path of travel from other areas shall be so located that they do not encroach upon the required

All exit doors for Occupancy Classifications A-1, A-2, A-3, A-4, A-5, B, D-1, D-2, and G shall be operated by bars or other panic hardware devices approved by the Superintendent. No lock or other device which prevents egress shall be permitted to be used on such doors during any periods of occupancy.

The unit widths are defined in Sec. 2805. No single door shall be less than one (1) unit in width nor more than two (2) units in width. Each separate opening shall constitute a doorway. Doorways constituting exits from stairways shall be equal in width to the stairways which they serve. Exit doors (except exterior doors) shall have a fire-resistive rating equal to that required for the partition or wall in which they are installed.

Revolving Doors

Sec. 2813. Revolving doors shall not be used on required exits except that approved collapsible revolving doors may be so used between street floor and street (but not as exits from stairways) for Occupancy Classifications C-2, D-3 and D-4. Except as otherwise provided in this section, revolving doors shall not constitute more than fifty (50) per cent of the required exit width. The clear width of the opening when the doors are in a collapsed position shall be used in determining the number of units of width to be allowed for each revolving door. At any location, the number of units of revolving door width shall not exceed the number of units of swinging door width within twenty (20) feet of such revolving doors.

Doors with a minimum diameter of six feet may be used to provide the total required width of exits when such doors serve a ground floor area only and when the occupancy is 75 persons or less in buildings of Types I and II Construction and 50 or less in buildings of other types of construction.

Aisles and Corridors

Sec. 2814. Either direct access to exits or safe and continuous corridors or aisles leading directly to every exit and so arranged as to be conveniently accessible to every occupant, shall be maintained at all times on all floors of all buildings.

The aggregate capacity of corridors or aisles leading to any exit shall be at least equal to the capacity of the exit. (See Table 28-C.)

Ramps

Sec. 2815. Ramps may be used in place of stairs in required exitways. The maximum pitch of ramps shall be 16⅔% (2 inches per foot). Ramps steeper than 10% shall have non-slip surface. Ramp arrangement, construction, enclosures, doorways, unit widths and vertical distance between landings shall conform to the requirements for stairs for the same occupancy. Vehicular ramps shall not be permitted as exitways for pedestrians. Ramps having a slope of more than 12½% shall be provided with handrails as required for stairways. Easements at top and bottom of ramps shall be not less than 4 inches in length for each degree of slope. The requirements of this section shall not apply to ramps in Class 2 garages.

Elevators

Sec. 2816. Elevators shall not be included in the calculations for required exitways.

Construction

Sec. 2821. (a) Outside fire escapes shall be constructed of incombustible materials and shall be designed to carry a uniform live load of not less than one hundred pounds per square foot of all landings and balconies and of the horizontal projection of all stairways. The minimum thickness of members, except rolled structural shapes other than angles, shall be one-quarter inch and the minimum diameter of rivets and bolts shall be five-sixteenths inch.

Design Requirements

Sec. 2821. (b) The width of all stairs shall be 24" between railings, and all balconies and railings shall be at least as wide as the stairs. For buildings exceeding three (3) stories in height or having an occupancy of fifty (50) persons, the width of the stairs, balconies and landings shall be that approved by the Superintendent to provide safe and adequate means of escape in case of fire or panic.

Risers shall not exceed 8" in height and treads shall not be less than 7" in width. The angle of the stairs shall not exceed 45 degrees unless conditions will not permit, in which case the Superintendent may approve an angle up to 60 degrees. The width, rise, and construction of a fire escape for any building used for "B" or "C-1" Occupancy shall be as approved by the Board of Standards and Appeals.

Counter-balanced Stairs

Sec. 2821. (c) The bottom run of stairs, unless fixed to the ground, shall be raised above the ground when not in use and counterbalanced by means of cast iron weights on a beam or on an extension of the stringers. When conditions will not permit the above methods, the Superintendent may approve the use of cast iron weights suspended on non-corrodible or galvanized chain of sufficient strength to carry the load, and not less than one-quarter inch, over malleable iron

Railings

Sec. 2821. (d) On exposed sides of all stairs, landings and balconies, rigid railings shall be provided not less than three feet in height constructed with top and bottom angle rail, angle posts not less than 1¾"x1¾"x¼" spaced not to exceed

seven feet on center and balusters spaced not to exceed six inches on center, except that railings for counterbalanced stairs may be a single angle or pipe rail without balusters. For buildings exceeding three stories in height or buildings occupied by fifty or more persons, the height and design of the railings shall be as approved by the Superintendent and shall be such as to provide safe egress under the conditions prevailing.

Escalators Sec. 2817. In buildings of any classification having one or more stairways conforming to the requirements of this Code for exitways, escalators normally operating in the direction of exit, or operating in the opposite direction if equipped at the head of each flight with a device for stopping all flights simultaneously, may be used as required exitways. All escalators for which credit is given shall be of the horizontal tread type, shall have a vertical travel of not more than one floor between landings, shall be provided with enclosures and directional signs and shall meet all other requirements for stairways. Barricades not readily removable in case of fire or panic shall be prohibited during all periods of occupancy.

Windows Sec. 2823. (c) Windows leading to fire escapes shall have openings large enough to provide safe and adequate means of egress with sills not over thirty (30) inches above inside floor level.

Locks Sec. 2823. (d) Where required by this Code, doors shall be equipped with panic hardware, otherwise doors and windows shall be equipped with locks readily opened from the inside without the use of a key.

Sill Height Sec. 2823. (e) The height of egress door or window sills above the fire escape balcony platform or landing shall not exceed eight (8) inches.

Fire Doors Sec. 2824. (a) Doorways leading to fire escapes shall be provided with Class "C" fire doors and frames.

Protection of Windows Sec. 2824. (b) All windows opening upon, over, under or within ten (10) feet laterally of the fire escape shall have metal frames and sash and shall be glazed with wire glass except as follows:

(1) Windows over a fire escape where the vertical distance from the window sill to the tread of the fire escape is more than six (6) feet need not be protected.

(2) Windows under a fire escape where the window is more than one full story below the nearest part of the fire escape need not be protected.

(3) Windows in buildings three stories or less in height and having an occupancy not exceeding twenty-five persons may have wire glass installed in existing frames and sash. No single light of wire glass shall exceed in area seven hundred and twenty square inches.

Enclosure of Vertical
Openings

Enclosure of Vertical Openings

When Required

Sec. 2501. Vertical openings shall be required to be enclosed in certain buildings, depending upon occupancy of building, height of building or Type of Construction. The vertical openings required to be enclosed are specified under Occupancy, in Part III. Fire-resistive requirements for enclosures for different types of buildings are set forth in Table 14-A.

Stairway, Ramp, and Elevator Enclosures

Sec. 2502. When stairways or ramps are required to be enclosed, such enclosures shall extend from the lowest point to the highest point required and shall also include passageways necessary to complete the exit which shall be not less in width at any point than the required width of such stairway or ramp. All doors opening into such enclosures, except as specifically exempted in this Code, shall be fire-resistive doors as specified for such openings under Types of Construction, and all such doors shall be self-closing and kept normally closed.

All windows in exterior walls shall be protected by fire-resistive windows when so required because of location. (See Chapter 24.)

Walls and partitions enclosing stairways, ramps or elevators shall be of not less than the fire-resistive construction as set forth in Table 14-A or as required under Types of Construction in Part V. Elevator shafts extending through more than two (2) stories shall be equipped with an approved means of ventilation to and through the main roof of the building.

No open unenclosed space shall be permitted under any elevator pit.

(See Chapter 28 for stairs abutting an elevator enclosure.)

Other Vertical Openings

Sec. 2503. All shafts, ducts, chutes and other vertical openings not covered in Sec. 2502 shall have enclosing walls conforming to the requirements specified under Types of Construction when they exceed nine (9) square feet in area. All other shafts (nine (9) square feet or less in area) shall have enclosing walls as above specified or be lined with sheet metal having lock jointed or riveted seams and joints. Combustible material or partitions and floors through which such ducts pass shall be kept at least three (3) inches from the metal lining or shall be protected by the equivalent of ⅜ inch of plaster or ¼ inch of asbestos or plaster board. Openings between ducts and the floor construction through which they pass shall be filled with incombustible materials securely held in place to prevent the passage of fire. All doors opening into such vertical shafts shall be of metal or shall be covered on the shaft side by the equivalent of ¼ inch of asbestos and not less than 26-gauge metal, turned around all edges and well fastened to the door. Windows in such shafts shall be wire glass and metal frames and sash or such frame and sash may be of wood entirely clad with metal of not less than 26 U. S. gauge.

The requirements of this section shall not apply to manlifts for Class 2 garages. See Section 1807.

Special Requirements for Group "A" Occupancies

Group "A" Occupancies

Sec. 2818. SPECIAL REQUIREMENTS FOR GROUP "A" OCCUPANCIES.

Seats

Sec. 2818. (a) In places of assembly in which seats in rows are provided, except in churches and other places for religious assembly, stadiums, and reviewing stands, individual seats shall be provided for the persons congregating therein.

The width of seat allotted for each person shall be not less than nineteen (19) inches.

Seats in rows, whether fixed or movable, shall, except in boxes or loges not exceeding sixty (60) square feet in area, be not less than thirty (30) inches apart from back to back measured in a horizontal direction.

When individual fixed seats are provided, no seat shall have more than six (6) seats intervening between it and an aisle, provided that, if the seating consists of fixed chairs with self-raising seats so spaced that when the seats are raised there is an unobstructed space of not less than eighteen (18) inches horizontal projection between the rows of seats and doorways leading directly to exit corridors are provided not more than five (5) feet apart along the sides of the auditorium, the number of seats in a row shall not be limited.

In boxes or loges not exceeding sixty (60) square feet in area, and in other locations where loose chairs are permitted, not more than one chair shall be provided for each six (6) square feet of floor space.

Aisles

Sec. 2818. (b) Every aisle shall lead to an exit door or to a cross-aisle, that is, an aisle running parallel with the seat rows and leading to an exit door.

Aisles, cross-aisles and corridors shall be of uniform width at least equal to the minimum width required for exits in this Code but in no case shall the width of an aisle or cross-aisle be less than the width of the widest aisle, cross-aisle or exit which it serves. No aisle shall be less in width than 36 inches, plus an increase of 1½ inches for each five feet of length of such aisle, i.e., from its beginning to an exit door or to a cross-aisle or between cross-aisles, except that when there is egress at each end of said aisle the increase of width shall be at the rate of ¾ inch for each five feet. Aisles with seats on one side only may be six inches less in width and, when not to exceed 60 seats are served by such an aisle, the minimum width shall be 30 inches. A cross-aisle shall be not less than 3 feet 6 inches wide and shall lead to an exit. A cross-aisle bordering on a means of entrance shall be not less than four feet wide.

In all balconies and galleries having more than twenty (20) rows of seats, there shall be provided a cross-aisle not less than four (4) feet wide leading directly to an exit, provided that there shall in no case be a difference of level exceeding eleven (11) feet between lowest or highest seat platform and cross-aisle or between intermediate cross-aisles.

Steps shall not be placed in aisles unless the gradient would exceed one (1) foot rise in ten (10) feet run. Steps, when necessary, shall be grouped and, so far as practicable, isolated steps shall be avoided. Such steps shall extend across the full width of the aisles and shall be illuminated; treads and risers shall conform to the requirements of this Chapter for exit stairs.

Aisles shall be used only for passage to and from seats and shall be kept unobstructed at all times.

Railings Sec. 2818. (c) The facias of boxes, balconies and galleries shall have substantial metal railings not less than twenty-six (26) inches high above the floor. The railings at the ends of aisles extending to the facia shall be not less than thirty (30) inches high for the width of the aisles or thirty-six (36) inches high, if at foot of steps.

Cross-aisles, except where the backs of seats on the front of the aisle project twenty-four (24) inches or more above the floor of the aisles, shall be provided with railings not less than twenty-six (26) inches high.

In balconies, galleries or other locations where seats are arranged on platforms or successive tiers and the height of rise from one platform to another below and in front of it exceeds twenty-one (21) inches, a substantial railing not less than thirty (30) inches high shall be placed at the edge of the platform along the entire row of seats.

For unenclosed places of assembly such as grandstands, stadiums, and reviewing stands, fixed seats between aisles shall not be limited but the required widths of the aisles shall be increased one-eighth (1/8) inch for each additional seat in any one row above the minimum number fixed in this section

Dressing Rooms Sec. 2818. (d) Dressing rooms shall have exits independent of the auditorium exits.

Each enclosure for motion picture projectors shall have at least two (2) exit doors, each not less than thirty (30) inches wide and six (6) feet high, protected by approved self-closing fire doors.

Exit Courts Sec. 2818. (e) All exits of assembly occupancies not opening directly upon a thoroughfare shall be accommodated or served by an exit court consisting of a space open to the sky or a corridor of Type I, fire-proof construction. Such exit court shall be not less than five (5) feet in width, but in no case of less width than required for exitways in Sec. 2809. Such exit court shall extend to a thoroughfare or shall be connected to the thoroughfare by a corridor of the same required width not less than eight (8) feet in height, of Type I, fire-proof construction. Where enclosed corridors are used, they shall be vented to outer air by wire mesh grilles with ventilating area at least fifty (50) per cent of the required door opening of such exit corridor. Slope of courts or passages shall not exceed one (1) in ten (10). All door openings into courts or corridors shall be arranged so as not to decrease the required clear width of court when open. Where an exit passage extends through the stage portion of a place of assembly, there shall be no openings between such stage portion and the exit court.

Balcony Exitway Sec. 2818. (h) The principal exitways from any balcony or gallery shall be so located that it will be necessary to ascend not more than 10 feet or descend not more than six feet to reach an exit door leading to the stair or an area of refuge. Where exitways to serve this purpose are required on more than one level they shall be placed at vertical distances of not more than 12 feet apart.

Stairways Sec. 2818. (i) Stairways from balconies, galleries, boxes or loges, discharging through a public lobby shall discharge in a direction parallel to and with the exit travel from the main assembly floor or shall have a rail separating the lines of travel.

Not more than two-thirds of the total exit capacity from any place of public assembly or from any balcony or tier thereof shall be through a single public lobby.

Group "G" Occupancies (Working Stages)

Group "G" Occupancies Defined

Sec. 1201. Group "G" Occupancy (Working Stage) shall be a permanent stage, in connection with any occupancy, which is equipped, or adaptable for equipment with a rigging loft or fly gallery, and which is used for theatrical, musical and like performances.

Construction

Sec. 1202. The construction of any building, structure, or any part thereof of Group "G" Occupancy shall be Type I construction. All walls separating Group "G" Occupancy from the remainder of the building shall be not less than 4-hour fire-resistive construction. The perimeter wall shall extend not less than four (4) feet above the roof surface of the stage or auditorium, whichever is the higher.

Permitted Openings

Permitted openings in stage walls:

1. SCENERY DOOR. This opening shall be in the rear or side walls of the stage and shall be an Underwriters' "B" label or 1½-hour fire-resistive, automatic door.
2. TWO OPENINGS, from stage to auditorium, not to exceed 35 square feet each in area, Underwriters' "A" label, or 3-hour fire-resistive, self-closing doors.
3. REQUIRED OPENINGS, from stage to fire stair towers, not to exceed 35 square feet each in area, Underwriters' "B" label or 1½-hour fire-resistive, self-closing doors.
4. TWO OPENINGS, from the space under the stage to the orchestra pit, not to exceed 21 square feet each in area, Underwriters' "A" label or 3-hour fire-resistive, self-closing doors.
5. MAIN PROSCENIUM OPENING shall be provided with a fire-resistive, automatic self-closing curtain, as defined in the building code of the National Board of Fire Underwriters, 1943 Edition, as recommended by the National Board of Fire Underwriters.

Location of Dressing Rooms, etc.

Sec. 1203. Dressing rooms, workshops and store rooms shall not be on the stage. They may be located under the stage if the partitions, floors and floor of the stage are of 2-hour fire-resistive construction and the rooms protected with Underwriters' "B" label or 1½-hour fire-resistive self-closing doors.

Interior Finish

Sec. 1204. Interior finish for all buildings, structures and parts thereof of Group "G" Occupancy shall be of non-combustible or non-flammable materials which will not develop toxic or noxious gases when exposed to heat or flame. The use of combustible material for decorative purposes shall comply with the requirements of flame-proofed materials as set forth in Sec. 604.

Sprinklers Sec. 1205. (a) In all Group "G" Occupancies, an approved system of automatic sprinklers shall be provided.

Standpipes Sec. 1205. (b) A 2½" standpipe outlet shall be provided on each side of the stage and such standpipe shall be constructed and equipped as specified in Chapter 32.

Automatic Ventilator Sec. 1206. On the roof of every stage shall be an automatic ventilator having a free ventilating area of not less than one-tenth (1/10) of the area of the stage, and constructed as required by Chapter 43.

Flammable Liquids Sec. 1207. No flammable liquids shall be placed or stored in any building or structure of Group "G" Occupancy.

Heating Plant Separation Sec. 1208. Every room containing a central heating plant shall be separated from the remainder of the building by a 2-hour occupancy separation as defined in Sec. 508.

Gridirons, Fly Galleries and Pin Rails Sec. 1209. Gridirons, fly galleries and pin rails shall be constructed of incombustible materials, and the fire-proofing of such combustible materials may be omitted. Gridirons and fly galleries shall be designed to support a live load of not less than 50 pounds per square foot. All parts of the stage which are not movable shall be of incombustible material except the floor covering of the stage which may be wood.

Stage Ventilators

General Sec. 3301. There shall be one or more ventilators constructed of metal or other incombustible material near the center and above the highest part of any permanent stage, raised above the stage roof and having a total ventilation area equal to at least 10 per cent of the floor area within the stage walls. The entire equipment shall conform to the following requirements or their equivalent:

1. Doors and other covers shall open by force of gravity sufficient to overcome the effects of neglect, rust, dirt, frost, snow or expansion by heat or warping of the framework.
2. Glass, if used in ventilators, must be protected against falling on the stage. A wire screen, if used under the glass must be so placed that if clogged it cannot reduce the required ventilating area or interfere with the operating mechanism or obstruct the distribution of water from the automatic sprinklers.
3. The doors and other covers shall be arranged to open instantly after the outbreak of fire by the use of approved heat actuated device. A manual control must also be provided by an incombustible cord running down to the stage at a point on each side of the stage as designated by the Superintendent.

Motion Picture Projection Booths

General

Sec. 3401. (a) Motion picture projectors using nitro-cellulose film shall be operated or set up for operation only within an approved enclosure not less than 48 square feet in size and 9 feet high, except that for any booth hereafter constructed in an existing occupancy, if such height is not possible, the height thereof shall be not less than 7 feet 6 inches. If more than one machine is to be operated an additional 24 square feet shall be provided for each additional machine.

Construction

Sec. 3401. (b) For any booth hereafter constructed within an existing occupancy, the walls and ceiling of the enclosure shall be built of brick, tile or plaster blocks, plastered on both sides, or of concrete, or of a rigid metal frame, properly braced, and sheathed and roofed with sheet metal of not less than No. 20 U. S. gauge metal, or with 1/4 inch hard asbestos board, securely riveted or bolted to the frame, or 2 inches of solid metal lath and cement or gypsum plaster. All joints shall be sufficiently tight to prevent the discharge of smoke. Non-combustible acoustical material may be used on ceiling and walls on top of the plaster. For any booth hereafter constructed in a new building or an existing building in which the occupancy is to be changed, the walls of the enclosure shall be constructed in accordance with the following requirements for partitions, with ceiling and floor of equivalent fire-resistance:

1. Hollow tile laid in cement mortar, cement lime mortar or gypsum mortar and plastered on both sides with not less than 1/2 inch of gypsum mortar or cement mortar.
2. Gypsum blocks, either solid or hollow, not less than 3 inches thick, laid in gypsum mortar and plastered on both sides with not less than 1/2 inch of gypsum mortar.
3. Metal lath supported by incombustible studs plastered on both sides to fully cover the metal lath and studs with not less than three-fourth inch of gypsum mortar or cement mortar and having a total thickness of not less than 2 1/2 inches.

Entrance Door

Sec. 3401. (c) The entrance door into the enclosure shall be at least 2'6" by 6 feet, of construction equivalent to the sheathing permitted above for rigid frame construction, and shall be self-closing, swinging out and shall be kept closed at all times when not used for egress or ingress.

Openings

Sec. 3401. (d) Two openings for each motion picture projector shall be provided; one for the projectionist's view (observation port) shall be not larger than 200 square inches and the other through which the picture is projected (projection port) shall be not larger than 120 square inches. Where separate stereopticon, spot or floor light machines are installed in the same enclosure with picture machines, not more than one opening for each such machine shall be provided for both the operator's view and for the projection of the light but two or more machines may be operated through the same opening; such openings shall be as small as practicable and shall be capable of being protected by approved automatic shutters.

Shutters

Sec. 3401. (e) Each opening shall be provided with an approved gravity shutter set into guides not less than one inch at sides and bottom and overlapping the top of the opening by not less than one inch when closed. Shutters shall be of not less than 10-gauge iron or its equivalent of ¼ inch hard asbestos board. Guides shall be of not less than 10-gauge or its equivalent. Shutters shall be suspended, arranged and interconnected so that all openings will close upon the operating of some suitable fusible or mechanical releasing device designed to operate automatically in case of fire or other contingency requiring the immediate and complete isolation of the contents of the enclosure from other portions of the building. Each shutter shall have a fusible link above it and there shall also be one located over each upper projector magazine which, upon operating, will close all the shutters. There shall also be provided suitable means for manually closing all shutters simultaneously from any projector head and from a point within the projection room near each exit door. Shutters on openings not in use shall be kept closed.

Incombustible Equipment and Materials

Sec. 3401. (f) All shelves, furniture and fixtures within the enclosure shall be constructed of incombustible material. Tables and racks used in connection with the handling of film shall be of metal or other non-combustible material. Tables shall not be provided with racks or shelves underneath them which might be used for keeping film or other material. No combustible material of any sort whatever shall be permitted to be within such enclosure, except the films used in the operation of the machine and film cement. No collodion, amyl acetate or other similar flammable cement or liquid in quantities greater than one pint shall be kept in the projection booth or room or rewind room.

Ventilation

Sec. 3401. (g) Ventilation shall be provided by one or more mechanical exhaust systems which shall draw air from each arc lamp housing and from one or more points near the ceiling. Systems shall exhaust to outdoors either directly or through a noncombustible flue used for no other purpose. Exhaust capacity shall be not less than 15 cubic feet per minute for each arc lamp, plus 200 cubic feet per minute for the room itself. Systems shall be controlled from within the enclosure, shall have pilot lights to indicate operation and shall be in operation at all times when the projection room is in use. The exhaust system serving the projection room may be extended to cover rooms associated therewith, such as rewind rooms. No dampers shall be installed in such exhaust systems. The air supply to the projection room may be taken from the general building ventilation or air conditioning system, provided that a fire shutter is installed in the projection room partition. No return air shall be taken from the projection room.

Exhaust Ducts

Sec. 3401. (h) Exhaust ducts shall be of non-combustible material, and shall either be kept one inch from combustible material or covered with ½ inch of non-combustible heat insulating material.

Air Intakes

Sec. 3401. (i) Fresh air intakes other than those direct to the open air shall be protected by approved fire shutters arranged to operate automatically with the port shutters.

Switch for Auditorium Lights

Sec. 3401. (j) Provision shall be made so that the auditorium lights can be turned on from inside the projection room.

NOTE: Automatic sprinklers in projection rooms have been very successful in controlling fires and reducing losses, and their installation is recommended wherever practicable.

Processing of Film

Sec. 3402. The processing of film such as cleaning, polishing, buffing and other special treatments, shall not be done in rooms where other operations are performed, except that, in motion picture theatres, cleaning of film may be done in the rewind room. Special processes for treating film shall be provided with such proper safeguards as are necessary for protection against the hazards involved.

Film cabinets shall be provided for the storage of film in each motion picture projection booth of a type approved by the Chief of the Bureau of Fire and suitable fire extinguishing equipment of a type approved by said Chief shall also be provided.

Proscenium Curtains for Working Stages

General

Sec. 3501. The curtain shall be lowered each evening at the close of a performance and shall be normally in the closed position. The closing of the curtain from the full open position shall be effected in less than 30 seconds but the last 5 feet of travel shall require not less than 5 seconds.

The proscenium opening shall be provided with a fireproof rigid curtain, or, when the opening does not exceed 28 feet in width nor 22 feet in height in places of assembly accommodating less than 1,000 persons, with a reinforced asbestos curtain or other approved material, sliding at its sides in metal grooves securely fastened to the proscenium wall and extending not less than 12 inches beyond each side of the opening into such grooves.

The proscenium curtain shall be so arranged and maintained that, in case of fire, it will be released automatically and instantly by an approved heat-actuated device and will descend safely and close completely the proscenium opening. It shall also be equipped with effective devices to permit prompt and immediate closing of the proscenium arch by manual means.

No part of such curtains shall be supported or fastened to combustible material.

Rigid curtains shall be so designed and constructed that they will prevent all passage of flame for at least 30 minutes and will withstand without failure, a temperature of not less than seventeen hundred degrees Fahrenheit and an air pressure of not less than 10 pounds per sq. ft. normal to their surface during such periods. Asbestos curtains shall be constructed of pure asbestos fiber interwoven and reinforced with wire strands and shall weigh not less than 3 pounds per square yard.

No oil paint or other combustible material shall be placed on any proscenium curtain.

All machines and hoisting gear shall be designed in accordance with safe practice.

Travel limit stops and room for over-travel shall be provided.

Test

Sec. 3502. The complete installation of every proscenium curtain shall be subjected to operating tests and any theatre or auditorium in which such proscenium curtain is placed shall not be opened to public performance until after the curtain has been accepted and aproved by the Superintendent and the Chief of the Bureau of Fire.

Table 14-A Fire Resistive Requirement for Construction Types

TABLE 14-A

MINIMUM FIRE-RESISTIVE REQUIREMENTS FOR THE VARIOUS TYPES OF CONSTRUCTION

TYPES OF CONSTRUCTION	TYPE I Fireproof	TYPE II Fire-Resistive	TYPE III Protected or Heavy Timber*	TYPE IV Incombustible
	Chapter 15	Chapter 16	Chapter 17	Chapter 18
WALLS**				
(a) Party and Fire Walls	4 hrs.	4 hrs.	4 hrs.	4 hrs.
(b) Exterior Bearing Walls	4 hrs.	3 hrs. (12)	2 hrs. (12)	NC (3) (4)
(c) Exterior Panel and Curtain Walls***	2 hrs.	2 hrs.	2 hrs.	NC (3) (4)
(d) Penthouse Enclosure Walls (not directly above (a) or (b)	3 hrs. (2)	2 hrs. (2)	2 hrs. (2)	NC (3)
(e) Bearing Partitions	4 hrs.	2 hrs.	1 hr.	NC (3) (4)
(f) Non-Bearing Partition (5)	1 hr.—NC (3)	1 hr.—NC (3)	1 hr.	NC (3)
COLUMNS** (11)				
(a) Supporting Masonry	4 hrs.	4 hrs.	3 hrs.	1 hr.—NC (3)
(b) 1 and 2-story Buildings	4 hrs.	3 hrs.	1 hr.	NC (3)
(c) 3 or more Stories	4 hrs.	3 hrs.	2 hrs. (14)	NC (3)(15)
(d) Supporting Roofs Only	3 hrs.	2 hrs.		
GIRDERS AND TRUSSES** (11)				
(a) Supporting Masonry Walls	4 hrs.	3 hrs.	3 hrs.	1 hr.—NC (3)
(b) Others	4 hrs. (7)	3 hrs. (8)	1 hr. (9)	NC (3)
(c) Supporting Roofs Only	3 hrs.	1 hr.		
FLOOR PANELS**				
Including Beams and Joists	3 hrs.	2 hrs.	1 hr.	NC (3)
ROOF PANELS**				
Including Beams and Joists	2 hrs. (7)	1 hr. (8)	1 hr. or NC (3) (9)	NC (3)
INTERIOR PARTITIONS				
(a) Enclosing Stairs and other vertical Openings	2 hrs. (10)	2 hrs. (10)	1 hr. (10)	NC (3)
(b) Enclosing Horizontal Exitways	1 hr.—NC (3)(16)	1 hr.—NC (3)(16)	1 hr. (16)	NC (3)

(Numerals in parentheses and asterisks refer to Footnotes on the following p:

Note:

Construction Types V, Ordinary Construction, and VI Wood Frame Construction, have been omitted since they are not appropriate for urban school construction.

NOTES FOR TABLE 14-A

(10) 2-hour fire-resistive enclosures shall be required for stairs and other vertical openings in buildings of all occupancies over 3-stories in height.

(11) 4-hour fire-resistive protection required in all cases where the member supports fire walls or party walls.

(12) Exterior walls of Type II, Type III Protected Incombustible or Type V buildings facing on streets or public places that are 30 feet or more in width may be of 2-hour fire-resistive construction.

Exterior walls of Type II, Type III Protected Incombustible or Type V buildings not over 3-stories in height housing occupancies of Groups "A", "B", "C", "D-3", "D-4" and "E", may be constructed of non-combustible materials or assemblies of materials providing fire-resistance against outside exposure not less than required by Table 14-A (as modified above) provided that resistance against fire exposure inside the buildings shall be as follows: where floor and roof constructions and their structural supports are non-combustible framing forming a part of the exterior walls shall be protected to provide not less than 2-hour fire-resistance inside the building.

(14) Type III (protected only) buildings for D-3a occupancy use of Class 2 garages shall have two hour protected columns for five (5) or less levels above grade.

(15) Type IV buildings for D-3a occupancy use of Class 2 garages shall have two (2) hour fire protected columns except that all exterior row of columns on open side walls may be unprotected incombustible type. See exception under Note 10, Page 41, for unprotected Type IV construction.

(16) Corridors having an exit in one end only shall have enclosing walls and ceiling of 1-hour fire construction and doors shall be at least Class "C" fire doors unless otherwise required by this Code.

Corridors having exits from each end shall have enclosing walls and ceiling of 1-hour fire construction and the doors may be of ordinary wood construction unless otherwise required by this Code.

(17) The fire resistance of ceilings shall conform to the requirements of the National Building Code, 1955 Edition.

*** Fire-resistive ratings for structural members do not apply to the timbers of heavy timber construction. (See Chapter 17.)**

**** FIRE-RESISTIVE REQUIREMENTS—ACCEPTABLE RATINGS: REINFORCED CONCRETE will be accepted as meeting the fire-resistive requirements of this table if it has a minimum thickness of concrete over the reinforcing steel, as follows:**

For COLUMNS—1½" of concrete when the fire-resistive requirement is 4-hour, 3-hour or 2-hour except that 2" of concrete will be required if the coarse aggregate is granite, sandstone or siliceous gravel. 1" of concrete when the fire-resistive requirement is 1-hour.

GIRDERS AND TRUSSES—1½" of concrete over the longitudinal reinforcing steel, when the fire-resistive requirement is 4-hour, 3-hour, or 2-hour. 1" of concrete over the longitudinal reinforcing steel, when the fire-resistive requirement is 1-hour.

FLOOR AND ROOF PANELS—(Slabs)—¾" of concrete over the reinforcing steel for all fire-resistive requirements. (Joists)—1" of concrete over the reinforcing steel for all fire-resistive requirements. (Walls)—¾" of concrete over the reinforcing steel for all fire-resistive requirements.

OTHER CONSTRUCTION—The fire-resistive ratings of all materials and constructions, other than reinforced concrete, as above set forth shall be as established by the provisions of Section 302(a) 8 and 9.

***** Exterior panel or curtain walls of Type I, II or III buildings may be of incombustible construction without a fire-resistive rating when the distances from adjoining buildings comply with the provisions of Chapter 24. Such walls shall be integrally attached to the structural frame.**

Construction Types

Type I Buildings (Fireproof)

Definition

Sec. 1501. Type I, Fireproof Construction, is that Type of Construction in which the walls, floors, roof and structural members are of approved masonry, reinforced concrete or other approved incombustible materials meeting all the requirements of this Code and having a minimum fire resistance as indicated in Table 14-A.

Height and Area Allowable

Sec. 1502. The height and ground area of Type I buildings shall not be limited except as set forth for Group "D" occupancies in Table 5-B and Sec. 902 (a) and (b), and as limited by the Zoning Ordinance.

Protection of Wall Openings

Sec. 1503. Required fire-resistive protection of wall openings is specified in Chapter 24.

Foundations

Sec. 1504. Foundations may be of any recognized materials, masonry, reinforced concrete, steel or iron properly encased, piling of wood, steel or concrete, concrete or masonry piers or caissons. Any foundation system shall be structurally sound and protected according to recognized engineering practice against deterioration from the action of ground water. In certain locations protection against deterioration from electrolysis may also be required.

Exterior Walls

Sec. 1505. Exterior walls shall have the fire-resistance specified in Table 14-A. Nonload-bearing exterior walls may be of incombustible construction without a fire-resistive rating when complying with the requirements of Table 14-A for exterior panel and curtain walls and when structural members are fire-protected as required in Sec. 1509.

Partitions and Inner Court Walls

Sec. 1506. Interior bearing partitions and inner court walls shall comply with the requirements of Table 14-A except as otherwise prescribed in Sec. 1505.
Interior non-bearing partitions shall be of incombustible materials and of not less than 1-hour fire-resistive construction.

EXCEPTION: Non-bearing partitions subdividing an area not exceeding 5,000 sq. ft. and occupied by a single tenancy may be of wood or metal panels or similar light construction without fire-resistive rating. Nonload-bearing partitions subdividing an area exceeding 5,000 square feet and occupied by a single tenancy may be of incombustible construction for D-4 occupancy.

Enclosure of Vertical Openings

Sec. 1507. Enclosures for elevator shafts, vent shafts, stair wells and other vertical openings, when required because of occupancy in Part III, shall be of not less than 2-hour fire-resistive construction and all openings therein shall be protected by Underwriters' Class "B" label or 1½-hour fire-resistive doors. Window openings in exterior walls shall be protected by Underwriters' Class "E" situation label or ¾-hour fire-resistive windows where required under Chapter 24. (See Chapter 25 for allowable enclosures for small shafts. See special provisions for Group C-2 occupancies, Section 809.)
A parapet wall at least 24 inches in height above the roof shall be provided around all open shaft enclosures extending through the roof.

Structural Frame

Sec. 1508. The structural frame shall be considered as the columns and girders, beams, trusses or spandrels having connections to the columns, and all other members essential to the stability of the frame. The members of floor or roof panels which have no connection to the columns shall be considered as secondary members. The structural frame and secondary members shall be designed and constructed to carry all dead, live and other loads to which they may be subjected during erection and after completion of the structure.

Fire Protection of Structural Members
Steel or Iron Members

Sec. 1509. (a) All structural steel or metal members shall be thoroughly fire-protected as set forth in Table 14-A.

EXCEPTIONS:

1. Structural steel and iron members for elevators, including door frames within an elevator shaft enclosure and not part of the structural frame of the building, may be unprotected.

2. The thickness of fire-protection on the outer edges of lugs or brackets of columns may be reduced to not less than 1 inch.

3. Masonry over window openings may be supported by a steel plate, angle or similar member which is not fire-protected on the under side, provided the member is supported at intervals not exceeding 4 feet from a structural beam or girder which is fire-protected on all sides. For openings not exceeding 7 feet in width in masonry bearing walls an angle or a similar member supported by masonry and not fire-protected on the under side may be used.

4. Fire-protective covering may be omitted from structural steel roof structures and from tension members of concrete roof structures of buildings housing any Group A or B occupancies, where every part of such roof structure is 25 feet or more above any floor, balcony, or gallery.

5. Structural steel roof structures, and tension members of concrete roof structures may have 1-hour fire-resistive protection in buildings housing any Groups A or B occupancies, where every part of such roof structure is 12 feet or more above any floor, balcony, or gallery, or such 1-hour fire-resistive protection may be omitted if the entire construction is protected on the under side by a continuous 1-hour fire-resistive ceiling with any openings in such ceiling protected by ducts or shafts of like construction to the roof.

6. For Type I buildings housing Groups D-1, D-2, and D-3 occupancies, structural steel beams, girders and trusses of the roof structure shall be protected with 3-hour fire-resistive covering, and for buildings of all other Occupancy Groups, with 2-hour fire-protective covering.

Reinforced Concrete Members

Sec. 1509. (b) All reinforced concrete members of the structural frame shall be thoroughly fire-protected in accordance with the requirements set forth in Table 14-A.

Additional Protection for "D-1" and "D-2" Occupancies

Sec. 1509. (c) For Type I buildings housing Groups D-1 and D-2 occupancies, fire-resistive protection in excess of that set forth in Table 14-A may be required in cases where unusual hazards are involved. See Sec. 902 (a) and (b).

Floor Construction

Sec. 1510. Floor panel construction shall consist of any incombustible floor system of not less than 3-hour fire-resistive construction as set forth in Table 14-A.

The floor and roof panel construction shall be so designed and constructed as to transfer horizontal forces to such parts of the structural frame as are designed to carry the horizontal forces to the foundations, unless such forces are otherwise provided for.

Where wood sleepers are used for wood floors, the space between the structural floor slab and the underside of the wood floor shall be filled with incombustible material in such manner that there will be no open spaces under the flooring, and such spaces shall be filled solidly under all permanent partitions so that there is no communication under the flooring between adjoining rooms.

Roof Construction

Sec. 1511. Roofs shall be constructed of any materials or combination of materials as allowed for floors in Section 1510 or as allowed under Exceptions in Section 1509.

Roof covering shall be any fire-retardant roofing meeting the requirements of Class A or Class B roofing under the specifications of the Underwriters' Laboratories, Inc. Roofs may be constructed with unprotected incombustible roof decking when such decking covers unprotected roof framing as allowed under Exceptions 4, 5 and 7 of Section 1509 (a).

Any drainage fill placed on a roof deck of any building shall be of incombustible material and such fill shall be considered as a part of the dead load in designing the roof framing.

Stair Construction

Sec. 1512. Stairs enclosed within 2-hour fire-resistive enclosures shall be constructed of reinforced concrete, iron, steel or other approved non-combustible material with treads and risers of hard, incombustible materials. Stairs not required to be enclosed in fire-resistive enclosures shall be constructed of approved incombustible materials.

All stairs shall be designed and constructed as specified in Chapter 28 and as required under Occupancy in Part III.

Projections from the Building

Sec. 1513. Bays, oriels and similar projections shall be constructed of incombustible material as specified in this Chapter and in Sections 2605 and 2705.

Type II Buildings (Fire-Resistive)

Definition

Sec. 1601. Type II, Fire-Resistive Construction is that Type of Construction in which the walls, floors, roof and structural members are of approved masonry, reinforced concrete or other approved incombustible materials meeting the requirements of this Code and having a fire-resistance not less than the requirements set forth in Table 14-A.

Height and Area Allowable

Sec. 1602. The height and ground area of Type II buildings shall not exceed the limits set forth in Table 5-B and Sec. 902 (a) and (b).

Protection of Wall Openings

Sec. 1603. Fire-resistive protection of wall openings is specified in Chapter 24.

Foundations

Sec. 1604. Foundations shall be constructed as specified in Section 1504.

Exterior Walls

Sec. 1605. Exterior walls shall have the fire resistance specified in Table 14-A. Nonload-bearing exterior walls may be of incombustible construction without a fire-resistive rating when complying with the requirements of Table 14-A for exterior panel and curtain walls and when structural members are fire-protected as required in Sec. 1509.

Partitions and Inner Court Walls

Sec. 1606. Interior bearing partitions and inner court walls shall be of incombustible materials and of not less than 2-hour fire-resistive construction.
Interior non-bearing partitions shall be of incombustible materials and of not less than 1-hour fire-resistive construction.

EXCEPTION: Non-bearing partitions subdividing an area not exceeding 3,000 sq. ft. and occupied by a single tenancy may be of wood or metal panels or similar light construction without fire-resistive rating. Nonload-bearing partitions subdividing an area exceeding 3,000 square feet and occupied by a single tenancy may be of incombustible construction for D-4 occupancy.

Enclosure of Vertical Openings

Sec. 1607. Enclosures for elevator shafts, vent shafts, stair wells and other vertical openings when required because of occupancy in Part III shall be of not less than 2-hour fire-resistive construction, and all openings therein shall be protected by Underwriters' Class "B" label, or 1½-hour fire-resistive doors. Window openings in exterior wall shall be protected by Underwriters' Class "E" situation label, or ¾-hour fire-resistive windows where required under Chapter 24. (See Chapter 25 for allowable enclosures for small shafts. See special provision for Group C-2 occupancies, Section 809.) A parapet wall at least 24 inches in height above the roof shall be provided around all open shaft enclosures extending through the roof.

Structural Frame

Sec. 1608. The structural frame shall be as designated in Section 1508.

Fire Protection of Structural Members
Steel or Iron Members

Sec. 1609. (a) All structural steel or iron members shall be thoroughly fire-protected with not less than 4-hour fire-resistive protection for columns supporting masonry, not less than 3-hour fire-resistive protection for all other columns, girders, beams, and trusses, not less than 2-hour protection for floor panels and 1-hour protection for roof panels, as set forth in Table 14-A.

EXCEPTIONS:

1. Structural steel and iron members for elevators including door frames within an elevator shaft enclosure and not part of the structural frame of the building may be unprotected.

2. The thickness of fire-protection on the outer edges of lugs or brackets of columns may be reduced to not less than 1 inch.

3. Masonry over window openings may be supported by a steel plate, angle or similar member which is not fire-protected on the underside, provided the member is supported at intervals not exceeding 4 feet from a structural beam or girder which is fire-protected on all sides. For openings in masonry bearing walls not exceeding 7 feet in width, an angle or a similar member supported by masonry and not fire-protected on the underside may be used.

4. Fire-protective covering may be omitted from structural steel roof structures, and from tension members of concrete roof structures, of buildings housing any Groups A or B occupancies, where every part of such roof structure is 20 feet or more above any floor, balcony, or gallery.

5. Structural steel roof structures, and tension members of concrete roof structures may have 1-hour fire-resistive protection in buildings housing any Groups A or B occupancies, where every part of such roof structure is 12 feet or more above any floor, balcony, or gallery; or such 1-hour fire-resistive protection may be omitted if the entire construction is protected on the underside by a continuous 1-hour fire-resistive ceiling, with any openings in such ceiling protected by ducts or shafts of like construction to the roof.

6. For any Type II building, structural steel beams, girders, and trusses of the roof structure may be protected with 2-hour fire-resistive covering.

Floor Construction

Sec. 1610. Floor panel construction shall consist of any incombustible floor system of not less than 2-hour fire-resistive construction as set forth in Table 14-A.

The floor and roof panel construction shall be so designed and constructed as to transfer horizontal forces to such parts of the structural frame as are designed to carry the horizontal forces to the foundations, unless such forces are otherwise provided for.

Where wood sleepers are used for wood floors the space between the structural floor slab and the underside of the wood floor shall be filled with incombustible material in such manner that there will be no open spaces under the flooring, and such spaces shall be filled solidly under all permanent partitions so that there is no communication under the flooring between adjoining rooms.

Roof Construction

Sec. 1611. Roofs shall be constructed of any materials or combination of materials as allowed for floors in Section 1610 or as allowed under Exceptions under Sec. 1609. Roof covering shall be any fire-retardant roofing meeting the requirements of Class A or Class B roofing under the specifications of the Underwriters' Laboratories, Inc. Roofs may be sheathed with unprotected incombustible roof decking, or with nominal 2-inch, tongue and groove or splined wood planking, when such sheathing covers unprotected roof framing, as allowed under Section 1609 (a), Exceptions 4, 5, and 7, or under Section 1609 (c).

Any drainage fill placed on a roof deck of any building shall be of incombustible material and such fill shall be considered as a part of the dead load in designing the roof framing.

Stair Construction

Sec. 1612. Stairs enclosed within 2-hour fire-resistive enclosures shall be constructed of reinforced concrete, iron, steel or other approved incombustible material with treads and risers of hard incombustible materials. Stairs not required to be enclosed in fire-resistive enclosures shall be constructed of approved incombustible materials. All stairs shall be designed and constructed as specified in Chapter 28 and as required under Occupancy in Part III.

Type III Buildings (Protected and Heavy Timber)

Definition

Sec. 1701. Type III, Protected and Heavy Timber Construction, are those types of Construction in which the exterior walls and fire walls are of masonry, reinforced concrete, or other approved incombustible materials meeting the requirements of this Code, and having a fire resistance not less than the minimum requirements set forth in Table 14-A, and in which the interior framing is of:

(a) INCOMBUSTIBLE OR COMBUSTIBLE MATERIALS, fire protected to have a minimum fire-resistance as set forth in Table 14-A for Type III Construction, or

(b) HEAVY TIMBER CONSTRUCTION, without concealed spaces and having members of the following minimum nominal sizes:

Columns	8" x 8" timber
Trusses supporting floors	6" x 6" timber
Trusses supporting roofs only	4" x 6" timber*
Girders supporting floors	8" x 10" timber
Girders supporting roofs only	6" x 10" timber
Beams supporting floors	6" x 10" timber
Beams supporting roofs only	4" x 8" timber
Floor panels	3"**
Roof panels	2"***

*Timber arches or trusses may be used to support roof loads. The framing members shall be of not less than 4" x 6" nominal dimensions, except that spaced members may be composed of two or more pieces, each of not less than 2" nominal thickness when blocked solidly throughout their intervening spaces or when such spaces are tightly closed by a continuous wood cover plate of not less than 2 inch nominal thickness secured to the underside of the members. Splice scabs shall be not less than 3 inch nominal thickness. When protected by approved automatic sprinklers under the roof deck, the framing members may be reduced to not less than 3 inch nominal thickness.

**Floors may be constructed of splined or tongue and groove plank of not less than 3 inch nominal thickness, covered with 1 inch flooring laid crosswise or diagonally or may be of laminated construction consisting of planks of not less than 4-inch nominal width, laid on edge and spiked together at intervals of 18 inches and covered with 1 inch flooring.

Laminated floors shall be laid with staggered joints and shall not be spiked to the supporting girders.

Flooring shall not be laid closer than ½ inch to walls, and the space so left shall be covered with a moulding

Height Allowable

Sec. 1702. The height of Type III buildings shall not exceed the limits set forth in Table 5-B.

Exterior Walls

Sec. 1705. Exterior walls shall be of materials meeting the requirements set forth in Chapter 23 and Table 14-A. Walls fronting on streets not less than 30 feet wide may be of incombustible construction with only the structural members fire-protected as required in Sec. 1709, except that incombustible construction shall not rest on, nor be supported by, combustible construction.

Partitions and Inner Court Walls

Sec. 1706. Inner court walls in Type III buildings, including Heavy Timber construction, shall be of not less than 2-hour fire-resistive construction.

(a) Interior bearing partitions for Type III, Protected Construction, shall be of not less than 1-hour fire-resistive construction.

(b) Interior non-bearing partitions for Type III, Protected Construction, shall be of incombustible or combustible materials with 1-hour fire-resistive protection.

(c) In Type III buildings of Heavy Timber Construction, interior partitions shall be of not less than 1-hour fire-resistive construction or may be of solid wood construction formed of 2 layers of 1 inch nominal matched boards, or may be of solid wood laminated construction of not less than 4 inch nominal thickness.

Fire Protection of Structural Members

Sec. 1709. (a) All structural steel, reinforced concrete, or iron members, and all wood members except in Heavy Timber Construction as allowed under Sec. 1701 (b) shall be thoroughly fire-protected with not less than the minimum fire-resistive protection as set forth in Table 14-A.

EXCEPTIONS:

1. Structural steel and iron members for elevators, including door frames within an elevator shaft enclosure and not part of the structural frame of the building, may be unprotected.

3. Masonry over window openings may be supported by a steel plate, angle or similar member which is not fire-protected on the underside, provided the member is supported at intervals not exceeding 4 feet from a structural beam or girder which is fire-protected on all sides. For openings not exceeding 7 feet in width in masonry bearing walls an angle or a similar member supported by masonry and not fire-protected on the underside may be used.

4. Where every part of the structural framework of the roof of a building housing any Groups A or B occupancies is not less than 20 feet above any floor, balcony or gallery, fire-protection of all members of the roof construction may be omitted.

5. Where every part of the structural framework of the roof of a building housing any Groups A or B occupancies is 12 feet or more above any floor, balcony or gallery the members of the roof framework may have fire-protection omitted if the entire construction is protected on the underside by a continuous suspended ceiling of not less than 1-hour fire-resistive construction, with any openings in such ceiling protected by shafts or ducts of like construction to the roof.

Floor Construction

Sec. 1710. Floor panel construction shall be of 1-hour fire-resistive construction as set forth in Table 14-A, except that floors may be of timber construction as specified in Sec. 1701 (b) in buildings where Heavy Timber Construction is allowed. (See Table 5-B.)

The floor and roof panel construction shall be so designed and constructed as to transfer horizontal forces to such parts of the structural frame as are designed to carry the horizontal forces to the foundations, unless such forces are otherwise provided for.

Where wood sleepers are used for wood floors, the space between the floor slab and the underside of the wood floor shall be filled with incombustible material in such manner that there will be no open spaces under the flooring and such spaces shall be filled solidly under all permanent partitions so that there will be no communication under the flooring between adjoining rooms.

Roof Construction

Sec. 1711. Roofs shall be constructed of any materials or combination of materials as allowed for floors in Sec. 1710 or as allowed under Exceptions under Sec. 1709. Roof covering shall be any fire-retardant roofing meeting the requirements of Class A or Class B roofing under the specifications of the Underwriters' Laboratories, Inc.

Roof decking may be of incombustible materials, or of heavy wood as specified for roofs in Sec. 1701 (b), on any building of Type III Construction, including Heavy Timber Construction. Roof decking of ordinary wood or other combustible construction may be used on buildings of Type III Construction, when 1-hour fire-resistive construction is provided on the underside of the ceiling joists.

Any drainage fill placed on a roof deck of any building shall be of incombustible material except fill on wood roofs must be of wood, and such fill shall be considered as part of the dead load in designing the roof framing.

Stair Construction

Sec. 1712. Stairs may be of incombustible materials or contructed of wood in buildings with wood framing if the soffits are protected by fire-resistive construction as allowed for 1-hour fire-resistive combustible ceilings. All stairs shall be designed and constructed as specified in Chapter 28. Stairs shall be enclosed where required under Occupancy, in Part III.

Type IV Buildings (Incombustible)

Definition

Sec. 1801. Type IV, Incombustible Construction, is that Type of Construction in which all the structural members including wall framing, floors, roofs and their supports shall be of steel, iron or of other incombustible materials and in which the exterior walls are of steel, iron or other metal or of asbestos, masonry, reinforced concrete or other incombustible materials which may not meet the fire-resistive requirements of a more fire-resistive Type of Construction but which will provide durable, weather-proof exterior walls. (See Sec. 2401, (c) 2 for Class 2 garages)

Height Allowable

Sec. 1802. The height of Type IV buildings shall not exceed the limitations set forth in Table 5-B.

Protection of Wall Openings

Sec. 1803. Fire-resistive protection of wall openings is specified in Chapter 24.

Foundations

Sec. 1804. Foundations shall be constructed as specified in Sec. 1504.

Exterior Walls

Sec. 1805. Exterior walls may be of any durable, incombustible materials properly protected against the weather and without fire-resistive rating, except where such fire resistive ratings are required for fire and party walls in Table 14-A. (See Sec. 2401, (c) 2 for Class 2 garages)

Inner Court Walls

Sec. 1806. Inner court walls shall be constructed of incombustible materials.

Enclosure of Vertical Openings

Sec. 1807. Any enclosures for elevator shafts, vent shafts, stair wells and other vertical openings, shall be of incombustible construction and all openings therein shall be protected by incombustible doors. Openings in exterior walls shall be protected by Underwriters' Class "F" situation label, or equivalent, fire-resistive windows where required under Chapter 24. Unenclosed ramps of incombustible construction shall be permitted for Class 2 garages in Type IV buildings. Manlifts meeting Pennsylvania Department of Labor and Industry requirements for screening and safety measures shall be permitted for Class 2 garages.

Structural Frame

Sec. 1808. The entire structural frame shall be designed and constructed to carry all dead and live loads to which it may be subjected during erection and after completion of the structure.

Fire Protection of Structural Members

Sec. 1809. In all buildings of Occupancy Groups A and B or C-1, structural steel beams or girders and floor joists over usable basement spaces shall be protected with not less than 1-hour fire-resistive ceiling construction. Any member of the structural frame supporting masonry shall have a minimum of 1-hour fire-resistive protection, or 4-hour protection, if it supports party or fire walls.

Floor Construction

Sec. 1810. The floor and roof panel construction shall be so designed and constructed as to transfer horizontal forces to such parts of the structural frame as are designed to carry the horizontal forces to the foundations, unless such forces are otherwise provided for.

Roof Covering

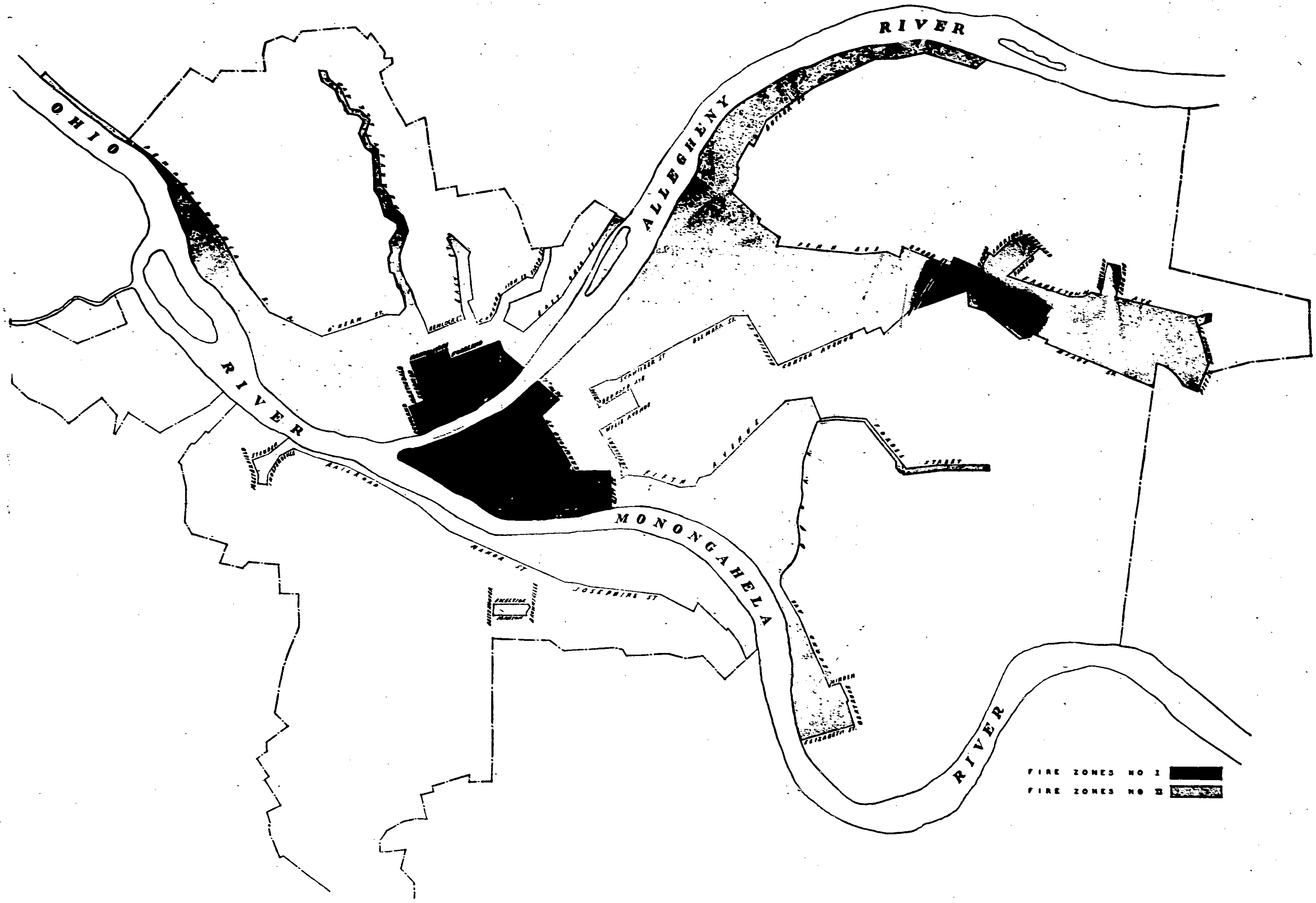
Sec. 1811. Roof covering in Fire Zone No. I shall be any fire-retardant roofing meeting the requirements of the specifications of the Underwriters' Laboratories, Inc., for Class A or B roofing.

Roof covering in Fire Zone No. II shall be any fire-retardant or ordinary roofing meeting the specifications of the Underwriters' Laboratories for Class A, B, or C roofings.

Stair Construction

Sec. 1812. All stairs shall be of incombustible materials designed and constructed as specified in Chapter 28.

Fire Zoning Regulations



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FIRE ZONE MAP CITY OF PITTSBURGH

PART IV

REQUIRED COMPLIANCE WITH FIRE ZONING REGULATIONS

CHAPTER 13

Restrictions in Fire Zones

General

Sec. 1301. Erection, enlargement, alteration, repair and occupancy of buildings and structures shall be restricted within Fire Zones No. I and No. II, as created by Ordinance No. 310, approved October 2, 1919, known as the Fire Zoning Regulations, in accordance with the provisions of this Chapter.

Fire Zone Map

Sec. 1302. The Fire Zone Map which is included as part of this Chapter outlines all areas within the City of Pittsburgh classified at the time of the enactment of this Code as Fire Zones No. I and No. II. All areas not so classified are within Zone No. III, as defined in the Fire Zoning Regulations. Any building or structure situated partly in one zone and partly in another shall be subject to the requirements which apply to the more highly restricted zone if more than one-third (1/3) of its ground area is within said zone.

Fire Zones No. II Buildings Prohibited

Sec. 1304. (a) In Fire Zones No. II erection of the following buildings shall be prohibited:

3. Any building of Type III construction except D-3a occupancy use, five (5) levels or less above grade, more than three (3) stories in height not equipped with a standard sprinkler system serving all floors.

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Fire Zones No. I Buildings Prohibited

Sec. 1305. (a) In Fire Zones No. I erection of the following buildings shall be prohibited:

3. Any building of Type III construction more than three (3) stories high, except D-3a occupancy use, five (5) levels or less above grade.

APPENDIX

Nationwide Survey of
Space Standards

Space Utilization in the
Vocational Laboratories
of Pittsburgh Schools

6

Prepared By The Research Team
For A Comprehensive Concept
For Vocational Education
Facilities

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Nationwide Survey of Space Standards
and
Space Utilization in the Vocational Laboratories of
Pittsburgh Schools

Techniques that can be used for planning vocational education facilities are one of the major concerns of this study. Although Unit Three, Space Determination, is devoted to the description of one such technique, the use of that technique as an effective planning tool depends on future refinement. For the present, a "rule of thumb" method may be helpful. Space utilization measured in square feet per student in existing or planned facilities can be evaluated by comparison with similar figures which are recommended for vocational space by departments of public instruction acro the nation. This will give facilities planners a starting point, even though its usefulness is limited.

A sampling of vocational education space standards recommended by various state departments of public instruction was conduct_d as a part of the research activities of this project. In combination with this survey, a study was made of space utilization in each of the vocational laboratories of the Pittsburgh school system. A relative evaluation of the amount of space provided for vocational education activities in Pittsburgh schools can be made by comparing these two sets of data.

Requests for standards were sent to the Department of Public Instruction of each of the fifty states. The requests were answered by thirty-four states, nine of which stated that standards were not available or were in the process of development. Therefore, the space standards tables in this section were compiled from twenty-five states. Although additional mailings might provide a better sample, this record of space standards from this group of states should be of general interest.

It was necessary to make two modifications to the information that was received in order to facilitate recording the standards in tabular form. Wherever possible, standards were converted to square feet per student units so that easy comparisons could be made. Where this was impossible, the standards appear expressed in total square feet. In addition, standards were grouped into broad subject categories.[1] Although this was done to simplify the tables, it may account, partially, for the deviations in recommended space by different states for the same subject category.

The space utilization tables for vocational laboratories in Pittsburgh schools are a combination of information. The approximate area of each vocational laboratory was calculated from dimensions taken from architectural plans. Storage areas were included in total room areas since similar areas were included in many state space standards. Student enrollment in every vocational class was

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[1] For example, the Pennsylvania standards for Cabinet and Mill Shop and Carpentry Shop were grouped to allow comparison with other states.

obtained from central office and individual high school records for 1965-1966. An index of space utilization was calculated by dividing the room area by the class size, giving square feet per student. Only the high and low extremes of class size and space utilization are given. The accuracy of dimensional measurements could be increased by on-site measurements of the actual rooms; also, student enrollments in all classes could be updated. Nevertheless, a useful, though general, evaluation of existing space is provided in these tables.

A note of caution must accompany the presentation of this material. At best, space standards can be no more than a very general guide in facility evaluation and planning. Although many states provide specific space recommendations, no respondent provided information about the curricula of the course for which these areas were recommended. It is probable that the activities included in the curriculum for a certain class in one state will vary considerably when compared to the activities for the same course in another state. Obviously, no evaluation of the space provided for a subject is meaningful without a clear picture of the activities that are carried on in the subject.

Also, it became evident that many states differ in their recommendations for class enrollment sizes. Some states even provided a total area recommendation with no reference to class size. However, recommendations for space requirements must consider class size. Unfortunately, it is difficult to determine how space requirements change as class size changes.

For these reasons, the information provided in this study should be used only as a general guide. Furthermore, the standards that were received were largely based on present courses being taught in existing classrooms and are not useful in planning space for new programs or new organizational techniques.

Effective planning grows out of the careful analysis of the needs that students create for space, equipment and environmental control as they engage in specific educational activities.

STATE STANDARDS - BUSINESS EDUCATION

Bookkeeping and Accounting

Alabama	20-25 sq. ft. /student
Florida	40-50 sq. ft. /student
Georgia	30 sq. ft. /student
Kentucky	38 sq. ft. /student + 228 sq. ft. storage
Mississippi	25-30 sq. ft. /student
New Jersey	36 sq. ft. /student
Pennsylvania	26 sq. ft. /student
South Carolina	1000 sq. ft.
Tennessee	34 sq. ft. /student
West Virginia	30 sq. ft. /student
Wisconsin	35 sq. ft. /student

Distributive Education

Florida	40-50 sq. ft. /student
Minnesota	1800 sq. ft.
New Jersey	48 sq. ft. /student + 200 sq. ft. storage
Virginia	900 sq. ft.

General Business Education

Alabama	20-25 sq. ft. /student
Arkansas	30 sq. ft. /student
Florida	40 sq. ft. /student
Georgia	30 sq. ft/student
Hawaii	1200 sq. ft. + 420 sq. ft. workroom
Kentucky	38 sq. ft. /student + 228 sq. ft. storage
Minnesota	2000 sq. ft.
Mississippi	768 sq. ft.
New Jersey	40 sq. ft. /student
North Dakota	20-25 sq. ft. /student
Oregon	25-35 sq. ft. /student
Pennsylvania	26 sq. ft. /student
South Carolina	1000 sq. ft.

General Business Education

Tennessee	24 sq.ft. /student
Virginia	3 rooms - 30' x 34' - 1020 sq.ft.
West Virginia	40 sq. ft. /student

Office Machines

California	45 sq. ft. /student
Florida	50-60 sq. ft. /student
Hawaii	1950 sq. ft.
Kentucky	38 sq. ft. /student + 228 sq. ft. storage
Minnesota	2400 sq. ft.
Mississippi	24' x 32' - 768 sq. ft.
New Jersey	40 sq. ft. /student
Oregon	25-35 sq. ft. /student
Pennsylvania	35 sq. ft. /student
South Carolina	1000 sq. ft.
Tennessee	34 sq. ft. /student
West Virginia	45 sq. ft. /student
Wisconsin	35 sq. ft. /student = 10-15% for storage

Typing Lab

Alabama	25-30 sq. ft. /student
California	30 sq. ft. /student
Florida	40-50 sq. ft. /student
Georgia	30 sq. ft. /student
Hawaii	1320 sq. ft. + 420 sq. ft. office and workroom
Kentucky	38 sq. ft. /student + 228 sq. ft. storage
Mississippi	25-30 sq. ft. /student
Minnesota	1200 sq. ft.
New Jersey	36 sq. ft. /student
North Dakota	20-25 sq. ft. /student
Oregon	25-35 sq. ft/student
Pennsylvania	26 sq. ft. /student
South Carolina	1000 sq. ft.
Tennessee	24 sq. ft. /student

Typing Lab

West Virginia	30 sq. ft. /student
Wisconsin	25 sq. ft. /student + 10-15% storage

Stenography Lab

Alabama	20-25 sq. ft. /student
California	27 sq. ft/student
Florida	40-50 sq. ft. /student
Georgia	25 sq. ft. /student
Kentucky	38 sq. ft. /student + 228 sq. ft. storage
Minnesota	1200 sq. ft.
Mississippi	25-30 sq. ft. /student
New Jersey	33 sq. ft. /student
North Dakota	20-25 sq. ft. /student
Oregon	25-35 sq. ft. /student
Pennsylvania	26 sq. ft. /student
South Carolina	1000 sq. ft.
Tennessee	24 sq. ft. /student
West Virginia	30 sq. ft. /student
Wisconsin	40 sq. ft. /student + 10-15% for storage

STATE STANDARDS - HOME ECONOMICS

Child Care

Florida	75-90 sq. ft. /student
Georgia	46 sq. ft. /student
Louisiana	1500 sq. ft.
New Jersey	80 sq. ft. /student
West Virginia	60-70 sq. ft. /student
Wisconsin	60 sq. ft. /student + 15% wall storage

Clothing - Textiles

Alabama	840 sq. ft.
Florida	60-75 sq. ft. /student
Georgia	46 sq. ft. /student
Idaho	24 pupil - 50' x 30' area; 72 pupil - 120' x 28' area; 100 pupil - 160' x 30'
Louisiana	1500 sq. ft.
Nebraska	80 sq. ft. /student - 1 room department
New Jersey	56 sq. ft. /student + 120 sq. ft. storage
North Dakota	50-60 sq. ft. /student
Ohio	1000 sq. ft.
Oregon	50-75 sq. ft. /student
South Carolina	140-375 sq. ft. /student
Tennessee	52 sq. ft. /student + 48 sq. ft. storage
Virginia	1 teacher unit 22' x 64' or 1408 sq. ft.
Washington	62 sq. ft. /student
West Virginia	40-50 sq. ft. /student + storage
Wisconsin	70 sq. ft. /student + 10% wall storage

Commercial Cooking

Florida	115 sq. ft. /student

Foods

Alabama	864 sq. ft.
Florida	65-75 sq. ft. /student
Georgia	46 sq. ft. /student
Idaho	24 pupil - 50' x 30' area; 72 pupil - 120' x 28' area; 100 pupil - 160' x 30'
Louisiana	1500 sq. ft.
Minnesota	1500 sq. ft.
Nebraska	80 sq. ft. /student
New Jersey	56 sq. ft. /student
North Dakota	50-60 sq. ft. /student
Ohio	1200 sq. ft.
Oregon	50-75 sq. ft. /student
Tennessee	52 sq. ft. /student + 48 sq. ft. storage
Virginia	1408 sq. ft. - 1 teacher unit or 2816 - 2 teacher units
Washington	62 sq. ft. /student
West Virginia	60-70 sq. ft. /student
Wisconsin	85 sq. ft. /student + 10% wall storage

Food Service

Minnesota	1500 sq. ft.
New Jersey	83 sq. ft. /student
Wisconsin	1500 sq. ft. + 300 sq. ft. for cafeteria

Home Management

New Jersey	50 sq. ft. /student
Wisconsin	65 sq. ft. /student + 15% wall storage

Industrial Sewing

Georgia	50 sq. ft/student (minimum) 75 sq. ft/student (adequate) 100 sq. ft, /student (desirable)
Michigan	100 sq. ft. /student
Ohio	1000 sq. ft. - 2000 sq. ft.
Oregon	50-75 sq. ft. /student
South Carolina	1363 sq. ft.
Tennessee	1920 sq. ft.
Washington	50 sq. ft. /student (minimum) 75 sq. ft. /student (adequate) 100 sq. ft. /student (desirable)

STATE STANDARDS - TRADE AND INDUSTRIAL

Air Conditioning, Refrigeration, and Heating Mechanics

Florida	150 sq. ft. /student
Georgia	100 sq. ft. /student (minimum) 150 sq. ft. / student (adequate) 200 sq. ft. /student (desirable)
Idaho	100 sq. ft. /student (minimum) 175 sq. ft. /student (desirable)
Kentucky	3000 sq. ft. + 300 sq. ft. storage
Michigan	100 sq. ft. /student
Minnesota	3200-3600 sq. ft.
New Jersey	2400 sq. ft. + 250 sq. ft. storage
Oregon	100-150 sq. ft. /student
Pennsylvania (heating & ventilating)	2000 sq. ft.
Pennsylvania (refrigeration & air conditioning)	1800 sq. ft.
South Carolina	80-100 sq. ft. /student
Texas	1000 sq. ft.
Virginia	165 sq. ft./student including storage

Appliance Repairs

Florida	120 sq. ft. /student
Georgia	50 sq. ft. /student (minimum) 75 sq. ft. / student (adequate) 100 sq. ft. /student (desirable)
Idaho	75-100 sq. ft. /student
Kentucky	150 sq. ft. /student
Michigan	100 sq. ft. /student
Minnesota	3000 sq. ft.
Mississippi	2500 sq. ft.
New Jersey	115 + 400 sq. ft. storage area
Pennsylvania	1600 sq. ft.

Auto Body

American Automotive Society	4920 sq. ft.
Arkansas	44 sq. ft. /student (work area)
Florida	130 sq. ft. /student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Idaho	100 sq. ft/student (minimum)
	175 sq. ft. /student (desirable)
Kentucky	150 sq. ft. /student
Louisiana	120 sq. ft. /student
Michigan	100 sq. ft. /student
Minnesota	6000 sq. ft.
Mississippi	3000 sq. ft.
New Jersey	4000 sq. ft. + 200 sq. ft. storage
Ohio	2000-4000 sq. ft.
Oregon	100 sq. ft. /student (minimum)
	150 sq. ft. /student (desirable
Pennsylvania	3200 sq. ft.
Tennessee	2400 sq. ft. + 288 sq. ft. for car painting + 96 sq. ft. storage
Virginia	4500 sq. ft. - 245 sq. ft. including spray booth and storage
Washington	100 sq. ft. /student (minimum)
	200 sq. ft. /student (desirable)
Wisconsin	175 sq. ft/student + 20% for storage

Auto Mechanics

Florida	220 sq. ft. /student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Idaho	100 sq. ft. /student (minimum)
	175 sq. ft. /student (adequate)
Kentucky	150 sq. ft. per pupil - 200 sq. ft. storage
	2700 sq. ft. - 1 teacher
	5000 sq. ft. - 2 teachers

Auto Mechanics

Louisiana	120 sq. ft. /student
Michigan	100 sq. ft. /student
Minnesota	6500 sq. ft.
Mississippi	3000 sq. ft.
New Jersey	3000 sq. ft. + 200 sq. ft. storage
Ohio	2000 sq. ft. - 3000 sq. ft. - 4000 sq. ft.
Oregon	100-150 sq. ft. /student
Pennsylvania	3000 sq. ft.
South Carolina	150-210 sq. ft. /student
Tennessee	2400 sq. ft. + 96 sq. ft. storage and tools
Texas	3500 sq. ft.
Virginia	4850 sq. ft. - 240 sq. ft. including storage
Washington	100 sq. ft. /student
Wisconsin	200 sq. ft. per pupil + 10% additional storage

Bricklaying

Florida	180 sq. ft./student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Michigan	100 sq. ft. /student
South Carolina	90-125 sq. ft. /student
Tennessee	1920 sq. ft. + 48 sq. ft. storage

Building Trades, Cabinet & .arpentry Shop

Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Idaho	100 sq. ft. /student (minimum
	175 sq. ft. /student (desirable)
Kentucky	150 sq. ft. /student
Louisiana	120 sq. ft. /student

Michigan	100 sq. ft. /student
Mississippi	3000 sq. ft.
Ohio	2000 sq. ft.
Oregon	100-150 sq. ft. /student
Florida	180 sq. ft. /student
Pennsylvania (cabinet & mill)	2800 sq. ft.
Pennsylvania (carpentry)	3000 sq. ft.
South Carolina	80-100 sq. ft. /student
Tennessee	1920 sq. ft. + 96 sq. ft. for storage and tools
Texas	3000 sq. ft.
Virginia	200 sq. ft. /student
Washington	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Wisconsin	125 sq. ft. /student + 20% for storage

<u>Drafting</u>

California	50 sq. ft. /student (minimum)
	100 sq. ft. /student (desirable)
Florida	90 sq. ft. /student
Georgia	50-100 sq. ft. /student - 75 sq. ft. /student (adequate)
Idaho	50-75 sq. ft. /student
Kentucky	75 sq. ft. /student
Michigan	60-70 sq. ft. /student
Minnesota	1400-1600 sq. ft.
Mississippi	74 sq. ft. /student
New Jersey	100 sq. ft. /student
Ohio	1000 sq. ft. -2000 sq. ft. -74 sq. ft.
Oregon	35-50 sq. ft. per pupil
Tennessee	1056 sq. ft. - 56 sq. ft. + 48 sq. ft. storage
Texas	1650 sq. ft.
Virginia	80 sq. ft. /student
Washington	50-100 sq. ft. /student
Wisconsin	65 sq. ft. /student + 5% additional for storage
Pennsylvania (drafting & design)	1400 sq. ft.
Pennsylvania (drafting Arch. desgn. & structure)	1600 sq. ft.

Electricity

Florida	150 sq. ft. /student
Georgia	50 sq. ft. /student (minimum)
	75 sq. ft. /student (adequate)
	100 sq. ft. /student (desirable)
Idaho	75 sq. ft. /student (minimum
	100 sq. ft. /student (desirable)
Kentucky	150 sq. ft. /student
Michigan	60 sq. ft. /student
Minnesota	2400-2800 sq. ft.
New Jersey	115 sq. ft. + 200 sq. ft. storage
Oregon	50-75 sq. ft./student
Pennsylvania	2600 sq. ft.
South Carolina	110-140 sq. ft. /student
Tennessee	1056 sq. ft. + 48 sq. ft. storage
Texas	3700 sq. ft.
Virginia	3040 sq. ft. - 150 sq. ft/student
Washington	100 sq. ft./student (minimum)
	200 sq. ft. /student (desirable)

Electronics

Florida	120 sq. ft. /student
Georgia	50 sq. ft. /student (minimum)
	75 sq. ft. /student (adequate)
	100 sq. ft. /student (desirable)
Michigan	60 sq. ft. /student
Minnesota	2000-2400 sq. ft.
Mississippi	2500 sq. ft.
New Jersey	90 sq. ft. /student + 300 sq. ft. tool room
Oregon	50-75 sq. ft. /student
Pennsylvania	1400 sq. ft.
Tennessee	1056 sq. ft. + 96 sq. ft. for tools and storage
Virginia	117 sq. ft. /student including storage
Wisconsin	110 sq. ft. /student + 12% for storage

Graphic Arts

California	75 sq. ft. /student (minimum)
	125 sq. ft. /student(desirable)
Florida	150 sq. ft. /student
Michigan	100 sq. ft. /student
Minnesota	2400 sq. ft.
New Jersey	120 sq. ft. /student + 400 sq. ft. storage
Ohio	2000 sq. ft. -4000 sq. ft.
Oregon	100-150 sq. ft./student
South Carolina	70-80 sq. ft. /student
Texas	2000-3000 sq. ft.
Virginia	4100 sq. ft. - 200 sq. ft. including storage
Washington	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Wisconsin	130 sq. ft. /student + 15% storage

Machine Shop

Florida	180 sq. ft. /student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Idaho	100 sq. ft. /student (minimum)
	175 sq. ft. /student (desirable)
Kentucky	200 sq. ft. /student
Louisiana	120 sq. ft. /student
Michigan	100 sq. ft. /student
Mississippi	3000 sq. ft.
New Jersey	120 sq. ft. /student + 300 sq. ft. storage
Ohio	2000 sq. ft. - 4000 sq. ft.
Oregon	100-150 sq. ft. /student
Pennsylvania	3000 sq. ft.
South Carolina	80-95 sq. ft. /student
Tennessee	1920 sq. ft. + 96 sq. ft. tools and storage
Texas	3700 sq. ft.
Virginia	200 sq. ft. /students
Washington	100 sq. ft. /students (minimum)
	200 sq. ft. /students (desirable)
Wisconsin	150 sq. ft. /students + 15% additional storage

Plumbing

Georgia	50 sq. ft. /student (minimum)
	75 sq. ft. /student (adequate)
	100 sq. ft. /student (desirable)
New Jersey	100 sq. ft. /student + 250 sq. ft. storage
Pennsylvania	2000 sq. ft.
Virginia	110 sq. ft. /student + 120 sq. ft. tool room

Radio & Television

Florida	120 sq. ft. /student
Georgia	50 sq. ft. /student (minimum)
	75 sq. ft. /student (adequate)
	100 sq. ft. /student (desirable)
Idaho	75 sq. ft. /student (minimum
	100 sq. ft. /student (desirable)
Kentucky	100 sq. ft. /student
Michigan	60 sq. ft. /student
Ohio	1000 sq. ft. - 2000 sq. ft.
Oregon	50-75 sq. ft. /student
South Carolina	60-80 sq. ft. /student
Tennessee	1056 + 48 sq. ft. storage
Texas	2000 sq. ft.
Washington	50 sq. ft./student (minimum)
	75 sq. ft./student (adequate)
	100 sq. ft./student (desirable)
Wisconsin	110 sq. ft. /student + 12% additional storage

Sheet Metal Shop

Florida	150 sq. ft. /student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Idaho	100 sq. ft. /student (minimum)
	175 sq. ft. /student (desirable)
Kentucky	2700 sq. ft. + 300 sq. ft. storage

Sheet Metal Shop

Louisiana	120 sq. ft. /student
Michigan	100 sq. ft. /student
Ohio	2000-4000 sq. ft.
Oregon	100-150 sq. ft. /student
Pennsylvania	2400 sq. ft.
Tennessee	1056 sq. ft. + 96 sq. ft. tools and storage
Texas	3500 sq. ft.
Virginia	165 sq. ft. /student
Washington	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Wisconsin	115 sq. ft. /student + 10% for storage

Shoe Repair

Florida	75 sq. ft. /student
Pennsylvania	1600 sq. ft.

Small Gasoline Engine Repair

Georgia	100 sq. ft./student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Michigan	100 sq. ft. /student

Tool and Die Making

Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Michigan	100 sq. ft. /student
Pennsylvania	2800 sq. ft.

Watchmaking

Florida	60 sq. ft. /student
Idaho	50 sq. ft. /student (minimum)
	75 sq. ft. /student (desirable)

Welding

Florida	110 sq. ft. /student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)
Kentucky	150 sq. ft. /student
Louisiana	120 sq. ft. /student
Michigan	100 sq. ft. /student
Minnesota	1800-2400 sq. ft.
Mississippi	2500 sq. ft.
New Jersey	2400 sq. ft. + 200 sq. ft. storage
Ohio	2000 sq. ft. - 4000 sq. ft.
Oregon	100-150 sq. ft. /student
Pennsylvania	1800 sq. ft.
South Carolina	70-90 sq. ft. /student
Tennessee	1920 sq. ft. + 48 sq. ft. for storage
Virginia	160 sq. ft. /student
Washington	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
Wisconsin	100 sq. ft. /student + 10% additional storage

Laundering & Dry cleaning

Florida	130 sq. ft. /student
Georgia	100 sq. ft. /student (minimum)
	150 sq. ft. /student (adequate)
	200 sq. ft. /student (desirable)

ALLDERDICE HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
304	858	Typing	29-31	28-30
306	880	Typing	24-30	29-36
312	858	General Business	25-38	23-34
313	704	Law & Sales	22-35	20-32
315	858	Bookkeeping	26-33	26-33
353	1166	Shorthand-Transcription	14-20	58-83
362	880	Shorthand Type-Notehand Exploratory Bus.	32-38	23-28

ALLDERDICE HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Students)
414	858	Home Economics	23-31	28-37
415	798	Clothing Scholars Clothing	17-35	23-46
422	805	Home Economics Home & Inst. Mgt.	18-26	31-45
424	1224	Home [illegible]nomics Mercha[illegible]e- Clothing	14-36	34-87

ALLDERDICE HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
218	924	Drafting & Design	18-30	31-51
225	1750	General Metals Machine Shop	22-31	55-78
226	1078	Graphic Arts	12-29	37-90
227	1298	General Metals	23-26	50-56
228	1078	Wood	19-30	36-57
230	1372	Electronic Tech. Electronics	15-29	47-91
231	1478	Wood	26-30	49-57
427	880	Commercial Art	31	28
429	814	Commercial Art	20	41

ALLEGHENY HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
126	984	General Business	29	34
205	840	Distributive Ed.	19-39	22-44
322	1056	Typing	35-41	26-30
323	840	Typing	28-42	20-30
324	1090	Bookkeeping	24-35	31-45
330	828	Clerical Train.	33-35	24-25
331	667	Shorthand General Business	26-34	20-26

ALLEGHENY HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
222	900	Clothing	16-25	36-56
227	1320	Food Science	17-20	66-77
228	1020	Foods	15-26	39-68

ALLEGHENY HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)

New Facilities Being Added

ARSENAL VOCATIONAL HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
206	572	Exploratory Bus. Recordkeeping General Business	15-23	25-38
301	858	Typing	15-26	33-57
302	836	Shorthand Typing Office Machines	17-31	27-49
304	726	Stenography Typing Shorthand Transcription	15-24	30-48
306	880	Bookkeeping Recordkeeping Personal Business	14-35	25-63

ARSENAL VOCATIONAL HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
110	1366	Food & Nutrition Pers[illegible] Develop.	18-26	53-76
114	704	Food Service	4-14	50-176
123	1034	Cosmetology Cosmetology-Science	26-30	34-40
127	1012	Cosmetology - Science	20-21	48-50
208	880	Industrial Sewing	12-20	44-73
211	880	Industrial Sewing Home Economics	11-23	38-80

CARRICK HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
7	782	Business Law	31	25
101	803	Typing	27-35	23-30
102	760	Bookkeeping	28-40	19-27
		Business Law		
		Shorthand		
		General Business		
110	781	General Business	31	25
113	735	General Business	37	20
114	799	Shorthand	24-37	22-33
		Transcription		
		Typing		
		Clerical Train.		
206	735	General Business	40	18

CARRICK HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
1	828	Home Economics	20-26	32-41
211	900	Home Economics	17-30	30-53

CARRICK HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
B-7	660	General Metal	11-27	24-60
B-8	776	Carpentry	14-28	28-55
		Wood		
210	799	Mechanical Dwg.	17-30	27-47

CONNELLEY VOCATIONAL-TECHNICAL HIGH SCHOOL - TRADE & INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
21-22	3944	Bricklaying	19-28	141-208
27	1743	Welding	13-20	87-134
121	3455	Electric Power	13-26	133-266
123-125	3520	Carpentry	13-25	141-271
126	1904	Air Conditioning & Refrigeration	26	73
127	2510	Auto Service	18-23	109-139
129	2792	Auto Electronics	19-20	140-147
130	1936	Plumbing	20-27	72-97
132	2314	Machine Shop	24-30	77-96
133	2408	Auto Mechanics	23-27	89-105
137-139	3520	Cabinet Shop	26-29	121-135
138	1820	Heating & Ventilating	19-26	70-96
141	1944	Electric Wiring	18-27	72-108
142	1792	Radio & T.V.	16-18	99-112
143	1770	O.V.T. Appliance	21	84
208	766	Printing	24-30	26-32
301	836	Commercial Art	24-32	26-35
400	1300	Drafting & Design	26-28	46-50
403	858	Mechanical Dwg.	31-34	25-28
404	1275	Mec[illegible]ical Dwg. Dra[illegible] Design	19-33	39-67

FIFTH AVENUE HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
206	1296	Distributive Ed.	17-27	48-76
		Economics & Law		
		Business Mgt.		
207	1036	Bookkeeping	17-32	32-61
		General Business		
208	1008	Clerical Train.	14-31	33-72
		Typing		
		Shorthand		
209	768	Exploratory Bus.	24-32	24-32
		Typing		
		Personal Bus.		
210	1080	Typing	29-32	34-37

FIFTH AVENUE HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
106	1120	Foods	21-27	41-53
110	1168	Family Living	23-37	32-51
		Overview		
		Fo[illegible]		
		Home [illegible] Mgt.		
		Child De[illegible]lopment		
111	1128	Clothing	20-31	36-56
		Foods		
		Overview		
112	1120	Clothing	19-27	41-59
		Clothing & Textiles		
114	1004	Nursing Arts	21	48

FIFTH AVENUE HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
2	1146	Graphic Arts	24-33	35-48
3	963	Maintenance-Repair	27	36
4	1451	Wood Special A	21-32	45-69
5	2384	General Metal Ornamental Iron	17-29	82-140
113	1120	Ornamental Iron Mechanical Dwg. Industrial Arts - Layout	18-32	35-62
303	1120	Scientific Helper	19	59

GLADSTONE HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Students)
202	792	Shorthand Typing General Business	22-39	20-36
214	792	Bookkeeping Shorthand	17-40	20-47
215	990	Typing Clerical Training Transcription	17-31	32-58

GLADSTONE HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Students)
B-8	504	Child Develop. Lab.	5-8	63-101
210	288	Child Develop. Lab.	34	9
211	792	Home Economics Overview	10-29	27-79
212	894	Clothing Overview Hom Economics	16-30	30-56

GLADSTONE HIGH SCHOOL _ T[illegible] AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Students)
B-2	1520	General Metal Machine Shop	20-25	61-76
2	1296	Maintenance Repair Wood	10-29	45-129
"3	1296	Service Station Mgt.	10-21	62-129
3	1296	Automotive	14-22	59-92
11	843	Mechanical Dwg.	18-28	30-47

LANGLEY HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
113	576	General Business	29	20
114	690	General Business Shorthand Business Law	19-29	24-36
115	744	Typing	27-37	20-28
116	736	Bookkeeping General Business	18-35	21-41
119	1084	Clerical Training Shorthand Typing	24-30	36-45
120	864	Shorthand Transcription Typing	12-29	30-41
215	494	Distributive Ed. General Business Sales	18-31	16-27

LANGLEY HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
130	836	Foods	14-22	38-60
210	1488	Foods	14-25	59-106
204	1464	Clothing	23-32	46-64

LANGLEY HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
11	1632	Machine Shop Metals	16-26	63-102
7	1944	Carpentry Wood	21-26	75-93
131	836	Commercial Art	9	93
9	1344	Mechanical Dwg.	17-35	38-79
134	1173	Duplicating-Processing Graphic Arts	13-25	47-90

OLIVER HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
110	1034	General Business	24-38	27-43
		Typing		
		Shorthand		
		Transcription		
114	660	Shorthand	24-33	20-28
		Bookkeeping		
115	1113	Clerical Training	29-37	30-38
		Office Machines		
116	814	Law & Economics	29-41	20-28
		Typing		
134	760	Bookkeeping	23-30	25-33
		Law & Economics		

OLIVER HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
208	1496	Home Nursing	22-31	48-68
		Foods		
214	1004	Clothing	13-32	31-77
		Merc[illegible]se-		
		Clothing		
239	1084	Clothing	15-28	39-72

OLIVER HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
37	1840	Printing Shop	12-35	53-153
43	1650	Electric Shop	13-30	55-127
44	849	Mechanical Dwg.	26-30	28-33
45	1496	Metal Shop	25-29	52-60
46	1578	Wood	28-37	43-56

PEABODY HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
109	900	Sales	25-30	30-36
201	840	Typing	19-39	22-44
		Notehand		
202	920	Typing	21-36	26-44
		Clerical Training		
203	874	Bookkeeping	27-37	24-32
204	805	General Business	25-40	20-32
		Shorthand		
206	1080	Shorthand	20	54
		Transcription		
207	1080	Shorthand	23-39	28-47
		Bookkeeping		
219	798	Sales	31	26

PEABODY HIGH SCHOOL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
221	597	Clothing	9-26	23-66
222	1728	Food	14-30	58-123
225	1062	Clot	20-31	34-53
317	1081	Clothing	27-35	31-40
318	1081	Clothing	22-36	30-49
319	1081	Clothing	26-34	32-42

PEABODY HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
9	1451	Printing Graphic Arts	23-27	54-63
10	1414	Wood Construction Tech.	13-27	52-108
13	1953	Ornamental Iron Metal Shop	13-32	61-150
139	726	Drafting Mechanical Dwg.	21-28	26-35
145	506	Mechanical Dwg.	20-29	17-25

PERRY HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
204	672	Bookkeeping Shorthand Law-Economics	26-38	18-26
205	672	Typing Law & Economics Shorthand	22-35	19-31
207	960	General Business Typing	23-40	24-42
208	952	Shorthand Transcription Clerical Training Typing	16-28	34-60

PERRY HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
304	1008	Foods & Nutrition	15-26	39-67
305	864	Family Health Nursing Arts	15-21	41-58
306	1272	Clothing & Textiles	15-33	39-85

PERRY HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
218	1452	Machine Shop Metals	17-33	44-85
221	1640	OVT Carpentry Exploratory Metals	17-32	51-96
224	1166	Electric Shop	17-23	51-69
323	924	Industrial Arts Mechanical Dwg. OVT Construction-Laboratory Construction Tech.	14-26	36-66

SCHENLEY HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
216	1175	Typing	34-40	29-35
218	1175	Office Machines	17-28	42-69
		Clerical Training		
220	750	General Business	32-33	23-23
303	792	Bookkeeping	25-31	26-32
202	792	Shorthand	24-37	21-33
		Transcription		
		Typing		
205	744	Distributive Ed.	28-34	22-27
		General Business		
210	552	Sales & Law	24-38	15-23
		General Business		
214	1728	Typing	21-32	54-82

SCHENLEY HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
209	1650	Food Science	7-9	183-236
213	1872	Foods & Nutrition	25-29	65-75
215	1175	Foods & Nutrition	16-30	39-73
217	1150	Clothing & Textiles	12-22	52-96
219	1200	Clothing & Textiles	18-36	33-67

SCHENLEY HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
B-4	1744	Gas Engine Repair	21-28	62-83
B-5	2206	Printing	26-30	74-85
		Graphic Arts		
B-6	2577	General Metal	20-27	95-129
B-7	1739	Wood	24-30	58-72
B-8	1011	Mechanical Dwg.	19-29	35-53

SOUTH HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
103	528	General Business	37	14
113	672	General Business	40	17
204	529	General Business	38	14
206	828	Shorthand Transcription Typing	25-34	24-33
207	736	Bookkeeping	26-38	19-28
208	989	Typing	31-35	28-32
224	504	General Business	40	13
306	759	Shorthand General Business	19-40	19-40
308	736	Typing Exploratory Business	27-33	22-27
309	1562	Office Machines Office Practice Clerical Training	21-35	74-45
323	2237	Distributive Ed. Sales	25-32	70-89

SOUTH HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
104	550	Child Develop.	33	17
105	1254	Child Develop.	6-9	139-209
124	1190	Foods	16-28	42-74
126	782	Clothing	13-24	33-60
311	1342	Cosmetology	26	52
307	989	Industrial Sewing Clothing Orientation	12-28	35-82
V-202	3097	Bake Shop	25-26	119-124

SOUTH HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
21	924	Shoe Shop	23	40
23	1101	General Metal	18-27	41-61
24	1545	Wood	19-27	57-81
112	836	Mechanical Dwg.	17-29	29-49
121	924	Mechanical Dwg. Orientation	4-32	29-231
V-103	3842	Cabinet	19-25	154-202
V-104	2659	Graphic Arts Printing	21-29	92-127
V-105	2554	Machine Shop	18-19	134-142
V-110	3320	Body & Fender Orientation	21-28	119-158
V-204	2652	Electric Power	21	126
V-205	2720	Electric Wiring Orientation	13-27	101-209

SOUTH HILLS HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
123	644	Sales & Law General Business	26-37	17-25
319	1012	Personal Typing Typing	14-37	27-72
320	690	General Business	31-39	18-22
321	672	General Business Shorthand Stenography	29-40	17-23
323	1416	Typing	36-44	32-40
324	1104	Bookkeeping	31-39	28-36
325	1012	Shorthand Transcription Clerical Training	30-39	26-34
326	690	Typing	31-39	18-22
327	720	Shorthand Bookkeeping	21-37	19-34

SOUTH HILLS HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
210	1101	Merchandise—Clothing Line, Color, & Design Clothing	23-37	30-48
212	1059	Clothing	28-37	29-38
214	1249	Foods	23-34	37-54

SOUTH HILLS HIGH SCHOOL TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
205	988	Wood	20-25	40-49
206	1687	Wood	15-26	65-112

SOUTH HILLS HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
207	1568	Wood	12-25	63-131
239	902	Exp. Automotive Automotive	17-20	45-53
240	1584	Electronics	19-26	61-83
241	2082	General Metal Ornamental Iron	14-25	83-149
419	759	Mechanical Dwg.	26-33	23-29

WASHINGTON VOCATIONAL-TECHNICAL HIGH SCHOOL - TRADE & INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
101	1856	Welding	24-25	74-77
102	1040	Auto Shop	20-31	34-52
103	2206	Structural Layout and Fitter	18-34	65-123
106	1775	Machine Shop	24-36	49-74
110	3245	Auto Mechanics	25-29	112-130
202	1850	Cabinet Shop	28-34	54-66
301	2077	Appliance Repair	28-33	63-74
302	1823	Electric Wiring	17-37	49-107
306	1728	Electronics	22-32	54-78
505	1225	Mechanical Dwg.	35-42	29-35
506	1320	Mechanical Dwg.	25-41	32-53

WESTINGHOUSE HIGH SCHOOL - BUSINESS EDUCATION

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
201	696	Law & Economics Distributive Ed. Business English	17-37	19-41
230	1012	Clerical Training Exploratory Bus. Typing	26-40	25-39
232	1310	Shorthand Transcription Office Practice Record Keeping Typing	25-34	39-52
234	770	Business Math Exploratory Bus. Law & Economics Recordkeeping	28-35	22-28
236	682	Bookkeeping Recordkeeping Typing	16-36	19-43
238	644	Typing Typing/Record-keeping Explor[illegible] Bus. Notehand	18-40	16-36

WESTINGHOUSE HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
B-27	1306	Commercial Laundry & Dry cleaning Merchandise-Clothing Clothing	12-24	54-109
312	1081	Clothing	22-31	35-49

WESTINGHOUSE HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
314	1150	Foods	22-30	38-52
		Personal Develop.		
315	725	Foods	16-24	30-45
316	943	Clothing	15-27	35-63
		Child Develop.		
101 & 102	1800	Child Develop.	7-26	69-257
328	552	Food Science	6-14	39-92
330	1248	Food Science	17-29	43-73
		Foods		
334	1536	Food Science	18-30	51-85
		Foods		
		Foods & Nutrition		
		Personal Develop.		
338	644	Nursing Arts	11-25	26-59

WESTINGHOUSE HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
14	1276	Print Shop	16-25	51-79
30	1981	Carpentry Shop	14-26	76-142
34	1632	Auto Shop	21-27	60-78
113	1458	OVT Horticulture	24-25	58-61
		Exp. Horticulture		
137	644	Mechanical Dwg.	18-25	26-36
131	1401	Small Appliance	19-30	47-74
		Repair		
155	1058	Drafting & Design	15-31	34-71
202	1128	Research Lab.	27	42
		Assistant		
212	1056	Research Lab.	24	44
		Assistant		
15/28	1081	Wood	13-27	40-83

WESTINGHOUSE HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
32	1638	Wood Mechanical Dwg.	18-30	55-91
33	1612	Metal Shop	15-32	50-107

CONROY JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
109	832	Clothing	14-26	32-59
111	832	Foods	6-23	36-138
209	832	Foods	21	39

CONROY JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
16	1750	General Metal	18-29	60-97
118	1586	Wood	20-27	59-79
219	671	Mechanical Dwg.	12-17	39-56

GREENFIELD JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
107	1008	Foods Clothing Overview	12-35	29-84
108	1400	Foods Clothing	13-29	48-108

GREENFIELD JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
101	1594	Wood	13-30	53-124
112	1008	Wood	13-30	34-78

HERRON HILL JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
215	682	Foods	18-24	28-38
217	682	Foods	11-23	30-62
306	1355	Clothing Foods	10-24	56-136
307	952	Foods Clothing	10-19	50-95

HERRON HILL JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
B-9	1464	Wood	14-27	54-104
8	1032	Graphic Arts	8-24	43-129
13	1122	Mechanical Dwg.	11-22	51-102

KNOXVILLE JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
212	1081	Clothing	23-34	32-47
213	1380	Foods	19-34	41-73

KNOXVILLE JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
11	1863	Wood	29-30	62-64
12	1364	General Metal	25-30	45-54
13	1320	Graphic Arts	22-31	43-60

LATIMER JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
103	728	Clothing	18-28	26-40
105	638	Clothing & Textiles	24-32	20-27
107	678	Clothing	14-20	34-48
109	649	Foods & Nutrition	14-30	22-46
111	667	Foods	16-35	19-42

LATIMER JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
106	850	Wood	17-34	25-50
110	966	General Metal	19-31	31-51
112	875	Wood	16-34	26-55
204	875	Mechanical Dwg.	21-30	29-42

MIFFLIN JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
112	1472	Foods	11-26	57-133

MIFFLIN JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
13	1700	Wood Mechanical Dwg. Electric Shop	16-25	68-106

PROSPECT JUNIOR HIGH SCHOOL - HOME ECONOMICS

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
102	858	Foods	20-32	27-43
313	1143	Clothing	22-33	35-52
315	858	Foods	21-31	28-41

PROSPECT JUNIOR HIGH SCHOOL - TRADE AND INDUSTRIAL

Room	Room Area (Square Feet)	Classes	Class Size (Students)	Space Utilization (Square Feet/Student)
101	1388	Mechanical Dwg.	16-38	37-87
115	1254	Electric	19-37	34-66
116	1298	Wood	22-33	39-59

Part 7 8 8

APPENDIX

Costs Associated with Facility Changes

Design Parameters for the Environmental System

Dimensional Analysis of Existing Vocational Space for Module Installation

A Survey of Ceiling Heights in the Vocational Laboratories of Pittsburgh Public Schools

7

Prepared by The Research Team For A Comprehensive Concept For Vocational Education Facilities

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SECTION ONE

COSTS ASSOCIATED WITH FACILITY CHANGES

Modifications to laboratories in buildings of standard, inflexible construction are expensive. To illustrate this, a list of typical changes is presented in this section. The items listed were taken from work statements in the files of the Occupational, Vocational, Technical Education Division of the Pittsburgh Public Schools. All items relate to relocation, removal, or installation of equipment and related work.

A further indication of the amount of money spent for such work is presented in the list of "Appropriations and Expenditures for Repairs and Replacement of Old Equipment and Purchase and Installation of New Equipment" and the summary chart that also appears in this section. These figures are taken from Pittsburgh Board of Public Education Minutes from 1948 to 1966. The dramatic increase in appropriations and expenditures occurred in 1965 partially because Federal programs provided the resources for a massive retooling of vocational facilities.

Although laboratories designed to accommodate future changes do not exist in Pittsburgh and comparisons cannot be made, the researchers believe that modifications to vocational facilities could be accomplished much less expensively in a building provided with the environmental system described in Unit Two.

Sample Expenditures for Relocation, Removal, or Installation of Equipment

1.	Disconnect 2 gas soldering furnaces. Remove and cap gas lines.	$ 72.32
2.	Remove chalk board	36.40
3.	Disconnect electrical connections to 18 machines and reconnect new machines using the existing power services.	105.56
4.	Disconnect 12 carpentry machines and replace with new similar equipment and install new 220 volt 3 phase outlet for radial saw.	750.20
5.	Connect mortiser	43.98
6.	Remove partition wall	125.00
7.	Connect 3 phase motor controls and power to single phase for new heater.	288.46
8.	Connect 2 grinders in Auto Shops	333.47
9.	Install conduit, 2 locking types receptacles and plugs for 3 phase welder in Sheet Metal Shop	93.21
10.	Remove and replace floor for electricians	49.32
11.	Disconnect and reconnect cooler	51.36
12.	Install electric plug for cash register.	34.51

13.	Construct and install exhaust hood over welding, melting, and treating area	$1,088.57
14.	Lift floor and replace sink for electricians	116.44
15.	Reconnect existing 220 volt line panel board	146.21
16.	Construct exhaust hood over proposed welding, heat-treating, and foundry area	1,101.23
17.	Install double convenience outlet in Wood Shop	68.84
18.	Make electrical connections for steam table	60.88
19.	Disconnect gas line on printing press	9.50
20.	Install conduit for installation of telephone in auto service center	368.40
21.	Move spindle sander to new location in Cabinet Shop	65.16
22.	Disconnect 3 pieces of equipment and connect with new equipment in Cabinet Shop	174.46
23.	Disconnect 36" band saw and connect 30" band saw in same location	63.69
24.	Disconnect and relocate drill press scroll saw. Disconnect wood lathe and replace with new machine. Dis-	

	connect one Mummert-Dixon. Install pedestal grinder, unisaw, planer, and sander.	$ 500.56
25.	Install soldering furnace	102.11
26.	Connect melting pot	30.64
27.	Disconnect 3 soldering furnaces and install 2 soldering furnaces on same bench. Connect melting furnace.	196.36
28.	Install 220 volt receptacles for welders and auto service and automotive shops	225.97
29.	Disconnect engine lathes in electric shop and install in auto shop	78.73
30.	Disconnect printing machines	20.68
31.	Connect nine pieces of new and existing equipment in manufacturing lab	830.85
32.	Install 6 double electrical outlets	169.67
33.	Disconnect old and connect new grinder motor in metal shop	276.30
34.	Install 3 air outlets in instrumentation lab	221.01

Appropriations and Expenditures for Repairs and Replacement of Old Equipment and Purchase and Installation of New Equipment, 1948-1966

January-December, 1948	Appropriations after Revision	Expenditures
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 26,790.73	$ 24,615.31
Home Economics	87,556.84	58,864.40
SPECIAL EQUIPMENT - Account 382		
Industrial Education	5,500.00	5,281.03
Home Economics	13,380.00	11,206.90
TOTAL	$133,227.57	$ 99,967.64

January-December, 1949		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 49,122.64	$ 46,599.92
Home Economics	92,161.48	91,225.41
SPECIAL EQUIPMENT - Account 382		
Industrial Education	4,250.00	4,116.93
Home Economics	3,126.56	2,934.17
TOTAL	$148,660.68	$144,876.43

January-December, 1950		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 47,139.36	$ 40,500.86
Home Economics	40,835.09	33,688.13
SPECIAL EQUIPMENT - Account 382		
Industrial Education	5,000.00	4,980.98
Home Economics	8,000.00	812.53
TOTAL	$100,974.45	$ 79,982.50

January-December, 1951	Appropriations after Revision	Expenditures
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Commercial Education	$ 1,500.00	$ 1,443.76
Industrial Education	30,086.80	29,055.91
Home Economics	14,620.64	14,487.42
SPECIAL EQUIPMENT - Account 382		
Commercial Education	10,150.00	7,969.44
Industrial Education	35,500.00	26,357.04
Home Economics	41,500.42	39,834.06
TOTAL	$133,357.86	$119,147.63
January-December, 1952		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 23,871.17	$ 23,436.94
Home Economics	7,068.71	4,539.81
Commercial Education	10,615.76	9,638.11
SPECIAL EQUIPMENT - Account 382		
Industrial Education	46,956.17	43,322.63
Home Economics	34,317.45	33,153.88
Commercial Education	6,017.19	3,882.20
TOTAL	$128,846.45	$117,973.57
January-December, 1953		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	22,930.33	21,841.61
Home Economics	9,197.83	8,544.84
Commercial Education	16,128.51	10,467.68
SPECIAL EQUIPMENT - Account 382		
Industrial Education	39,581.25	36,626.14
Home Economics	33,740.73	25,199.03
Commercial Education	5,501.00	5,415.82
TOTAL	$127,079.65	$108,095.12

January-December, 1954	Appropriations after Revision	Expenditures
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Commercial Education	$ 16,647.86	$ 15,391.66
Industrial Education	25,548.22	22,524.61
Home Economics	3,402.22	3,238.61
SPECIAL EQUIPMENT - Account 382		
Commercial Education	1,600.00	1,572.99
Industrial Education	7,914.05	5,026.58
Home Economics	24,474.39	16,939.57
TOTAL	$ 79,586.74	$ 64,694.02

January-December, 1955		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Commercial Education	15,092.99	14,184.87
Industrial Education	20,323.50	19,707.25
Home Economics	8,879.44	8,570.33
SPECIAL EQUIPMENT - Account 382		
Commercial Education	1,500.00	1,335.02
Industrial Education	10,281.68	8,098.63
Home Economics	18,601.21	18,592.41
TOTAL	$ 74,678.82	$ 70,488.51

January-December, 1956		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 19,058.00	$ 17,897.99
Home Economics	8,473.40	3,211.30
Commercial Education	21,555.07	20,872.87
SPECIAL EQUIPMENT - Account 382		
Industrial Education	26,074.84	21,084.34
Home Economics	11,650.00	10,074.92
Commercial Education	4,088.00	3,487.90
TOTAL	$ 90,899.31	$ 76,629.32

January-December, 1957	Appropriations after Revision	Expenditures
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Commercial Education	$ 22,951.93	$ 21,554.65
Industrial Education	19,037.56	18,679.40
Home Economics	11,720.95	11,331.32
SPECIAL EQUIPMENT - Account 382		
Commercial Education	1,900.15	1,887.34
Industrial Education	19,828.12	19,100.85
Home Economics	17,521.17	15,485.45
TOTAL	$92,959.88	$ 88,039.01

January-December, 1958		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 27,340.76	$ 26,161.16
Home Economics	6,767.83	5,950.16
Commercial Education	48,254.64	46,937.63
SPECIAL EQUIPMENT - Account 382		
Industrial Education	4,178.35	3,077.07
Home Economics	15,154.51	14,642.12
Commercial Education	6,680.00	6,519.25
TOTAL	$108,376.09	$103,287.39

January-December, 1959		
REPAIRS AND REPLACEMENT OF EQUIPMENT - Account 282		
Industrial Education	$ 13,233.24	$ 13,233.24
Home Economics	11,036.26	11,036.26
Commercial Education	16,433.54	15,179.54
SPECIAL EQUIPMENT - Account 382		
Industrial Education	8,985.96	3,986.81
Home Economics	10,401.58	10,258.73
Commercial Education	4,060.00	4,041.62
TOTAL	$ 64,150.58	$ 57,736.20

January-December, 1960	Appropriations after Revision	Expenditures
MAINTENANCE OF SCHOOL PLANT Item 2		
Repairs and Replacement of Equipment:		
Vocational Education	$ 39,600.00	$ 32,549.38
Home Economics	20,200.00	16,868.82
Business Education	75,864.00	26,186.16
SPECIAL INSTRUCTION APPARATUS-Item 3		
Vocational Education	10,690.00	6,761.64
Home Economics	8,468.28	4,836.72
Business Education	8,500.00	6,798.90
TOTAL	$163,322.28	$ 94,001.62

January-December, 1961	Appropriations after Transfers	Expenditures	Accounts Payabl[e]
MAINTENANCE OF SCHOOL PLANT - Item 2			
Repairs and Replacement of equipment:			
Vocational Education	$ 36,704.48	$26,293.17	$10,405.04
Home Economics	22,395.03	15,763.71	6,596.81
Business Education	72,211.25	61,938.08	10,061.05
SPECIAL INSTRUCTION APPARATUS - Item 3			
Vocational Education	11,718.47	6,533.21	5,179.23
Home Economics	15,425.90	7,182.62	8,243.28
Business Education	3,975.88	2,720.88	1,255.00
TOTAL	$162,431.01	$162,172.08	

January-December, 1962	Appropriations after Transfers	Expenditures	Encumbrances
MAINTENANCE OF SCHOOL PLANT - Item 2			
Equipment Repairs and Replacement by shop:			
Vocational and Industrial Arts	$ 9,545.51	$ 9,257.63	$ 249.79
Home Economics	1,888.24	1,883.95	-
Business Education	475.67	475.67	-
Equipment Repairs and Replacement by contract:			
Vocational and Industrial Arts	9,011.11	7,259.34	1,748.06
Home Economics	14,257.90	11,974.19	2,283.57
Business Education	45,177.14	44,243.09	643.77
SPECIAL INSTRUCTION APPARATUS - Item 3			
Instructional equipment by shop:			
Vocational and Industrial Arts	312.00	312.00	-
Business Education	39.97	39.97	-

SPECIAL INSTRUCTION APPARATUS - Item 3 continued - 1962

	Appropriations after Transfers	Expenditures	Encumbrances
Instructional equipment by contract:			
Vocational and Industrial Arts	$ 4,138.00	$ 3,628.68	$ 490.35
Home Economics	6,005.32	5,942.64	-
Business Education	12,946.22	12,851.22	-
TOTAL	$103,797.08	$103,283.92	
January-December, 1963			
MAINTENANCE OF SCHOOL PLANT - Item 2			
Equipment Repairs by shop:			
Vocational and Industrial Arts	$ 11,350.00	$ 10,808.62	$ 471.05
Home Economics	1,156.45	1,153.05	-
Business Education	54.84	54.84	-
Equipment repairs by contract:			
Vocational and Industrial Arts	9,735.00	5,535.95	4,168.56
Home Economics	11,483.73	9,447.19	1,858.97
Business Education	11,405.16	10,231.27	1,152.70
SPECIAL INSTRUCTION APPARATUS - Item 3			
Instructional Equipment by shop:			
Vocational and Industrial Arts	1,500.00	951.96	1.60
Instructional Equipment by contract:			
Vocational and Industrial Arts	4,603.00	3,153.05	1,405.25
Home Economics	7,502.30	7,318.19	-
Business Education	9,498.40	8,893.73	585.00
TOTAL	$ 68,288.88	$67,190.98	
January-December, 1964			
MAINTENANCE OF SCHOOL PLANT - Item 2			
Equipment Repair by shop:			
Vocational and Industrial Arts	$ 12,300.00	$ 11,310.79	$ 652.99

Equipment repair by shop continued - 1964

	Appropriations after Transfers	Expenditures	Encumbrances
Home Economics	$ 987.01	$ 976.57	$ 10.41
Business Education	500.00	99.21	-
Equipment repairs by contract:			
Vocational and Industrial Arts	48,135.29	25,979.52	22,144.70
Home Economics	8,231.01	7,180.09	775.51
Business Education	15,285.00	12,891.08	2,377.97
SPECIAL INSTRUCTION APPARATUS - Item 3			
Instructional Equipment by shop:			
Vocational and Industrial Arts	287.36	287.36	-
Instructional equipment by contract:			
Vocational and Industrial Arts	29,988.88	29,356.23	632.65
Home Economics	37,181.56	30,920.05	5,915.00
Business Education	4,293.67	3,250.15	618.88
TOTAL	$157,189.78	$155.378.86	

January-December, 1965

	Appropriations after Transfers	Expenditures	Encumbrances
MAINTENANCE OF SCHOOL PLANTS- Item 2			
Equipment repairs by shop:			
O. V. T.	$ 32,499.34	$ 28,888.14	$ 847.55
Home Economics	534.71	534.71	-
Business Education	115.95	115.95	-
Equipment repairs by contract:			
O. V. T.	306,150.46	54,281.89	148,203.68
Home Economics	1,101.56	1,101.56	-
Business Education	15,588.00	13,733.00	1,855.00
SPECIAL INSTRUCTION APPARATUS- Item 3			
Instructional equipment by shop:			
O. V. T.	$ 2,000.00	$ 1,121.75	$ -

SPECIAL INSTRUCTION APPARATUS continued - 1965

	Appropriations after Transfers	Expenditures	Encumbrances
Instructional equipment by contract:			
O. V. T.	$338,499.55	$216,531.95	$121,691.21
Home Economics	7,067.85	2,994.69	4,073.16
Business Education	2,932.60	2,932.59	-
TOTAL	$706,490.02	$598,926.83	

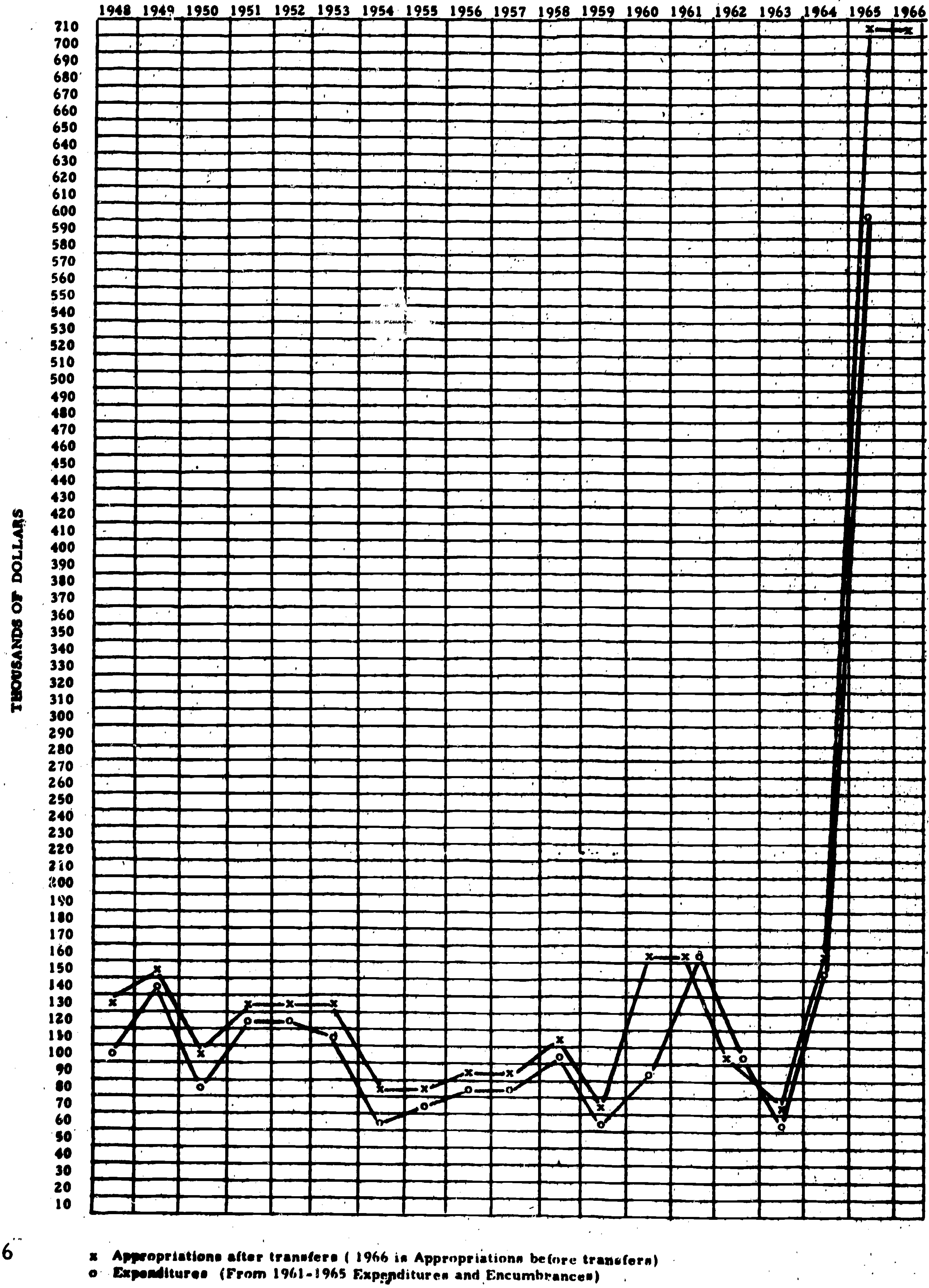
January-December, 1966

	Appropriations before Transfers
Shop Repair	$ 48,000.00
Equipment Repairs and Replacement	2,900.00
Equipment Installation	45,250.00
New Equipment	615,499.00
TOTAL	$711,649.00

APPROPRIATIONS AND EXPENDITURES

REPAIRS AND REPLACEMENT OF OLD EQUIPMENT
and
PURCHASE AND INSTALLATION OF NEW EQUIPMENT

1948 - 1966



x Appropriations after transfers (1966 is Appropriations before transfers)
o Expenditures (From 1961-1965 Expenditures and Encumbrances)

SECTION TWO

DESIGN PARAMETERS FOR THE ENVIRONMENTAL SYSTEM

Development of the environmental system, described in Unit Two, required detailed engineering analysis based on the best assumptions that could be made about the needs for mechanical and electrical systems in vocational laboratories. The following section includes the design analysis performed by the mechanical engineer. This analysis will facilitate evaluation of the environmental system by other technicians and form a basis for further refinement.

Unedited

Preliminary Study for Mechanical and Electrical Systems

1. General Conditions

   a. Buildings to be applied with are primarily existing.

   b. The smallest module unit is 5'-6" x 5'-6" (30 sq. ft.)

   c. The largest width between the exterior walls of a building is 66' or 12 modules.

   d. Ceiling and floor is furred as required.

   e. Finished floor to ceiling height is 9'6".

   f. Each module is entirely flexible to various kinds of usage, including classroom, audio-visual use, chemical laboratory, cosmetology practice, machine tool shop, etc.

   g. Space partitioning is flexible along module lines.

   h. The building is occupied from 8 a.m. to 10 p.m.

   i. Curriculum scheduled is of a high school level.

j. All components are to be arranged same for all modules as much as possible and be assembled at factory shop as much as possible. Field work is to be minimized.

2. HEATING, VENTILATING & AIR CONDITIONING

a. Design Conditions

(1) Lighting load - 5W per sq. ft. or 150W per module (3-40W flourescent lamps).

(2) Equipment load - 5W per sq. ft. or 150W per module (1 smal lab. burner per 2 modules or 1 hair dryer per 3 modules or 1 HP motor per 6 modules).

(3) Occupancy 1 person per module (if more crowded, equipment load is assumed to be lower).

(4) Design temperatures (65-66 ASHRAE Guide, 99% volume).

	Outdoors	Indoors
summer	90°DB/75°WB	78°DB50%RH
winter	5°DB	70°DB

(5) Exterior surface 5'-6"W x 9'-6" = 52 sq. ft.

Window 60% 5'-6"W x 6'-0" = 33 sq.

ft.

Wall 40% 5'-6"W x 3'-6" = 22 sq. ft.

(6) Glass area is furnished with a shade to cut the direct solar radiation.

b. Heat gain (per module)

(1) Sensible heat gain

	Interior	Exterior
lights (150W)	500 BWH	500 BWH
equipment (150W)	500	500
people (1-sedentary work)	250	250
glass - solar	---	---
glass - transmission	---	---
	1,250BWH	2,200 BWH

(2) Latent heat gain

people (1-sedentary work)	200 BWH	200 BWH
equipment (1-bunsen burner)	250	250
	450 BWH	450 BWH

(3) Total heat gain	1,700 BWH	2,650 BWH
(4) Room sensible heat factor	.74	.83
use	.8 for unit	
(5) Supply air @ 58°F.	60cfm	100cfm

c. Heat Loss (exterior module only)

		Interior	Exterior
(1)	Transmission through glass	2,400 BWH	
	heat gain (lights & people)	750	
	net heat loss (day max.)	1,650 BWH	
(2)	heat loss at night (for 60°F)	2,000 BWH	
(3)	supply air temperature	85°F (day) 80°F (night)	

d. Ventilation

(1) Supply air required for air conditioning:

interior module 60 cfm or 2 cfm/sq. ft. or 12.5 air changes per hr.

experior module 100 cfm or 3.3 cfm/sq. ft. or 20 air changes per hr.

They are adequate for any type of room.

(2) Minimum outside air requirement:

7.5 to 10 cfm/person

(3) Maximum outside air requirement to depend on exhaust requirement. Chemical lab. fume hood is one of the largest

exhaust requiring equipment. 70/80 fpm velocity is required through hood opening.

3 foot hood requires 400/500 cfm exhaust.

4 foot hood requires 600/700 cfm exhaust.

5 foot hood requires 800/900 cfm exhaust

that is:

1-3 foot hood per 6 modules

1-5 foot hood per 12 modules

(4) If a row of 6 consecutive modules including 1 exterior module is considered as an ventilation unit,

Total supply air per row	400 cfm
minimum o. A.	60 cfm (15%)
maximum O. A.	400 cfm (100%)

(5) outside air load (per row)

		cooling (dh=8.58W/lb.)	heating (dt=65°)
100%	400 cfm	15,000 BWH	28,000BWH
50%	200 cfm	7,500	14,000
30%	120 cfm	4,500	8,400
15%	60 cfm	2,250	4,200

3. Load Summary (row=6 modules)

	1 row	2 rows	3 rows	6 rows
Supply air cfm	400	800	1200	2400
Min. OA, cfm	60	120	180	360
Cooling w/min. OA, BTU	13,400	26,800	40,200	80,400
Cooling w/min. OA, ton	1.1	2.2	3.3	6.6
Cooling w/max. OA, BTU	26,150	52,300	78,450	156,900
Cooling w/max. OA, ton	2.2	4.4	6.6	13.2
heating, w/min. OA, BTU	5,850	11,700	17,550	35,100
heating, w/min. OA, KW	1.7	3.4	4.2	8.2
heating w/max. OA, BTU	29,650	59,300	88,950	177,900
heating, w/max. OA, KW	8.7	17.4	26.1	52.2

f. System Selection

(1) Module control may be achieved by means of:

(a) terminal reheating and re-cooling

(b) terminal induction unit

(c) dual air mixing unit

Method (1) requires extensive network of cold and hot water piping over the space and needs large space and maintenance at terminal point.

Method (2) does not meet a large exhaust requirement.

By elimination, method (3) is considered.

(2) Air conditioning & heating unit

(a) Totally packaged unit per a group of modules. No central equipment. For instance,

2 ton - 400 cfm unit per 1 row of 6 modules.

3 ton - 800 cfm unit per 2 rows of 6 modules.

5 ton - 1200 cfm unit per 3 rows of 6 modules.

A unit of more than 3 ton unit would become too bulky for local installation.

A 3 ton unit per 2 rows are suggested.

(b) Dual air fan-coil unit per a group of modules. Chilled water and hot water (or steam) are generated centrally and distributed to each fan-coil unit with piping..

400 cfm unit per 1 row

800 cfm unit per 2 rows

1200 cfm unit per 3 rows

2400 cfm unit per 6 rows

A unit of more than 1500 cfm would become too bulky for local installation. 1200 cfm unit per 3 rows are suggested.

(c) Central dual air distribution as well as central chilled and hot water generation and distribution. All local equipment except the terminal dual air mixing devices.

The more a system is centralized, the more it would deviate from the overall modular conception. A centralized system, however, would offer a sizable saving in installation cost as well as operating cost, when the building becomes large. Cost study must be made to determine which system is the most feasible for each particular application.

If a central system is proved to be the most economical for a particular application, an economic study should be made with various fuel available.

For individual unit system, electricity would be the most feasible energy source because the electrical equipment would give the most compact assembly of the unit and also because it creates the least problem of controlling and maintenance of a large number of units.

3. ELECTRICAL SYSTEM

a. Design Conditions

(1) Lighting level - normal 70 F.C.

(2) Power source: 208V, 3 phase, 60 cycle, AC or 110V, 1 phase, 60 cycles, AC

(3) Power sources to be available to each module.

(4) Maximum power requirement is assumed to be 10HP per two modules or 5 HP per module.

(5) Wiring for lighting to run in furred ceiling. Wiring for power and signal to run in raised floor space.

b. Lighting fixtures

Use flourescent lamps.

module 5'-6" x 5'-6" (30 sq. ft.) x 9'-6" high

Total lumens/module = $\frac{F.C. \times area}{M.F. \times C.U.}$

F.C. = Foot-candles 70 F.C.

M.F. = maintenance factor, use .75

C.U. = coefficient of utilization, use .5

For F.C. - 70 lumens = $\frac{70 \times 30}{.75 \times .5}$ = 5,600

4'-40W fixture gives 3,100 lumens

3'-30W fixture gives 2,300 lumens

Thus required numbers of fixtures are as follows:

	70 F.C.
4'-40W	2
3'-30W	3

Use 3-4'-40W fixture.

Total wattage required for 40W fixture = 50W

2 x 50W = 100W/module or 5W/sq. ft.

Branch wire for 6 modules = 600 W

Use 120V, single phase, 10 A. for a row

c. <u>Floor outlets</u>

Each module to have two outlet boxes at both ends, each box consisting of:

1 - 208V, 3 phase, 60 cycle, AC, 30A (10 HP)

1 - 208V, 1 phase, 60 cycle, AC, 30A (5KW)

2 - 120V, 1 phase, 60 cycle, 15A (1.5KW)

1 - telephone

1 - signal

208V, 3 phase, 4 wire branch main runs along a row of 6 modules and is sized for 50A. This allows the following load per the 6 modules: one 208V, 3p, 10H^o motor or 208V, 1p, 5 KW equipment and 120V, 1p, 1.5KW appliance at the same time for maximum.

4. PLUMBING SYSTEM

a. Design Conditions

(1) Required connections per module

1/2" cold water

1/2" hot water

1/2" gas

1/2" compressed air

2" acid waste

(2) Connections are readily accessible and connectable for use, but concealed when not in use and should not stick out of the finished floor.

(3) All plumbing piping are installed in the raised floor space.

b. Branch main pipe sizes

A branch main of each service runs through every row of 6 modules with 2 outlets connections per module (12 outlets per branch main) assume 3 outlets in use at the same time.

Branch main size: cold water 1"
hot water 1"
*gas 11/4"
compressed air 1"
acid waste 3"
waste vent 2"

*6 outlets in use at the same time. Much diversity factor may not be taken for gas service because of a danger of starving caused by too low a gas pressure.

c. Drain pipe requires a slope 1/3" to a foot. Thus about 4" slope is necessary for 33' run.

SECTION THREE

DIMENSIONAL ANALYSIS OF EXISTING VOCATIONAL SPACE FOR MODULE INSTALLATION

A flexible environmental system was described in detail in Unit Two, Flexibility Through Modularity. In the proposed system, mechanical equipment elements are arranged in what might be described as boxes which hang from the ceiling or rest on the floor slab of an existing structural frame. The dimensions of these boxes establish the perimeter of "service modules." Although this system can be installed in new construction, one very important use could be in existing school buildings. In such buildings, the dimension of the module are determined by the dimensions of the existing structural frame. For example, the distance between the exterior walls and the location of columns between the walls dictates the dimension and number of modules that can be placed in the structure.

Although the secondary school buildings in Pittsburgh have varying structural dimensions, a standard module size is necessary in order to enable mass production of the environmental system elements. A standard module had to be designed which, if installed in most existing school buildings, would leave a minimum of area along walls or around columns. The quantity and complexity of the required information indicated that the use of a computer might facilitate analysis. A description of a technique that could be used to explore this type of problem is presented in the preliminary, unedited consultant's report. Data from existing Pittsburgh secondary schools are used to illustrate the process. These interior dimensions were taken from architectural plans and not from actual measurements; however, more accurate dimensions would be necessary before actual computation begins.

Dimensional Analysis Technique

The purpose of this report is to demonstrate the feasibility of using computer techniques in the design of modular elements for the Pittsburgh School Project.

The problem, simply stated, is to arrive at an optimum module size which, when applied to any of a given number of existing school buildings, will cover the greatest amount of surface area and leave the least amount of area to be built as special construction. ("fill-in" conditions to match the established module).

As the data giving the dimensions of rooms, location of structural columns and walls, etc. are considerable, to approach the problem as stated using empirical methods of analysis would be to arrive at a compromise solution at best. However, by establishing appropriate mathematical relationships among the given variables, the data at once become input information for a computer and can be analyzed, correlated, and retrieved in many different forms by programming instructions into the computer as to how to act on the stored data. As the information relating to the remodeled school buildings lends itself to being stated in a form which is acceptable to a computer, to use the computer in its analysis seems obvious.

Without going into the mechanics of program writing or the technical make-up of a computer, perhaps a comment about the computing process will more clearly illustrate the applicability of computer techniques to the stated problem.

The digital computer is physically analogous to a desk calculator, differing from the latter in only three main respects. The computer has a memory, it is faster, and it can make decisions based upon pre-determined criteria. The principal components of the computer are:

1. One or more <u>input devices</u>, such as keyboard, punched card, magnetic tape, and

paper-tape readers;

2. A memory, wherein are stored the coded instructions and numerical values pertinent to the problem being executed;

3. One or more output devices, such as card and paper-tape punches, typewriter and line printers, magnetic tape writers, and oscilloscope picture display;

4. An arithmetic and logical unit capable of addition, subtraction, multiplication, and division, as well as of sensing either a negative or a zero value; and finally

5. A control mechanism whose function is to control the sequence of events within the computer and to interpret and cause execution of the special coded orders which the control unit receives.

The relationships between the five principal computer components can best be understood by examining the system diagram shown in Figure 1.

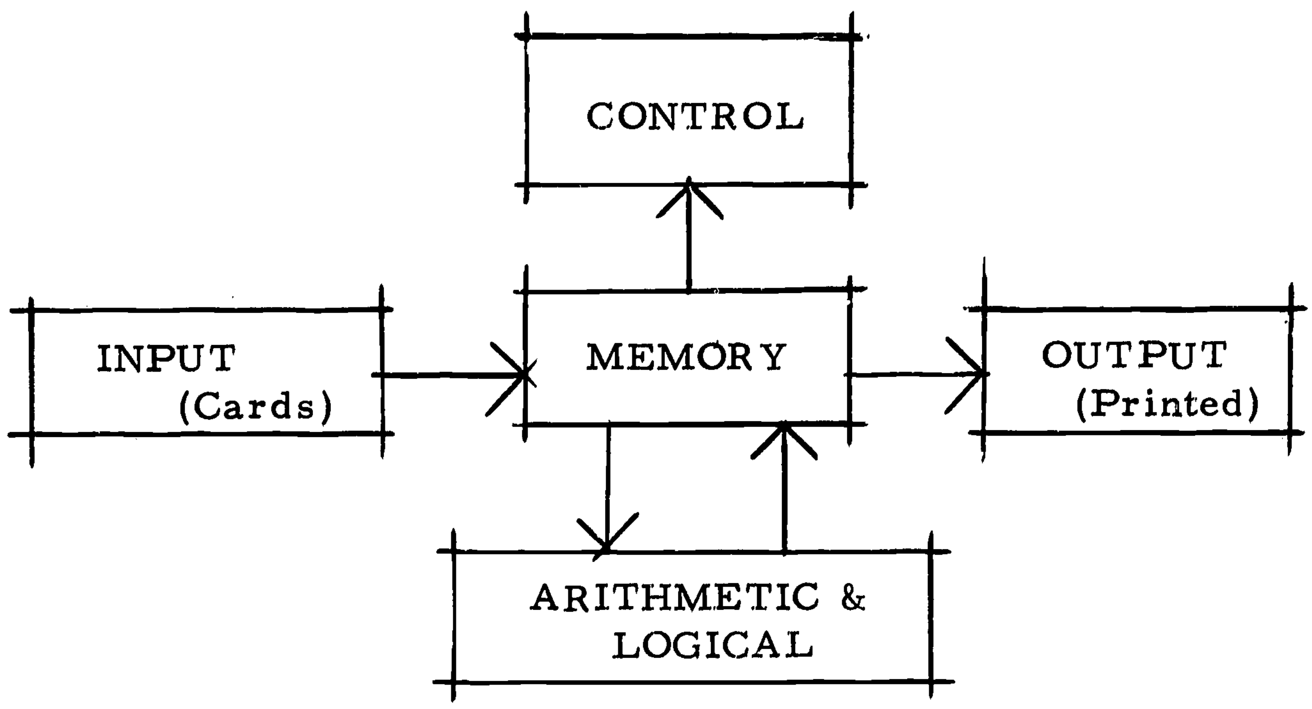


Figure 1

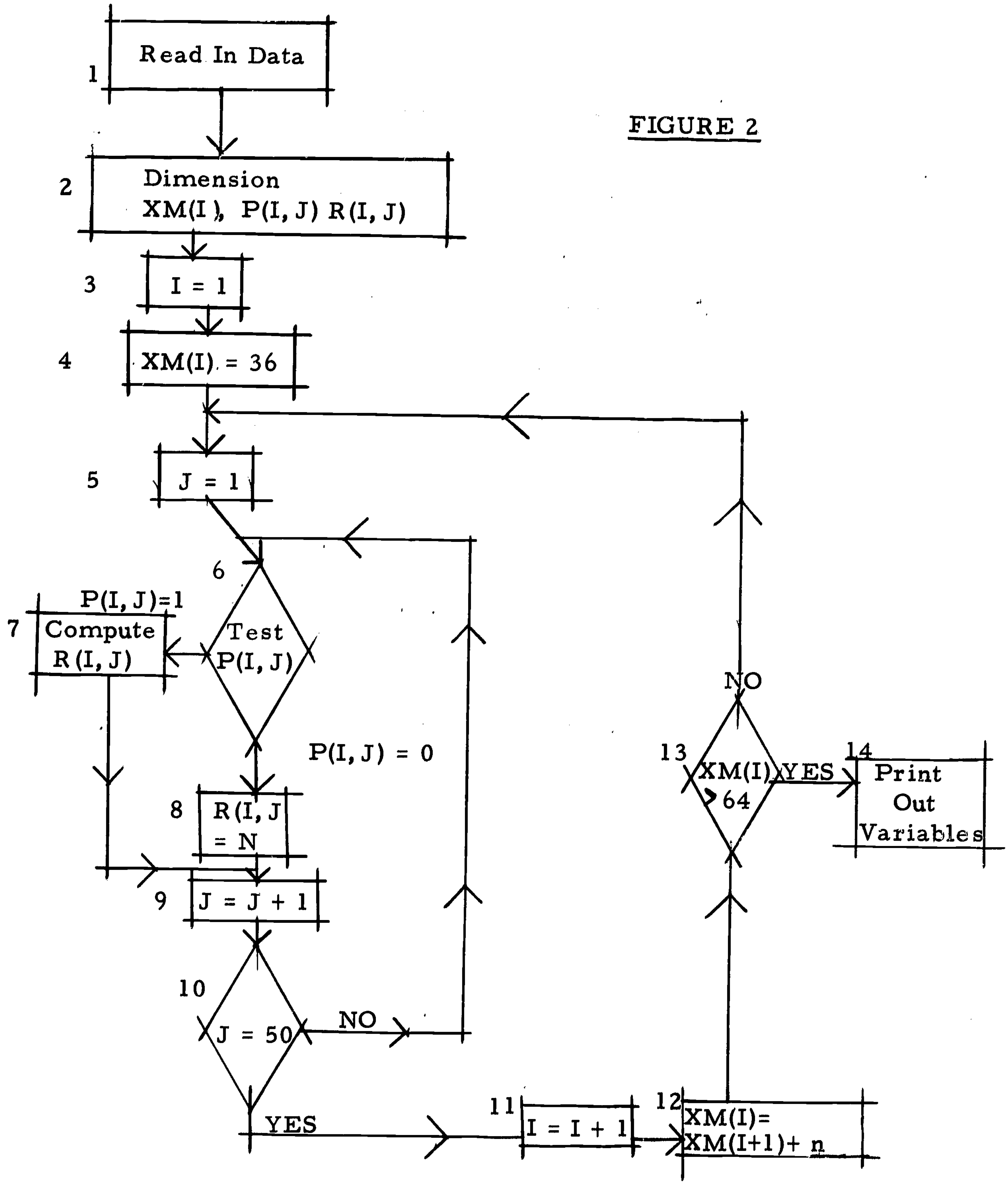
The larger computers most commonly used today (IBM 7090, 7094, 360) can execute many programs simultaneously. As the input and output process is slow when compared to the computing process, the information on cards is converted by an independent device to magnetic tape which is then used as the input tape. Likewise, information on the output tape is converted by an independent device and displayed a line at a time by a printer or presented graphically on a scope. Using an IBM 7094, the actual computing time of the problem with which we are dealing is on the order of 2-5 minutes.

Obviously the greatest human effort is in preparing the material for use by the computer and writing the instructions by which the computer is to act on the information (source program). It is with this task that we shall focus our concern as through the program itself we control the computer.

The task of writing computer programs would seem to depend, among other things, upon our ability to master every computer we wish to use. Fortunately this is not the case. Instead attention must be focused primarily on the definition of the problem and upon the structure or plan for its solution. Ultimate reduction of the plan to a sequence of machine instructions, while absolutely essential, is a process which has been mechanized and therefore not an essential skill required of the programmer. The function which we call programming, therefore, consists of first stating the problem to be solved and then defining step-by-step the procedure for solving the problem.

Shown in Figure 2 is a flow chart which graphically illustrates the logic of the program for determining the optimum modules size for use in the remodeling of discrete school buildings in Pittsburgh. The instructions themselves are written in numerical or alphabetic codes according to the programming language known as Fortran, a computer language commonly used in the solution of scientifically oriented problems. In appearance, Fortran resembles ordinary algebraic expressions. The flow chart itself adequately describes how the computer handles the information as instructed by the source program.

FIGURE 2



1
Read In Data
2
Dimension
XM(I), P(I, J) R(I, J)
3
I = 1
4
XM(I) = 36
5
J = 1
6
Test
P(I, J)
P(I, J)=1
7
Compute
R(I, J)
P(I, J) = 0
8
R(I, J
= N
9
J = J + 1
10
J = 50
NO
YES
11
I = I + 1
12
XM(I)=
XM(I+1)+ n
13
XM(I)
> 64
NO
YES
14
Print
Out
Variables

Explanation of Flow Chart

In the flow chart, the following notations are used:

I = module number

J = wing number

"I" and "J" simply identify the module and wing under consideration at a given point in the program.

i.e.

I - module considered first may have the following characteristics:

width - 36"

J - the first wing considered may have the following characteristics:

length - 200'

width - 70'

column spacing

℄ to ℄	w_1 = 30'	l_1 = 30'
	w_2 = 9'	l_2 = 30'
	w_3 = 31'	l_3 = 30'
		etc.

column size

column line A	15" x 12"
column line B	15" x 18"

Information about the various wings is stored in the computer memory and is called on as needed.

Variables:

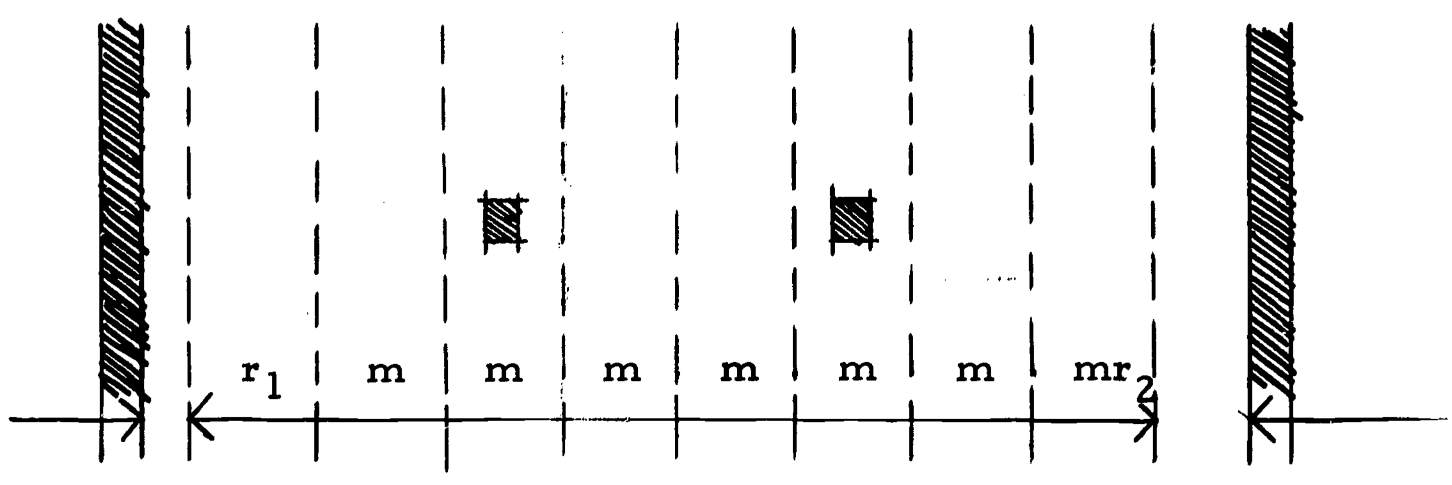
XM(I) - size of Module 1

P(I, J) - characteristic function

1 if module fits
2 if module does not fit

This function relates the module size with the column spacing, window placement, etc. to determine if it is applicable to the particular wing under consideration or not.

R(I, J) - Remaining area not covered by a multiple of the modular element. i.e.



$R(I, J) = r_1 + r_2$

Operation 1

Reads all data into the computer.

Operation 2

Establishes storage locations in memory for the computed results.

Operation 3

Identifies the first module to be considered.

Operation 4

States that the first module is 36" wide.

Operation 5

Identifies the first wing to be considered.

Operation 6

Test to see if the first module is compatible with the first wing. i.e., check to see if module does not interfere with column spacing, etc.

Operation 7

If the module is compatible, the remainder is calculated and the result is stored in memory.

Operation 8

If the module is not compatible, the fact is noted and stored in memory.

Operation 9

The second wing is considered. The same module (36") is evaluated with respect to the particular characteristics of the second wing (re. column spacing, etc.)

Operation 10

Check to see if all the wings have been considered. Until J = the total number of wings, lets say 50, the loop from Operation 6 to 10 is repeatedly processed. When J = total number of wings (i.e. 50), the next module size is ready to be evaluated.

Operation 11

Identifies the second module to be considered.

Operation 12

Increments the first module size by n" so that XM(I) = XM(I+1) + n" or, in fact, the second module = 36" + n".

Operation 13

Similar to Operation 10. Determines if all the modules have been considered. If the range of modules to be considered is, say between 3'-0" and 7'-0", and I is incremented when XM(I) = 64 (7'-0" - 3'-0" = 4'-0"   4'-0" = n" x <u>64</u>), the process is complete. If XM(I) $\leqslant$ 64 the loop is repeated from Operation 5 to 13.

Operation 14

Results printed out in whatever format the programmer prescribes (tabular form, graph, percentages, etc.). This group of results can now be considered as new data and other mathematical operations can be performed using the same procedure in which Operations 1 - 14 were performed.

It becomes apparent how the computer can produce a highly refined result. Human ingenuity can again take over after the miasma of data is once sorted and correlated by the machine. This ultimate product potentially can be the best of what man and machine together can offer. Evidence at hand certainly supports that position.

In the second phase of this project, actual data would form the body of input information for the computer and the process herein described would be written in minute detail in Fortran IV. The subsequent results from the computer should indicate an optimum modular element for the given conditions. Other parameters may be added by enlarging and re-fining the basic program.

DIMENSION SURVEY OF VOCATIONAL ROOMS

1886

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1886	Conroy	16	70 x 25											X																									
A-1935		109	32 x 25											X							X																		
A-1895		111	32 x 25											X							X																		
A-1908		118	61 x 26												X																								
		209	33 x 25											X								X																	
		219	21 x 32							X											X																		

1890

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1890 A-1912	Peabody	9	35 x 38																					X			X												
A-1923			14 x 6																																				
		10	35 x 37																					X		X													
			18 x 6				X																																
			8 x 6																																				
		13	63 x 31																	X																			
		109	36 x 25											X											X														
		139	33 x 22								X											X																	
		145	23 x 22								X	X																											
		201	35 x 24										X											X															
		202	34 x 23									X											X																
			23 x 6									X																											
		203	33 x 23									X										X																	
			23 x 5									X																											
		204	35 x 23									X												X															
		206	36 x 24										X												X														
			24 x 6										X																										
		207	36 x 25											X											X														
			23 x 5									X																											
		219	34 x 21							X													X																
			28 x 3														X																						
		221	25 x 18				X							X																									
			21 x 7								X																												
	Peabody cont.	222	48 x 24										X																								X		
			24 x 24										XX																										
		225	46 x 21							X																									X				
			40 x 2																										X										
			8 x 2																																				
		317	47 x 23									X																								X			
		318	47 x 23									X																								X			
		319	47 x 23									X																								X			

1894

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1894	Fifth	2	31 x 32																	X	X																		
A-1925			11 x 14																																				
		3	27 x 33													x						x																	
			12 x 6																																				
		4	33 x 36																			X			X														
			11 x 23									X																											
		5	68 x 31																	X																			
			46 x 6																																X				
		106	33 x 32																		X	X																	
			11 x 4																																				
			5 x 4																																				
		110	33 x 32																		X	X																	
			16 x 7		X																																		
		111	33 x 32																		X	X																	
			12 x 6																																				
		112	33 x 38																			X					X												
		113	33 x 37																			X				X													
		114	28 x 33														X					X																	
			10 x 8																																				
		206	32 x 28														X				X																		
			11 x 5																																				
			25 x 2											X																									
		207	29 x 32															X			X																		
			16 x 3		X																																		
			15 x 4	X																																			
		208	27 x 32													X					X																		
			12 x 2																																				
		209	21 x 32							X											X																		
			16 x 6		X																																		
		210	29 x 32															X			X																		
		303	33 x 37																			X				X													

Chronological Order 1886-1894 Sheet I

DIMENSION SURVEY OF VOCATIONAL ROOMS

1897

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1897	South	103	24 x 22								X		X																										
A-1922		104	25 x 22								X			X																									
A-1935		105	57 x 22								X																												
A-1938		113	32 x 21							X											X																		
		121	33 x 28														X					X																	
		21	33 x 28														X					X																	
		23	33 x 27													X						X																	
			14 x 15	X																																			
		24	34 x 27													X							X																
			19 x 33					X														X																	
		112	38 x 22								X																X												
		124	33 x 27													X						X																	
			15 x 16	X	X																																		
			12 x 10																																				
		126	34 x 23									X											X																
		204	23 x 23									XX																											
		206	36 x 23									X													X														
		207	23 x 32									X									X																		
		208	43 x 23									X																				X							
		224	28 x 18				X										X																						
		306	33 x 23									X										X																	
		307	43 x 23									X																				X							
		308	32 x 23									X									X																		
		309	71 x 22								X																												
		311	61 x 22								X																												
		323	64 x 27													X																							
			13 x 25											X																									
			8 x 8																																				
			15 x 8	X																																			
		V-103	113 x 34																				X																
		V-104	70 x 34																				X																
			9 x 31																	X																			
		V-105	60 x 33																	X		X																	
			10 x 31																	X																			
		V-110	86 x 35																					X															
			10 x 31																	X																			
		V-202	80 x 35																					X															
			7 x 21							X																													
			8 x 10																																				
		V-204	70 x 35																					X															
			9 x 24										X																										
	South cont.	V-205	80 x 34																				X																

1901

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1901	Latimer	103	26 x 28												X		X																						
		105	29 x 22								X							X																					
		106	34 x 25											X									X																
		107	29 x 18				X											X																					
			26 x 6												X																								
		109	26 x 23									X			X																								
			3 x 17			X																																	
		110	33 x 25											X								X																	
			12 x 8																																				
			9 x 5																																				
		111	29 x 23									X						X																					
		112	35 x 25											X										X															
		204	35 x 25											X										X															

1901

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1901	Perry	204	28 x 24										X				X																						
A-1921		205	28 x 24										X				X																						
A-1925		207	24 x 40										X																X										
		208	28 x 34														X						X																
		218	52 x 22								X																												
			32 x 8																		X																		
		221	54 x 30																X																				
			10 x 12																																				
		224	38 x 23								X																X												
			32 x 7																		X																		
		304	42 x 24										X																		X								
		305	36 x 24										X												X														
		306	53 x 24										X																										
		323	42 x 22								X																				X								

Chronological Order 1897 - 1901 Sheet II

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DIMENSION SURVEY OF VOCATIONAL ROOMS

1904

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1904	Allegh.	22	49 x 30																X																			X	
A-1936			20 x 8						X																														
			11 x 5																																				
		24	51 x 30																X																				
			30 x 5																X																				
			27 x 2													X																							
		122	73 x 30																X																				
			30 x 2																X																				
		126	32 x 30.																X		X																		
			12 x 2																																				
		205	32 x 22								X										X																		
		222	30 x 29															X	X																				
		227	43 x 29															X														X							
			5 x 2																																				
		228	32 x 24										X								X																		
			20 x 10												X																								
	Allegh. cont.	323	28 x 30														X		X																				
		324	35 x 30																X					X															
			20 x 2						X																														
		330	26 x 30												X				X																				
			24 x 2										X																										
		331	23 x 29									X						X																					

1909

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1909	Wash.	101	58 x 34																				X																
A-1930		102	26 x 40												X														X										
A-1935		103	51 x 33																			X																	
			7 x 32																		X																		
			23 x 13									X																											
		106	71 x 25											X																									
		110	65 x 43																													X							
			5 x 9																																				
			9 x 45																																X					
		202	27 x 40													X													X										
			32 x 2																		X																		
			34 x 23									X											X																
		301	59 x 35																					X															
			6 x 2																																				
		302	25 x 7											X																									
			26 x 32												X						X																		
			24 x 34										X										X																
		306	72 x 24										X																										
		505	49 x 24										X																									X	
		506	55 x 24										X																										

1914

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1914	Glad.	Med.Of.	24 x 21							X			X																										
A-1922		2	41 x 24										X																	X									
A-1925			7 x 12																																				
			16 x 11		X																																		
		2B	42 x 49																												X							X	
			6 x 11																																				
			6 x 16		X																																		
		3	47 x 23									X																								X			
			10 x 11																																				
	Glad. cont.	11	31 x 24										X							X																			
			8 x 8																																				
		202	33 x 24										X									X																	
		210	24 x 12										X																										
		211	30 x 24										X						X																				
			4 x 18				X																																
		212	24 x 31										X							X																			
			6 x 25											X																									
		214	24 x 33										X									X																	
		215	35 x 18				X																	X															
			30 x 7																X																				
			6 x 25											X																									

Chronological Order 1904 - 1914 Sheet III

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DIMENSION SURVEY OF VOCATIONAL ROOMS

1915

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1918	Schen.	B-4	56 x 29															X																					
			15 x 8	X																																			
		B-5	76 x 27													X																							
			14 x 11																																				
		B-6	92 x 26												X																								
			13 x 11																																				
			6 x 7																																				
	Schen. cont.	B-7	60 x 27													X																							
			17 x 7			X																																	
		B-8	33 x 26												X							X																	
			15 x 7	X																																			
			8 x 6																																				
		202	33 x 24										X									X																	
		205	31 x 24										X							X																			
		209																																					
		210	23 x 24									X	X																										
		211	26 x 28												X		X																						
		213	50 x 25											X																									X
		214	25 x 51											X																									
		215	47 x 25											X																				X			
		216	47 x 25											X																				X			
		217	46 x 25											X																			X				
		218	47 x 25											X																				X			
		219	48 x 25											X																					X		
		220	30 x 25											X					X																		
		303	33 x 24										X									X																	

1915

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1915 A-1923	South Hills	123	28 x 23									X					X																						
		[illegible]	29 x 28														X	X																					
			16 x 11		X																																		
		206	50 x 28														X																						
			41 x 7																											X									X
		207	56 x 28														X																						
		210	44 x 24										X																				X						
		212	46 x 15	X																															X				
			41 x 9																											X									
		214	50 x 23									X																											X
			9 x 11																																				
		239	41 x 22								X																			X									
		240	56 x 22								X																												
			16 x 7		X																																		
		241	66 x 29															X																					
			24 x 7										X																										
		319	44 x 23									X																					X						
		320	30 x 23									X							X																				
	South Hills cont.	321	28 x 24										X				X																						
		323	59 x 24										X																										
		324	46 x 24										X																						X				
		325	44 x 23									X																					X						
		326	30 x 23									X							X																				
		327	30 x 24										X						X																				
		419	33 x 23									X										X																	

1921

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1921	Green.	107	42 x 24										X																		X								
		108	56 x 25											X																									
		101	45 x 24										X																					X					
			10 x 25											X																									
			22 x 12								X																												
		112	42 x 24										X																		X								

1921

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1921 A-1926	Landry	7	66 x 24										X																										
			15 x 24	X									X																										
		9	53 x 23									X																											
			12 x 6																																				
		11	67 x 24										X																										
			12 x 20						X																														
		113	20 x 24						X				X																										
		114	30 x 23									X							X																				
		115	31 x 24										X							X																			
		116	32 x 23									X									X																		
		119	46 x 23									X																							X				
			2 x 13																																				
		120	36 x 24										X												X														
		215	26 x 19					X							X																								
		130	38 x 22								X																X												
		131	38 x 22								X																X												
		134	51 x 23									X																											
		204	61 x 24										X																										
		210	62 x 21							X																													

Chronological Order 1915-1921 Sheet IV

BEST AVAILABLE COPY

DIMENSION SURVEY OF VOCATIONAL ROOMS

1923

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1923	Alld.	218	42 x 22								X																				X								
A-1929		225	86 x 20						X																														
		226	49 x 22								X																											X	
		227	59 x 22								X																												
		228	49 x 22								X																											X	
		230	56 x 23									X																											
			12 x 7																																				
		231	59 x 22								X																												
			15 x 12	X																																			
		304	39 x 22								X																	X											
		306	40 x 22								X																		X										
		312	39 x 22								X																	X											
		313	32 x 22								X										X																		
		315	39 x 22								X																	X											
		353	53 x 22								X																												
		362	40 x 22								X																		X										
		414	39 x 22								X																	X											
		415	38 x 21							X																	X												
		422	35 x 23									X												X															
		424	45 x 23									X																						X					
			11 x 3																																				
			12 x 13																																				
		427	40 x 22								X																		X										
		429	37 x 22								X															X													

1923

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1923	Oliver	37	79 x 22								X																												
A-1927		43	75 x 22								X																												
		44	37 x 21							X																X													
			9 x 8																																				
		45	68 x 22								X																												
		46	67 x 22								X																												
			8 x 13																																				
		110	47 x 22								X																									X			
		114	30 x 22								X								X																				
		115	53 x 21							X																													
		116	37 x 22								X															X													
		134	38 x 20						X																		X												
		208	68 x 22								X																												
		214	38 x 22								X																X												
			8 x 21							X																													
		239	46 x 22								X																								X				
			8 x 9																																				

1923

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
A-1923	West	B-27	5 x 21							X																													
A-1931			24 x 28										X				X																						
1921			23 x 23									XX																											
		14	58 x 22								X																												
			29 x 4															X																					
			22 x 2								X																												
		15	47 x 23									X																								X			
		30	85 x 21							X																													
			49 x 4																																			X	
		32	66 x 23									X																											
			5 x 24										X																										
		33	64 x 23									X																											
			20 x 7						X																														
	West, cont.	34	63 x 24										X																										
			30 x 7						X																														
		113	63 x 23									X																											
			19 x 7					X																															
		101&102	24 x 29										X					X																					
			46 x 24										X																						X				
		137	28 x 23									X					X																						
		201	29 x 24										X					X																					
		202	47 x 24										X																							X			
		212	44 x 24										X																					X					
		151	39 x 23									X																X											
			18 x 15	X			X																																
			2 x 15	X																																			
			17 x 12			X																																	
		155	46 x 23									X																							X				
		230	44 x 23									X																					X						
		232	40 x 26												X														X										
			7 x 26												X																								
			4 x 22								X																												
		234	35 x 22								X													X															
		236	31 x 22								X									X																			
		238	28 x 23									X					X																						
		312	47 x 23									X																								X			
		314	50 x 23									X																											X
		315	29 x 25											X				X																					
		316	41 x 23									X																		X									
		328	24 x 23									X	X																										
		330	24 x 22								X	X																											
			19 x 26					X							X																								
		334	43 x 22								X																							X						
			8 x 26												X																								
		338	28 x 23									X					X																						

DIMENSION SURVEY OF VOCATIONAL ROOMS

1924

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1924 A-1965	Carrick	B-7	31 x 23									X								X																			
			11 x 3																																				
		B-8	32 x 23									X									X																		
		1	33 x 24										X									X																	
			12 x 3																																				
		7	34 x 23									X											X																
		101	33 x 23									X										X																	
			12 x 2																																				
		102	32 x 23									X									X																		
			12 x 2																																				
		110	33 x 23									X										X																	
			8 x 11																																				
		113	31 x 23									X								X																			
			8 x 11																																				
		114	33 x 23									X										X																	
			10 x 8																																				
		206	31 x 23									X								X																			
			11 x 2																																				
		218	33 x 23									X										X																	
			10 x 2																																				
	Carrick cont.	211	36 x 17			X																			X														
			28 x 3														X																						
			34 x 6																				X																

1926

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1926	Herron Hill	B-9	52 x 23									X																											
			28 x 6														X																						
			13 x 12																																				
		8	40 x 21							X																			X										
			12 x 16		X																																		
		9	63 x 21							X																													
		13	51 x 22								X																												
		215	31 x 22								X									X																			
		217	31 x 22								X									X																			
		306	36 x 21							X															X														
			12 x 16		X																																		
			11 x 37																							X													
		307	36 x 22								X														X														
			10 x 16		X																																		

1927

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1927 A-1935	Knox.	11	81 x 23									X																											
		12	62 x 21							X																													
		13	60 x 22								X																												
		212	47 x 23									X																				X							
		213	60 x 23									X																											

1928

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
[illegible]	Conn.	21&22	116 x 34																				X																
		27	83 x 21							X																													
		121	57 x 54																																				
			35 x 4																					X															
			22 x 9								X																												
			13 x 3																																				
		123-125	64 x 55																																				
		126	68 x 28														X																						
		130	64 x 23									X																											
			40 x 6																										X										
			28 x 8														X																						
		132	67 x 34																				X																
			4 x 9																																				
		133	56 x 43																															X							
			31 x 27													X				X																			
		137-139	64 x 55																																				
		138	65 x 28														X																						
		141	59 x 27													X																							
			27 x 13													X																							
		142	65 x 28														X																						
			11 x 28														X																						
			55 x 9																																				
		143	54 x 27													X																							
			12 x 13																																				
			12 x 13																																				
		208	33 x 22								X											X																	
			8 x 5																																				
		301	38 x 22								X																X												
		400	50 x 26												X																								
		403	39 x 22								X																	X											
		404	51 x 25											X																									

Chronological Order 1924 - 1928 Sheet VI

BEST AVAILABLE COPY

DIMENSION SURVEY OF VOCATIONAL ROOMS

1930

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1930 A-1938	Arsenal	110	24 x 14															X																					
			32 x 23									X									X																		
			28 x 8														X																						
		114	32 x 22								X										X																		
		123	47 x 22								X																									X			
		127	38 x 22								X																X												
			8 x 5																																				
		206	33 x 22								X											X																	
		208	40 x 22								X																		X										
		211	40 x 22								X																		X										
		301	39 x 22								X																	X											
		302	38 x 22								X																X												
		304	33 x 22								X											X																	
		306	40 x 22								X																		X										

1931

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1931 A-1956	Mifflin	13	39 x 34																				X					X											
			4 x 3																																				
			8 x 24										X																										
		112	63 x 23									X																											

1931

Date	School	Room	Dimension	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1931 A-1936	Pros.	101	60 x 22								X																												
			8 x 7																																				
			4 x 3																																				
		102	39 x 22								X																	X											
		115	57 x 22								X																												
		116	59 x 22								X																												
		313	51 x 22								X																												
			9 x 3																																				
		315	39 x 22								X																	X											

Chronological Order 1930 - 1931 Sheet VII

BEST AVAILABLE COPY

SECTION FOUR

A SURVEY OF CEILING HEIGHTS IN THE VOCATIONAL LABORATORIES OF PITTSBURGH PUBLIC SCHOOLS

Installation of environmental system elements which are hung from the ceilings and placed on the floors of existing school buildings requires adequate distance from the surface of structural floor slabs to the bottom of structural beams. If both ceiling and floor units are installed, this distance must be approximately 12' for typical classrooms. If only ceiling units are installed, this distance need be only 10'6". Of course, higher ceiling heights are needed for some industrial laboratories.

The following table lists ceiling and beam heights in the existing secondary schools. Beam heights are listed from lowest to highest, grouping rooms of the same height. These measurements were taken from architectural drawings of the schools. Study of the beam heights show that the majority of existing school buildings could receive ceiling units and that over half could receive both ceiling and floor units.

Ceiling and Beam Heights in Secondary Schools in Pittsburgh

Schools	Room No.	Beam Height	Ceiling Height
Conroy	16	8'0"	9'2"
Schenley	B-3	8'6"	9'10"
	B-4	8'6"	9'10"
	B-6	8'6"	9'10"
	B-7	8'6"	9'10"
	B-8	8'6"	9'10"
Allegheny	22	9'6"	11'0"
	24	9'6"	11'0"
Peabody	225	9'6"	10'3"
	221	9'6"	10'3"
	222	9'6"	10'3"
	229	9'6"	10'3"
	204	9'6"	10'3"
	202	9'6"	10'3"
	203	9'6"	10'3"
	206	9'6"	10'3"
	201	9'6"	10'3"
	207	9'6"	10'3"
	317	9'6"	
	318	9'6"	
	319	9'6"	
Gladstone	B-2	10'0"	10'6"
	B-8	10'0"	10'6"
Arsenal	123	10'6"	12'0"
	127	10'6"	12'0"
	208	10'6"	12'0"
	211	10'6"	12'0"
Mifflin	13	10'6"	11'10"
	112	10'6"	11'10"
Oliver	37	10'9"	12'0"
	43	10'9"	12'0"
	45	10'9"	12'0"
	44	10'9"	12'0"
	46	10'9"	12'0"
	110	10'9"	12'0"
	114	10'9"	12'0"
	116	10'9"	12'0"
	115	10'9"	12'0"
	134	10'9"	12'0"
	Basement	10'9"	12'0"

Schools	Room No.	Beam Height	Ceiling Height
Carrick	1	11'0"	12'0"
	7	11'0"	12'0"
	101	11'0"	12'0"
	102	11'0"	12'0"
	110	11'0"	12'0"
	114	11'0"	12'0"
	206	11'0"	12'0"
	210	11'0"	12'0"
	211	11'0"	12'0"
Langley	7	11'0"	12'0"
	9	11'0"	12'0"
	11	11'0"	12'0"
	130	11'0"	12'0"
	131	11'0"	12'0"
	134	11'0"	12'0"
South	103	11'0"	12'6"
	104	11'0"	12'6"
	105	11'0"	12'6"
	112	11'0"	12'6"
	113	11'0"	12'6"
	204	11'0"	12'6"
	206	11'0"	12'6"
	207	11'0"	12'6"
	208	11'0"	12'6"
South Hills	123	11'0"	12'7"
Knoxville	11	11'2"	12'4"
	12	11'2"	12'4"
	13	11'2"	12'4"
Herron Hill	B-9	11'3"	12'0"
	13	11'3"	12'0"
	9	11'3"	12'0"
	8	11'3"	12'0"
Allderdice	218	11'6"	12'0"
	304	11'6"	12'0"
	306	11'6"	12'0"
	312	11'6"	12'0"
	313	11'6"	12'0"
	353	11'6"	12'0"
	362	11'6"	12'0"
Carrick	B-7	11'6"	12'0"
	B-8	11'6"	12'0

Schools	Room No.	Beam Height	Ceiling Height
Connelley	208	11'6"	12'0"
	301	11'6"	12'0"
Conroy	109	11'6"	12'2"
	111	11'6"	12'2"
	118	11'6"	12'2"
Perry	218	11'6"	12'0"
	221	11'6"	12'0"
	224	11'6"	12'0"
Prospect	101	11'6"	12'0"
	102	11'6"	12'0"
	115	11'6"	12'0"
	116	11'6"	12'0"
	313	11'6"	12'0"
	315	11'6"	12'0"
Washington	101	11'6"	12'0"
	102	11'6"	12'0"
	103	11'6"	12'0"
	106	11'6"	12'0"
	301	11'6"	12'0"
	302	11'6"	12'0"
	306	11'6"	12'0"
Westinghouse	B-27	11'6"	12'0"
	14	11'6"	12'0"
	28	11'6"	12'0"
	30	11'6"	12'0"
	32	11'6"	12'0"
	33	11'6"	12'0"
Oliver	1st floor	11'9"	12'0"
Allderdice	414	12'0"	19'6"
	415	12'0"	19'6"
	422	12'0"	19'6"
	424	12'0"	19'6"
	427	12'0"	19'6"
	429	12'0"	19'6"
Allegheny	205	12'0"	12'4"
Arsenal	302	12'0" suspd.clg.	14'6"
	304	12'0"	14'6"
	306	12'0"	14'6"
	301	12'0"	14'6"

Schools	Room No.	Beam Height	Ceiling Height
Greenfield	101	12'0"	12'10"
	107	12'0"	12'10"
	108	12'0"	12'10"
	112	12'0"	12'10"
South Hills	205	12'0"	13'6"
	206	12'0"	13'6"
	207	12'0"	13'6"
	210	12'0"	13'6"
	212	12'0"	13'6"
	214	12'0"	13'6"
	239	12'0"	13'6"
	240	12'0"	13'6"
	241	12'0"	13'6"
	319	12'0"	13'7"
	320	12'0"	13'7"
	321	12'0"	13'7"
	323	12'0"	13'7"
	324	12'0"	13'7"
	325	12'0"	13'7"
	326	12'0"	13'7"
	327	12'0"	13'7"
Washington	202	12'0"	13'0"
Peabody	9	12'3"	13'0"
	13	12'3"	13'0"
	10	12'3"	13'0"
Allegheny	322	12'6"	14'4"
	323	12'6"	14'4"
	324	12'6"	14'4"
	330	12'6"	14'4"
	331	12'6"	14'4"
Langley	114	12'6"	13'6"
	115	12'6"	13'6"
	116	12'6"	13'6"
	119	12'6"	13'6"
	120	12'6"	13'6"
	215	12'6"	13'6"
	210	12'6"	13'6"
	204	12'6"	13'6"
Schenley	202	12'6"	13'0"
	205	12'6"	13'0"
	210	12'6"	13'0"
	213	12'6"	13'0"

Schools	Room No.	Beam Height	Ceiling Height
Schenley (continued)	214	12'6"	13'0"
	215	12'6"	13'0"
	216	12'6"	13'0"
	217	12'6"	13'0"
	218	12'6"	13'0"
	219	12'6"	13'0"
	220	12'6"	13'0"
South Voc.	103	12'6"	14'2"
	104	12'6"	14'2"
	105	12'6"	14'2"
	110	12'6"	14'2"
Westinghouse	202	12'6"	13'2"
	212	12'6"	13'2"
	230	12'6"	13'2"
	232	12'6"	13'2"
	234	12'6"	13'2"
	236	12'6"	13'2"
Latimer	204	12'8"	14'0"
Conroy	209	12'9" suspd clg.	16'6"
	219	12'9" "	16'6"
Allderdice	225	13'0"	
	226	13'0"	
	228	13'0"	
	230	13'0"	
Arsenal	110	13'0"	14'4"
	112	13'0"	14'4"
	114	13'0"	14'4"
Perry	204	13'0"	13'6"
	205	13'0"	13'6"
	207	13'0"	13'6"
	208	13'0"	13'6"
South	306	13'0" suspd. clg.	15'0" structural clg.
	307	13'0" "	15'0" "
	308	13'0" "	15'0" "
	309	13'0" "	15'0" "
	311	13'0" "	15'0" "
Westinghouse	113	13'0"	13'6"
	137	13'0"	13'6"
	151	13'0"	13'6"

Schools	Room No.	Beam Height	Ceiling Height
Westinghouse (continued)	155	13'0"	13'6"
	314	13'0"	13'8"
	315	13'0"	13'8"
	330	13'0"	13'8"
	334	13'0"	13'8"
	328	13'0"	13'8"
	338	13'0"	13'8"
Peabody	109	13'3"	14'3"
	145	13'3"	14'3"
Allegheny	122	13'6"	15'0"
	126	13'6"	15'0"
	222	13'6"	15'0"
	227	13'6"	15'0"
	228	13'6"	15'0"
Gladstone	2	13'6"	14'0"
	3	13'6"	14'0"
	11	13'6"	14'0"
	202	13'6" furred clg.	15'0"
	210	13'6" "	15'0"
	211	13'6" "	15'0"
	212	13'6" "	15'0"
	214	13'6" "	15'0"
	215	13'6" "	15'0"
South Hills	419	13'6"	15'0"
Latimer	103	13'8"	14'6"
	105	13'8"	14'6"
	106	13'8"	14'6"
	107	13'8"	14'6"
	109	13'8"	14'6"
	110	13'8"	14'6"
	111	13'8"	14'6"
	112	13'8"	14'6"
Oliver	2nd floor	14'2"	
Knoxville	213	14'6"	15'4"
	212	14'6"	15'4"
Perry	323	15'0" suspd. clg.	
Schenley	303	15'2"	16'6"
Connelley	121	16'0"	27'0"
	123	16'0"	27'0"

Schools	Room No.	Beam Height	Ceiling Height
Connelley (continued)	125	16'0"	27'0"
	126	16'0"	27'0"
	127	16'0"	27'0"
	128	16'0"	27'0"
	129	16'0"	27'0"
	130	16'0"	27'0"
	132	16'0"	27'0"
	133	16'0"	27'0"
	137	16'0"	27'0"
	138	16'0"	27'0"
	139	16'0"	27'0"
	141	16'0"	27'0"
	142	16'0"	27'0"
	143	16'0"	27'0"
South Voc.	202	17'0"	18'0"
	204	17'0"	18'0"
	205	17'0"	18'0"
Perry	304	19'0" suspd. clg.	
	305	19'0" "	
	306	19'0" "	
Connelley	21	24'0"	25'6"
	22	24'0"	25'6"
	27	24'0"	25'6"
Washington	505	13'0" to 13'6"	
	506	13'0" to 13'6"	
Allderdice	227	13'0" to 14'0"	
	231	13'0" to 14'0"	
Oliver	208 & 210	14'3" to 15'0"	16'0" to 15'3"
	214	14'3" to 15'0"	16'0" to 15'3"
	239	14'3" to 15'0"	16'0" to 15'3"
Connelley	400	17'6" to 18'0"	
	403	17'6" to 18'0"	
	404	17'6" to 18'0"	

Fifth — Ceiling heights and beam heights for Fifth Avenue are not recorded. Ceiling height estimated to be 13'6"

South — Rooms 21, 23, 24, 121, 124, 126, 224, and 323 in old building and no ceiling heights and beam heights available.

RESEARCH AND DEMONSTRATION REPORT ON A COMPREHENSIVE CONCEPT FOR VOCATIONAL EDUCATION FACILITIES

SUMMARY

Submitted by Dr. Louis J. Kishkunas
Assistant Superintendent, Division of Occupational, Vocational, and Technical Education
The Pittsburgh Board of Public Education

Submitted to The State Director of Vocational Education, Department of Public Instruction
Commonwealth of Pennsylvania

October, 1966

CREDITS

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Interpretation of Project Goals

The following goals have been interpreted from the text of the "Research and Demonstration Proposal on a Comprehensive Conception for Facilities for Vocational Education" which appears in the appendix of this summary.

1. Develop concepts for facilities that meet the needs of "emerging vocationally-oriented curricula" and also relate vocational education activities to academic education activities in "comprehensive schools."

2. Develop methods of providing high quality vocational education facilities in new school buildings, existing school buildings, and existing "community" buildings.

3. Inventory existing spaces in schools and "community" buildings that are either used for vocational education now or may be used for vocational education in the future.

4. "Establish the specific facility requirements," in terms of space, equipment, and mechanical services "needed in each school to offer a completely comprehensive program of education."

Methodology

The particular approach to solving the problems of this project evolved as a result of investigations into the Pittsburgh situation which revealed two significant factors. Many problems seen in existing vocational facilities fell into repeated patterns that might best be solved by a city-wide attack rather than by individual treatment. Furthermore, the Pittsburgh Board of Education decided to build five new comprehensive high schools for all students in grades nine through twelve. Since every vocational program in the city would be affected, this problem also had to be solved in terms of all facilities rather than in terms of individual facilities. The resulting decision to place the emphasis of this project on general, long range solutions as opposed to specific, short range solutions is discussed in detail in the following paragraphs.

Existing vocational facilities in Pittsburgh were evaluated in the light of the principal objectives of this study which were to "completely relate" vocational activities to academic activities in comprehensive high schools and to investigate the "facility needs which the emerging vocationally-oriented curricula will create" in comprehensive high schools. The following problems fit into a pattern that was typical for a majority of the existing facilities.

A. Space division and mechanical service systems were found to be inflexible. This tended to prevent cross-discipline coordination between related vocational activities and between vocational and academic activities. Activities were limited by the sizes of existing rooms. Installation of new equipment for various activities involved major alteration of mechanical services which was expensive and time consuming.

B. Permanent division of space and arrangement of mechanical services limited certain activities.

Usually in order to hold lectures and discussion sessions, it was necessary to move part or all of the class to another room. Acoustical isolation was designed to contain noise within classrooms, rather than at sources, so that occupants within the rooms were still distracted by noise. The sharing of presentations and the use of equipment, both of which were of value to more than one class, were limited.

C. Equipment and material handling was limited by awkward arrangements of rooms and halls. A common situation was to unload twenty feet lengths of lumber from trucks that had been pulled up onto sidewalks; then pass it through windows, around corners, and up or down stairways. Delivering and installing large machines often occupied as many as four men for more than a day.

Since these major problems were so common in existing facilities, specific recommendations for each facility and for each program would not have been as valuable as broad recommendations for new approaches to providing all vocational facilities.

The second factor was created by the dynamics of the Pittsburgh situation. This project was conducted in an environment of change. For example, new programs were being designed in Pittsburgh that would equip students with marketable skills in up-to-date industries. In addition, vocational education was being integrated with academic education in comprehensive high schools. Central to these developments were proposals for five large comprehensive high schools to be built in the near future. This new construction would have a great impact on the use of existing space. Many buildings that were being used for senior high schools also were planned for conversion to middle schools, meaning that all facilities for vocational students in grades nine through twelve were scheduled to be moved out of their present buildings.

Planning for these massive changes in Pittsburgh schools was in progress at the beginning of the project. Exact use of existing buildings and the nature and location of the new schools had not been determined. For this reason, such studies as specific recommendations for existing facilities and inventories of existing community buildings that would relate to schools seemed to be academic. However, these issues were important ones and demanded some treatment. It was decided to develop solutions to these problems which would be equally useful no matter what overall planning decisions were made.

Specific approaches to each of the goals listed in the original proposal are discussed in the following sections.

Objectives

1. Facilities for Comprehensive Education

This proposal is particularly concerned with the facility needs which the emerging vocationally-oriented curricula will create in all of the comprehensive schools in the city. [1*]

The specific objectives of this project are to completely relate comprehensive high school facilities with complete occupational-vocational-technical training facilities. This will enable the skill-centered programs to be more completely oriented with academic and general programs and will enable all students entering skill-centered curricula to obtain a more rounded education, which is becoming increasingly important in order to obtain satisfactory and permanent job placement. [5]

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*See paragraphs similarly noted in margins of project proposal.

The recommendations set forth in this report suggest that, in order to provide facilities that meet the needs of these vocational programs and to relate them to corresponding academic programs in comprehensive high schools, overall environmental flexibility must be provided. It is suggested that a high quality environment be provided which meets the individual needs of each activity. This environment must be modified to allow for interdisciplinary sharing of experiences, to allow for the installation of new equipment associated with emerging courses, to allow for new developments in environmental technology, and to allow for any arrangement of space which best simulates modern industrial practice. Specific proposals deal with flexible systems of space division, flexible systems of mechanical service distribution, mobile equipment, and acoustical control. Discussion of these proposals will be found in Unit One, Introduction and Unit Two, Flexibility Through Modularity.

2. Facilities in Different Kinds of Buildings

New conceptions must be evolved which will transcend the traditional facility requirements, particularly in relationship to construction and remodeling.[2]

In opening up new opportunities for carrying school experiences--academic as well as vocational--to space in the community, we will in turn open up new opportunities for the use of space in existing school facilities. In some cases, of course, these new opportunities will lead to recommendations for significant alteration of existing space.

Finally, we will consider needs and creative forms for new schools or supplementary facilities--supplementary to existing space in the community as well as the schools. In short, in its design to produce innovative conceptions for facilities for vocational (OVT) education, this research program places particular emphasis on conceptions for utilizing and relating space for educational programs in both school and community facilities.[4]

Consultants from the three major fields related to school facilities, i. e., Educational Specifications, Architectural and Engineering, will investigate all existing facilities and will recommend the remodeling, additions, and/or construction necessary to adequately accommodate the emerging OVT programs in comprehensive, regional, and specialized school buildings and/or community structures.[7]

These three distinct types of buildings, which are used for education, are mentioned in the proposal: new school buildings, existing school buildings, and existing buildings in the community which may become schools for short or long periods of time.

Recommendations of this report suggest that high quality, vocational education environment can be provided in all three. It is proposed that an environmental system which includes mechanical services, equipment services, and space dividers be developed as an entity independent of the limitations of inflexible structural frames. Among other advantages, this system would make it possible for educators to specify the kind of environment which they desire and to have the resulting environmental system installed in existing as well as new buildings. A discussion of this concept appears in Unit Four, Schematic Modernization. To illustrate the proposal, an existing Pittsburgh school building was subjected to a hypothetical modernization and the results were presented in a set of architectural schematic drawings.

One additional investigation grew out of this part of the project. To relate proposals for flexible space division and mechanical service distribution to specifications of applicable building codes, a synthesis of the Pittsburgh Building Code was made in terms of school building regulations. Because the Pittsburgh Building Code is one of the nation's more modern and up-to-date codes, its synthesis, presented in Unit Five, A School Planner's Guide to The Pittsburgh Building Code, may be of interest to all educators facing similar challenges.

3. Inventories of Existing School and Community Facilities

> Our objectives for the research and developmental program include not only a general inventory of existing secondary school facilities, but an inventory of space in neighborhood and community facilities that might be appropriate to a fuller school experience of a secondary school youngster.[3]

A comprehensive inventory of the dimensions, both horizontal and vertical, of all existing vocational rooms in the Pittsburgh School System was made. For the purposes of comparison, a preliminary survey of space standards was made with details taken from the Pittsburgh Building Code, the State of Pennsylvania, and from many states across the nation. It was possible to begin to evaluate the space that Pittsburgh now provides for each vocational course. Results of these surveys and comparisons are presented in Unit Six, Appendix.

The difficulties of conducting an inventory of community facilities have already been discussed. A more useful inventory might be conducted when the specific vocational offerings in each of the proposed middle schools and the locations of the proposed comprehensive high schools have been determined. At that time it will be possible to locate community facilities which, by their structural quality and physical proximity to a school building, are ideally suited for educational use.

In these preliminary remarks, it may be appropriate to discuss some of the aspects of using community facilities for educational purposes. The use of space in a community facility for certain vocational activities has certain advantages. This approach, obviously, would provide supplementary space for a school system. Also, it is possible that adults might find attending evening classes in such a building a more inviting prospect than attending classes in the formal atmosphere of a school building. Pittsburgh has implemented this concept successfully in several existing buildings.

One reservation, formulated in the context of this project, might be expressed. The word "comprehensive" is used in the title of the project. This would seem to imply a quality of integration between different vocational courses and between vocational and academic courses. This interdisciplinary coordination of activities is one of the main themes of this project. It is possible that the placement of some vocational spaces in community facilities would result in the discouragement of potential interrelationships between courses. Also it is possible that teachers and students who are assigned to such buildings might feel isolated from the activities of the central school building and identified too strongly with a supplementary facility. An evaluation of these possibilities might be a wise preliminary step to further application of this concept.

4. Planning for Specific Facility Needs

> The immediate objectives of this project are to establish the specific facility requirements needed in each school to offer a completely comprehensive program of education.[6]
>
> Equipment needs will also be reviewed and repair, modernization, and/or purchase will be recommended as required to offer adequate programs.[8]

In view of the dynamic quality of overall educational planning in Pittsburgh at this time, specific recommendations for facilities and equipment would be out of date before they could be implemented. It was decided that recommendations for methods to be employed as planning proceeded would be more useful. Planning for vocational programs, which are supposed to keep abreast of a rapidly evolving technology, is not an easy task. One of the solutions that vocational educators are now applying is to cluster courses that may be described as belonging to a single occupational family group into one comprehensive facility.

In Pittsburgh, proposals are being developed for such cluster spaces that will house Business Education, Manufacturing Technology, and other identifiable families of courses. These concepts pose new problems for facility needs of courses in separate rooms. Vocational facility standards in many states provide a wealth of recommendations for individual classrooms. The question, however, is not how big a room is required for thirty students at typewriters, but how big a room is required for varying numbers of students at typewriters, calculators, duplicators, and data processing equipment. When ordering equipment, one might question how many typewriters are needed in an area where typing, shorthand, and office practice classes all require typewriters at varying times.

To solve some of the problems of planning vocational facilities in an age of rapid technological development, a new planning technique was investigated and the preliminary results presented in this report. This technique has the potential of simulating new course combinations without the need for having live students for experimentation. The results of using the technique provide planners with better information about equipment and space requirements of these combinations. Preliminary applications already suggest where money should be spent in re-equipping individual classrooms. This technique is discussed in Unit Three, Space Determination.

A Final Note

The objectives set forth in the proposal and the responses to these objectives set forth in this report both grow out of specific problems in Pittsburgh. It is possible to consider Pittsburgh as a laboratory in which these problems are representative of similar problems that exist throughout the nation. It is hoped that, although the following report is undeniably a product of what is happening to vocational education in Pittsburgh, the discussions contained in the report will be of interest to all educators.

APPENDIX

RESEARCH AND DEMONSTRATION PROPOSAL

ON A COMPREHENSIVE CONCEPTION FOR

FACILITIES FOR VOCATIONAL EDUCATION

Submitted to the State Director of Vocational Education
Department of Public Instruction
Commonwealth of Pennsylvania

by the Pittsburgh Board of Public Education

VE-I

Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION
Harrisburg 17126

Fiscal Year	
Project No.	
Date Rec'd	

APPLICATION FOR APPROVAL OF
RESEARCH, EXPERIMENTAL, DEVELOPMENTAL, PILOT PROGRAMS
IN
VOCATIONAL EDUCATION

Educational Agency Pittsburgh Board of Public Education County Allegheny

Address 341 S. Bellefield Avenue, Pittsburgh 13, Pa. Telephone No. 682-1700

Project Title A Comprehensive Conception For Facilities For Vocational Education

Prepared By Louis J. Kishkunas Date May 24, 1965

Title or Position Asst. Superintendent for Occupational, Vocational, and Technical Education

Nature of Project

Vocational Field(s)

___ Agriculture
___ Business
___ Distributive Ed.
___ Home Economics
___ Trade and Ind.
___ Health Occupations
___ Technical
X All Fields

Major Category(s)

X Research
___ Experimental
X Developmental
___ Pilot

Specific Category(s)

___ Administration-Supervision
___ Curriculum Development
___ Staff Development
___ Instruction Methods
___ Evaluation
___ Guidance
X Building Facility
___ Teacher Education
___ Curriculum Materials
X Equipment
___ Public Relations
___ Adult Education
___ Apprentice Education
___ ________

SIGNATURES

The program described herein has been developed and approved by the following:

________ 5/24/65
Vocational Education Admin. Date

Title Asst. Supt. OVT

________ ______
Advisory Committee Chairman Date

________ 5/24/65
Sponsoring Agency Administrator Date

Title Superintendent

DPI APPROVALS

No Area Supervisor
Vocational Ed. Area Supervisor Date

No State Supervisor
State Supervisor Date

________ ______
Review Committee Date

________ ______
State Director Vocational Ed. Date

BOARD APPROVAL

The Board of Directors or Trustees hereby signifies its desire to establish and operate the vocational education program described herein in conformity with the State Plan for Vocational Education and desires approval of Department of Public Instruction.

This application was approved by the Pittsburgh Board of Public Educa. Board

18th day of May, 1965.

Submitted by Authority of the Board

________ Chief School Admin.

________ President

________ Secretary

VE-VI

Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION
Harrisburg 17126

BUDGET APPLICATION
AND
REIMBURSEMENT VOUCHER*

___ Budget Request
___ Claim for Funds

DPI Use Only
Fiscal Year ________
Project No. ________
Date Rec'd ________

Sponsoring Agency Pittsburgh Board of Public Education Date May 24, 1965

Address 341 S. Bellefield Avenue, Pittsburgh 13, Pa. County Allegheny

Name and Address of Treasurer David A. Smith, City County Building, Grant Street, Pittsburgh 19, Penna.

Project Title A Comprehensive Conception For Facilities for Vocational Education

Nature of Project

Vocational Field(s)	Educational	Ancillary
___ Agriculture	X High School	X Research
___ Business	___ Out-of-School Youth	___ Experimental,
___ Distributive	___ Adults	X Developmental, Pilot
___ Home Economics	___ Handicapped	___ Other
___ Trade and Industrial		
___ Health Occupations		
___ Technical		
X All Fields		

(Complete only when used as a reimbursement voucher)

I certify that this request together with supporting Statistical Report accurately sets forth the statistical and financial records according to the School Laws of Pennsylvania and policies pertaining to the conduct of these programs. Reimbursement is hereby requested.

________________________ ________
Vocational Education Admin. Date

________________________ ________
School Board Secretary Date

________________________ ________
Chief School Administrator Date

____
DPI Approval

*This form may be used for budget estimate in applying for approval of funds or reimbursement purposes following expenditure(s).

SALARY SCHEDULE

Position	Name	Certificate Number	Time Employed For Period	Rate	COST Local	COST State
1. Instruction	See Narrative Attachments					
2. Supervision						
3. Clerical		XXXXXXXXXX				
		XXXXXXXXXX				
4. Janitorial		XXXXXXXXXX				

ITEM SCHEDULE

	Local	State
5. Instructional Services		
.Instructional supplies		
.Rental of instructional equipment		
.Travel		
.		
6. Fixed Charges		
.Rental of nonpublic space		
.Social Security: ________		
.Retirement		
.		
7. Equipment Purchases		
.Instructional equipment		
.		
8. Other Costs		
.Utilities (list)		
.Communications		
.Miscellaneous Costs (itemize)		
.		
.		
.		
.		
9. GRAND TOTAL . . . . . See Narrative Attachments		

RESEARCH AND DEMONSTRATION PROPOSAL ON A COMPREHENSIVE CONCEPTION FOR FACILITIES FOR VOCATIONAL EDUCATION

Submitted to the State Director of Vocational Education
Department of Public Instruction
Commonwealth of Pennsylvania

by the Pittsburgh Board of Public Education

1. PROBLEM

For many years the vocational education programs in the Pittsburgh Public Schools have been pursued by only approximately ten percent of all secondary school students. With the exception of business education, the major vocational curricula have been offered only in special vocational schools located throughout the city.

The Pittsburgh Public Schools are now creating a comprehensive occupational-vocational-technical series of curricula which will be pursued within the next two years by more than sixty percent of all secondary school youth. Most of these skill-centered curricula will be offered in the comprehensive high schools. Regional centers and formerly classified vocational schools will be utilized only for programs which, due to limited enrollment and employment needs, cannot be offered in each comprehensive school. These major programming revisions present the school district many challenges and problems, particularly in matters relating to financing, staffing, and facilities.

This proposal is particularly concerned with the facility needs 1
which the emerging vocationally-oriented curricula will create
in all of the comprehensive schools in the city. New concep- 2
tions must be evolved which will transcend the traditional
facility requirements, particularly in relationship to con-
struction and remodeling. To adequately plan these new
facilities and to determine the needs which must be met in
each of the several areas of the city, it is necessary that
expert research be conducted far exceeding the capacity of
the present and permanent facilities and research staffs of the
city school system.

This proposal, therefore, concentrates on the obtaining of appropriate consultant staff to enable immediate research into the creative conceptions for facilities required to accommodate the emerging occupational-vocational-technical curricula to be located in the comprehensive secondary schools in the City of Pittsburgh.

2. BACKGROUND INFORMATION

Present school facilities planning of the Pittsburgh Schools proceeds largely in terms of individual projects for individual schools. These projects are related to a very general and, therefore, flexible long-range building plan of the Board of Public Education. This plan involves over fifty million dollars and extends over more than a decade. Preliminary planning for these projects is coordinated by staff members of the Business Office of the Pittsburgh Schools. Actual new construction or renovation is carried out either by our Plant Operation and Maintenance Staff or by private contractors.

The only general research study on school facilities now available to the Pittsburgh staff is a 1963 study of enrollment and school capacity. With respect to our present research needs, the statistics of this study are somewhat gross measures in that they do not account for the children or space requirements of specific programs concentrating on skill-centered education.

There have been a number of research studies on school facilities throughout the nation in recent years--including those under the financial auspices of special organizations like the Educational Facilities Laboratories of New York City--but we do not believe that there are any studies that would preempt the need for the research program we propose here and the school district plans to use all such studies as the basis for the research proposed herein.

3. GENERAL DESCRIPTION, IMPORTANCE, AND NEED

This program, we contemplate, will not be unique in terms of its general inventory of existing facilities; this is a common form of research undertaken by public school systems. However in terms of its development of comprehensive and creative conceptions of appropriate space in school and community facilities for the vocational (OVT) education of an entire city, we hope it will be very unusual. As we have noted earlier, this particular kind of research has not existed in the past in Pitsburgh or, apparently, in other cities. This research program will, therefore, be highly relevant to the problem we have in the Pittsburgh Public Schools, and to problems related to vocational education facilities at large. This study will be of benefit to all school districts or area vocational-technical districts which are planning or will later plan to expand comprehensive vocational programs within the general secondary structures of their districts or of the feeder districts involved in the area programs.

4. OBJECTIVES

Our objectives for the research and developmental program include 3
not only a general inventory of existing secondary school facilities

but an inventory of space in neighborhood and community facilities 3
that might be appropriate to a fuller school experience of a
secondary school youngster. In opening up new opportunities 4
for carrying school experiences--academic as well as vocational--to space in the community, we will in turn open up new opportunities for the use of space in existing school facilities. In some cases, of course, these new opportunities will lead to recommendations for significant alteration of existing space. Finally, we will consider needs and creative forms for new schools or supplementary facilities--supplementary to existing space in the community as well as the schools. In short, in its design to produce innovative conceptions for facilities for vocational (OVT) education, this research program places particular emphasis on conceptions for utilizing and relating space for educational programs in both school and community facilities.

The specific objectives of this project are to completely relate 5
comprehensive high school facilities with complete occupational-vocational-technical training facilities. This will enable the skill-centered programs to be more completely oriented with academic and general programs and will enable all students entering skill-centered curricula to obtain a more rounded education, which is becoming increasingly important in order to obtain satisfactory and permanent job placement.

The immediate objectives of this project are to establish the 6
specific facility requirements needed in each school to offer a completely comprehensive program of education.

5. ADVISORY OR CONSULTANT GROUP

The over-all advisory committee responsible for project and facility planning follows:

Ryan, Robert H. (Chairman)	President, Regional Industrial Development Corporation
Aiken, Regis C.	International Vice President, Plumbing and Pipefitting Industry
Aikenhead, Robert	Chief Engineer, American Society Tool and Manufacturing Engineers
Concannon, Dr. Joseph T.	Allegheny General Hospital
Doty, Arthur M.	Personnel Relations Department, Aluminum Company of America
Ferguson, Robert W.	General Operations Manager, The Bell Telephone Company of Pennsylvania
Grace, Dr. J. Nelson	American Nuclear Society, Westinghouse-Bettis Atomic Power Laboratory
Henrici, Stanley B.	Manager, Industrial Engineering, H. J. Heinz Company
McGill, George S.	District Manager, Bureau of Employment Security
McManus, Dr. Ivy R.	Associate Research Professor, De-

	partment of Biochemistry and Nutrition, Graduate School of Public Health, University of Pittsburgh
Narick, Emil E.	Assistant General Counsel, United Steelworkers of America
Newman, Dr. Carl A.	Supervising Principal, Gateway Union School District
Palmer, George A.	Vice President - Personnel, Joseph Horne Co.
Smith, Robert W., Jr.	Research Mathematician, United States Department of Interior, Bureau of Mines
Beattie, Dr. Alfred W.	Superintendent, Allegheny County Schools
Clark, Dr. A.G.	Assistant Superintendent, Allegheny County Schools
Marland, Dr. S.P., Jr.	Superintendent, Pittsburgh Public Schools
Dauwalder, Dr. D.D.	Consultant, Pittsburgh Public Schools
Kishkunas, Dr. L.J.	Assistant Superintendent, Division of Occupational, Vocational, and Technical Education, Pittsburgh Public Schools

The advisory committee has approved the conducting of OVT programs in the comprehensive high schools and the general areas of study to be covered. It has recommended the full determination of the facilities and equipment which will be necessary to implement completely comprehensive skill-centered educational programs.

6. PROCEDURES, METHODS, MECHANICS

Consultants from the three major fields related to school facilities, 7
i.e., Educational Specifications, Architectural and Engineering, will investigate all existing facilities and will recommend the remodeling, additions, and/or construction necessary to adequately accommodate the emerging OVT programs in comprehensive, regional, and specialized school buildings and/or community structures. 8
Equipment needs will also be reviewed and repair, modernization, and/or purchase will be recommended as required to offer adequate programs.

The exact methods, procedures and materials to be used in the conduct of the program will be determined very largely by the consultants we hope to engage. These are listed in sections 7 and 13. For this reason, the major elements of the operational plan for this research program by the consultants working with the Board and Staff and Advisory Groups of the Pittsburgh Public Schools.

7. PERSONNEL

The administrative staff of the Pittsburgh Public Schools who will be directly related to this research and developmental program are listed in the budget section, 13. The percentages of time alloted by each are also itemized in the budget section. Qualifications as specified by the Pittsburgh Board of Public Education and/or by the Commonwealth have been met for each employee. Their responsibilities are evident from the classification titles.

Although the nature of the research and developmental project as proposed is such that we cannot specify at this time the names of the personnel who will fill the new roles designated especially for the program, we can note that we have already carried on preliminary conversations with potental personnel of the highest calibre from the Pittsburgh area and around the nation.

We can describe the basic qualifications and experience of the several types of personnel we will seek for the staff for this research program. We seek highly competent architects, engineers, and educators specializing in Educational Specifications--all of whom have had commendable experience in research work related to facilities for educational programs and in preparing and working with Educational Specifications and Facility Specifications. The specific titles of the consultants listed in budget section 13 are descriptive of the general duty requirements.

8. ADMINISTRATION - SUPERVISION

The primary responsibility for vocational education in the Pittsburgh Public Schools rests with the Division of OVT Education. This Division is directed by an Assistant Superintendent who is, in turn, directly responsible to the Superintendent of Schools.

The staff of this research program will be directly responsible to the Assistant Superintendent for OVT Education; he will provide for appropriate liaison between the research program staff, his own Division staff, the Business Office Staff, and the general staff of the Pittsburgh Public Schools.

The special staff of the research program will include:

Project Director - a consultant to be employed on a continuing basis for the duration of the program; responsible for coordinating all research activities of the program. Special qualifications will center around architectural planning and educational specifications.

Consultants - to be employed on a temporary basis for various phases of the research program; responsible for conducting the research on the specific elements of the program consistent with their specific tallents--e.g. educational specifications; architectural design; construction evaluation; facilities and equipment specifications; and other special short-term requirements as determined by the Project Director and the Assistant Superintendent for OVT.

9. TIME SCHEDULE

This program is designed for a period of six months. By June 24, 1965, we will have engaged consultants and conducted preliminary planning meetings for the program. Before July 1 the Project Director will begin intensified work in directing the program. Research will be conducted through December 31, 1965. During the early months of research, the consultants will devote considerable time to data collection (including facilities inventories); during the latter months, they will be concerned largely with analysis of data, recommendations for action on facilities, and suggestions for further research, demonstration, and/or implementation.

10. EVALUATION

We are not prepared to suggest here the specific procedures with which this program will eventually be evaluated. We have defined our basic problem and objectives. At this point, we need consultants who can recommend and carry out appropriate plans for gathering and analyzing data. The evaluation of the program will rest with the appropriateness and relevance of these data and analyses to the broader problem and objectives we have started for the overall program.

It is anticipated that evaluation will also be conducted by the Bureau of Technical and Continuing Education and that the research and demonstration findings can be applied not only to the contemplate expanded or modified programs requiring a review of facilities and equipment needed for modernized skill-centered curricular offerings.

11. FACILITIES

The staff of this program will be provided with appropriate offices and other work space in existing facilities of the Pittsburgh Public Schools--most probably in the "OVT Center" housing the administrative staff of the Division for OVT Education and in the offices of the Division of Plant Operation.

12. REPORT

The results of the research and demonstration program will be reported to the Assistant Superintendent for OVT Education and to the Superintendent of Schools. This report will be forwarded to the State Department of Public Instruction and it is hoped there can be a joint evaluation and reporting to the State Board for Vocational Education. It is expected that the report on this program will suggest the need for further research and evaluation, both Statewide and in Pittsburgh, to establish guidelines for educational specifications and the utilization of facilities for Vocational-Technical programs in the Commonwealth.

13. BUDGET (computed for a six-month period)

	Percent of Time Assigned to Project	Cost: Local	Cost: State
A. Personnel			
Dr. S. P. Marland, Jr., Superintendent	5	Not computed	
Mr. C. F. Mellinger, Associate Superintendent for Business	15	$1,500	
Mr. B. J. McCormick, Assistant Superintendent Curriculum and Research	10	765	
Dr. Louis J. Kishkunas, Assistant Superintendent, OVT	20	1,530	
Mr. Clair H. Cogan, Assistant Superintendent Secondary Education	10	765	
Dr. Donald D. Dauwalder, Consultant, OVT	20	1,500	
Mr. John C. Garlick Director, OVT	20	1,264	
Dr. Jerry Olson, Curriculum Supervisor, OVT	10	546	
Mr. John H. Thompson, Director, Division of Plant Operation	20	1,459	
Mr. Richard Barrick Educational Facilities Coordinator	30	2,038	
Mr. Allan Albig Assistant Director, Division of Plant Operation	30	1,827	
Mr. J.R. Brooks, Supervisor of Construction	20	1,408	

	Percent of Time Assigned to Project	Cost Local	State
Mr. Paul Bott, Designing Architect	20	$1,264	
Mr. Harold Carter, Project Architect	20	889	
Mr. J.N. Geyser, Construction and Repair Planning Coordinator	10	423	
Mr. Alva Loretta, Project Architect	20	889	
Mr. Arthur Lynch, Electrical Draftsman	10	384	
Mr. Fred Ely, Architectural Draftsman	20	731	
Mr. Louis Miller, Architectural Draftsman	20	731	
Mr. Francis Spilka Heating-Plumbing Draftsman	10	365	
Mr. Larry Cribbins, Heating-Plumbing Draftsman	10	365	
Mr. Leslie Lehoczky, Draftsman	20	572	
Mr. Charles J. Pepine, Project Architect	20	846	
2 Secretaries	100		$5,000
Project Director (Educational Specifications Specialist)	100		7,500
Chief Architect (30 days @ $150 per day)	--		4,500
Architects and Expense (Total of 120 days @$75 per day)	--		9,000
Chief Engineer (30 days @$150 per day)	--		4,500

		Percent of Time Assigned to Project	Cost Local	State
	Engineers and Expense (Total of 120 days @$75 per day)	--		$9,000
	Chief of Educational Specifications (Consultants for 30 days @$150 per day)	--		4,500
	Educational Specifications Consultants and Expense (Total of 120 days @$75 per day)	--		9,000
	Other Consultant Help and Expense	--		9,000
	Districts participation on Principals' salary during six-month study period	10	$12,100	
	Total Personnel Costs and Direct Expense ($96,161)		$34,161	$62,000
B.	Social Security, Retirement, Workmen's Compensation, etc.		Not computed; borne by district	
C.	Janitorial, Telephone, and Building Facilities		7,200	
D.	Travel and perdiem for consultants and travel for regular personnel		5,500	11,150
E.	Architectural, Drafting, Engineering Supplies and Materials		1,600	6,750
F.	Secretarial and Office Supplies		750	200
	Total Project Costs		$49,211	$80,100

(Of the $129,311 total project costs the School District plans to participate to the extent of 38.06 percent as itemized above.)