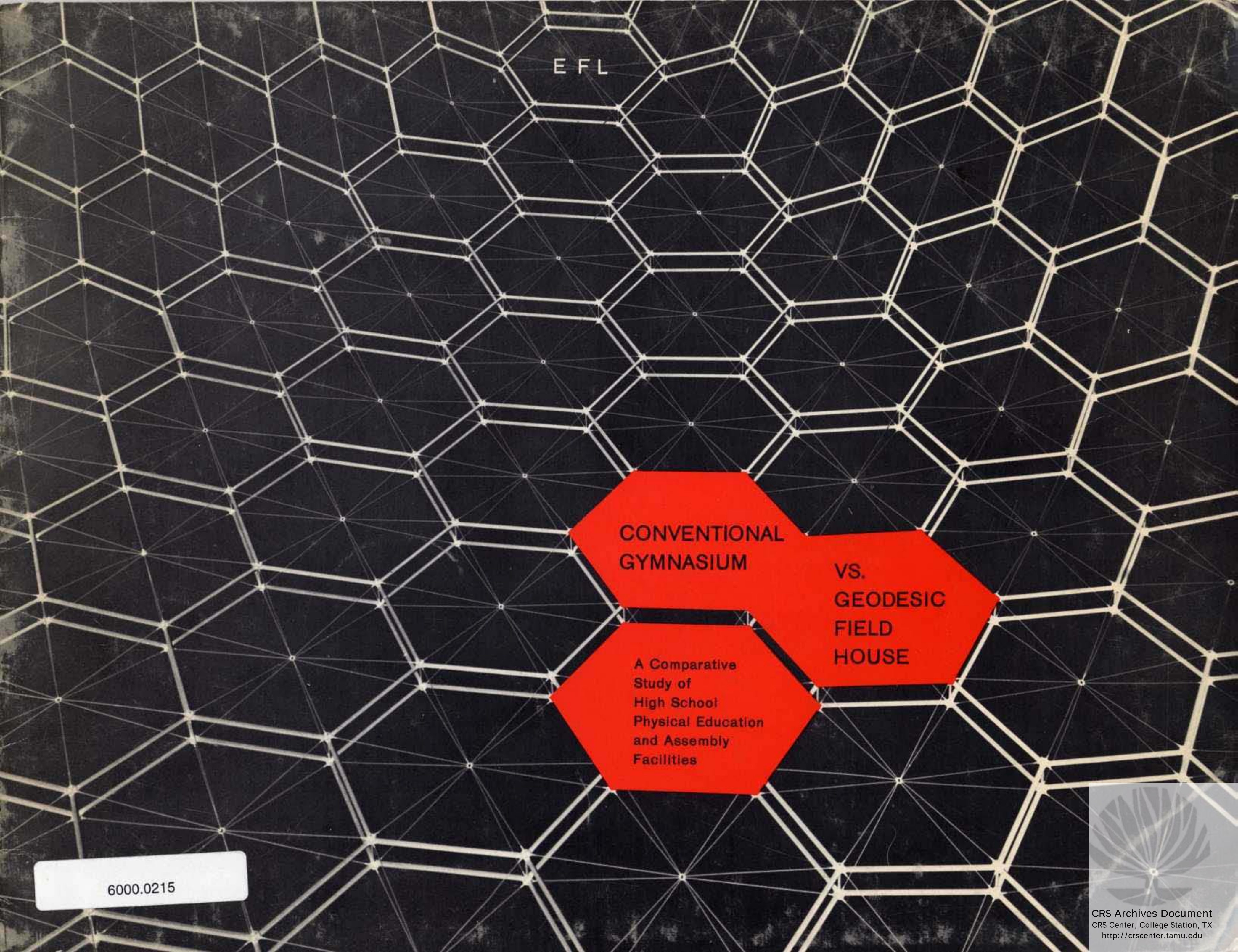
EFL



CONVENTIONAL GYMNASIUM VS. GEODESIC FIELD HOUSE

A Comparative Study of High School Physical Education and Assembly Facilities

Educational Facilities Laboratories, Inc. is a nonprofit corporation established by the Ford Foundation in 1958, with an appropriation of 4.5 million dollars, to help American schools and colleges with their physical problems by the encouragement of research and experimentation and the dissemination of knowledge regarding educational facilities.

Participants

Board of Education of Montgomery County, Maryland

Paul C. Howard	*President of Board*
Harold Breimyer	*Vice President*
Clifford Beck	*Members of Board*
Rose C. Kramer	
Robert Morrow	
Helen Scharf	
William Thomas, III	

School Staff

C. Taylor Whittier	*Superintendent*
Lester J. Welch	*Director of School Facilities*
James H. Sheldon	*Director of Construction*
Crescent Bride	*Physical Education Supervisor*

Architects and Consulting Engineers

McLeod and Ferrara, *Architects, A.I.A.*

J. Gibson Wilson, Jr., *Structural Engineer*

Kluckmuhr and McDavid, *Mechanical Engineers*

Kenneth W. Cobb, *Electrical Engineer*

Synergetics, Inc., *Consultants for the Geodesic Dome*

Case Studies of Educational Facilities #1

A Report from Educational Facilities Laboratories

Prepared by McLeod and Ferrara, Architects, A.I.A.

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Foreword

This is a report on one school's physical education facilities. The Montgomery County Board of Education wanted more than the conventional box gymnasium and yet were understandably reluctant to commit public funds to the planning of an alternative solution, a domed field house.

Educational Facilities Laboratories agreed that a study of the comparative costs of a geodesic dome field house and a conventional gymnasium would be of interest far beyond the confines of Montgomery County. Consequently two grants, one of $8,500 and another of $17,000, were made to finance the study.

Historically, facilities for physical education have been shaped by at least two movements:

The first was the interest in body building which German and Scandinavian immigrants brought with them to this country in the middle of the 1800's. As the result of pressures they brought to bear, calisthenics and gymnastics were introduced into the schools. These set the tone for physical education in the school system for the next half century.

The second was the game of basketball, invented in 1891, which became extremely popular and was being played in YMCA's and schools throughout the country within 20 years after it came into being.

In contrast to the gymnastics and basketball box which resulted from these two forces, the dome may offer possibilities of more successfully accommodating a complete program of physical education for boys and girls irrespective of their native athletic endowments. The following factors are in its favor:

A. The dome offers interior space unmarked by structural supports. Whatever barriers are placed within the structure can be dictated by the program of physical education, not by the need for holding up the roof. The mutable interior space of the dome offers freedom of movement for program and occupants. Whatever the nature of physical education is in this century and the next, the dome should be adaptable enough to accommodate it.

B. Because of the repetitive nature of the component parts there is reason to believe that, should domed structures come into frequent use, the cost of enclosed space for physical education may well be reduced. Money which is thus freed from the cost of structure could well be invested in equipment and teaching to improve the physical education of all students. Even this prototype dome will cost somewhat less than a conventional gymnasium.

C. As a place of assembly the domed structure provides assembly in the round, an arrangement that may be superior to the rectangle.

D. The dome is architecturally exciting, offering a silhouette that brings relief from the rigid rectangular geometry of the conventional structure.

EFL was eager to support the Montgomery County Board of Education in its desire to search out the facts with respect to this unusual structure. The answers found in Montgomery County should be of interest to schools and colleges generally.

These were grants with a happy ending. An alert School Board, Superintendent, and architectural firm combined to create a new kind of facility for education, one that provides more space at a slightly lower cost.

The report which follows was prepared by architects McLeod and Ferrara for EFL and the Montgomery County Board of Education. It is the first in a series of *Case Studies of Educational Facilities* which EFL plans to publish. They will deal with elements of school and college facilities.

EDUCATIONAL FACILITIES LABORATORIES

Background and purpose of the study

In July, 1959, the Board of Education of Montgomery County, Maryland, awarded a contract to McLeod and Ferrara, Architects, A. I. A., of Washington, D. C., for the design of the new West Bethesda High School to be erected in Bethesda, Maryland, a suburb of Washington, D. C. The construction cost of the project was established at $3,150,000.

In awarding this contract the Board of Education, through its Superintendent of Schools, Dr. C. Taylor Whittier, requested the architects to make a special study of facilities for physical education. This study was to determine whether or not some new design form or construction technique was available, or could be developed, which would produce better and more versatile physical education facilities than those provided by the typical double gymnasium. Further, it was hoped that such a new type of structure could be constructed for the same cost as, or a lower cost than, the conventional model.

As the architects carried on their research, they became increasingly interested in the possibilities of the geodesic dome structure as a possible solution to their particular problem. The geodesic dome was conceived by R. Buckminster Fuller, a famous engineer and mathematician, who originated the geodesic dome by using in a somewhat new and different way the forces of compression and tension upon which all structures depend for strength and stability. Geodesic dome structures are remarkably light weight and can span large distances without the use of intermediate supports.

At this stage of their investigation the architects learned that construction of a new high school incorporating the use of a wood dome into the design of a field house was just starting in Wayland, Massachusetts. After a visit to the site and following discussions with E. J. Anderson, the Superintendent of Schools, and the architects, The Architects Collaborative of Boston, McLeod and Ferrara were firmly convinced that a dome structure had great possibilities for West Bethesda High School.

With drawings and cost data loaned to them by The Architects Collaborative, McLeod and Ferrara presented their findings to the Board of Education. While the cost information for the Wayland High School project impressed the Board favorably with respect to the dome concept, there was still an open question in their minds as to whether or not such a structure would result in savings at West Bethesda. Thereupon the Board requested Lester Welch, Director of School Facilities, and James Sheldon, Director of Construction, to confer with the architects to determine a course of action for the Board's further consideration of the subject.

It was obvious, at this point, that the only way in which true costs could be determined, would be by taking comparative bids on (*1*) the conventional gymnasium and (*2*) the geodesic field house. It was also obvious, in view of the additional design costs involved, that the Board could not undertake such a comparative cost study with its own funds. It was then decided to seek outside financial assistance in carrying out the study, since both Board enthusiasm and public interest in the project had been gradually increasing.

Educational Facilities Laboratories was approached and discussions were held with Harold Gores, President, and Jonathan King, Secretary and Treasurer, of EFL. Educational Facilities Laboratories indicated considerable interest in the project and recognized the significance, on a national scale, of the comparative cost study proposed at Bethesda.

Tentative approval of the research project was given by Educational Facilities Laboratories with the suggestion that the task be accomplished in two separate stages. In the first stage, the architects were to develop complete preliminary drawings and cost analyses for both the conventional gymnasium and the geodesic field house. If, at the completion of this phase of the study, it appeared that both space provisions and cost figures for the two types were reasonably close together and that further development would be meaningful, then the second stage grant would be made.

Conferences were held between Dr. Whittier, Mr. Welch, and Mr. Sheldon for the school system, Dr. Gores and Mr. King for Educational Facilities Laboratories, and John W. McLeod for the architects, to establish ground rules for the study. Agreement was reached on several important basic considerations which would govern the comparative study. Dr. Gores indicated that Educational Facilities Laboratories' interest lay in a comparison of the basic structures themselves, and that any extraneous variables which might affect the validity of the comparisons should be eliminated insofar as this was possible.

The basic conditions for the study were subsequently established as follows:

(*1*) The space requirements and relationships already carefully spelled out in the educational program for the conventional gymnasium, would, in like manner, serve as design criteria for the geodesic field house. It was not intended that the designs for either type reflect an absolutely minimum facility, but that the two types meet the usual Montgomery County standards for a physical education plant.

(*2*) Insofar as possible, variables, such as site preparation, storm drainage, etc., would be separated from the basic structure, by taking these costs as separate bid items. Similarly, equipment items, such as backstops, lockers, bleachers, etc., would be either equivalent in number, type, etc., or if this was not possible removed entirely from the comparison and purchased as separate equipment items.

(*3*) Square foot areas for the two types should be roughly the same, or should at least meet the program requirements. In this connection, it was felt that two questions might need to be answered in the preliminary design stage, namely, could the geodesic dome design provide *equal* facilities for *less* cost than the gymnasium, or, as another consideration, could the geodesic dome design produce *larger* or *better* facilities than the gymnasium for the *same* cost?

Following the establishment of the above set of principles, formal presentation was made and acceptance given of the proposal both by the Board of Education and by Educational Facilities Laboratories.

Note:

In using the words "gymnasium" and "field house" throughout this report, it is not intended that the terms designate two entirely different use-types, but they are used as a simple means to differentiate between the two types of structures.

The educational program

That part of the educational program which pertained to physical education facilities outlined the various space and activity needs for the conventional gymnasium, and, as has been noted, these requirements also formed the basis for the design of the geodesic field house. It should be noted that, in addition to purely physical education activities, this building would also serve as an auditorium for both school and community purposes. Because of the tremendous pressures of expanding enrollment over the past 10 years, Montgomery County has not incorporated auditoriums into its new schools, hence the need for using a combination auditorium-gymnasium.

Without going into the merits of such a compromise between physical education needs and drama and assembly accommodations, it is sufficient to say that the typical Montgomery County gymnasium-auditorium combination is similar to that found in thousands of American secondary schools. The basic requirements of a standard basketball court with folding bleacher seats on either side, the playing area subdivided through the middle by a folding door to form a boys' gymnasium in the one half and a girls' gymnasium in the other half, with a stage at the end of the room, and locker, shower, and other auxiliary areas arranged to suit, make up the conventional gymnasium plan in Montgomery County. The exact specifications, as listed in the educational program for West Bethesda High School, are as follows:

Design considerations

"The size of the gymnasium is to be 100 X 100 feet and shall be equipped with folding bleachers to seat approximately 1,500, and maximum floor seating for auditorium use. Ceiling clearance is to be a minimum of 22 feet. Install folding doors electrically operated to fold back between the bleachers. Install climbing ropes, traveling rings, horizontal bars, and six baskets, four of which are to be cross court. A stage is to be located at one end of the gymnasium. Exercise care in planning a stage apron so as not to interfere with the proper use of the gymnasium floor. The approximate size of the stage is to be: depth 30 feet and the proscenium 36 feet. It is to be arranged, designed, and equipped for proper sound projection to the gymnasium without the use of microphones. Microphone outlets, however, are to be available. Include cyclorama stage curtain. There is to be chair storage for 1,000 folding chairs. Public toilets are to be located near the gymnasium. Space should be made available at either end of the stage for two dressing rooms and stage storage. Other storage shall include piano storage, a small outside storage room, and a gymnasium storage room of approximately 25 square feet with double doors leading to it.

"Two physical education auxiliary areas, one for boys and one for girls, are to be approximately 1,200 square feet each. They are to be located near the locker areas and near the gymnasium.

"The related physical education facilities for boys and girls are to be as follows:

	Square Footage	
	Boys	Girls
1. Locker room and dressing space and toilets, to handle a total of 800 students, with no more than 160 during one period. The room should be so arranged that it might be expanded at a later date.	2240	2240
2. Shower room, soaping area, showers with central control, and individually controlled showers.	800 for 24 shower heads	800 for 22 shower heads
3. Drying room.	500	500
4. Two individual girls' shower stalls.		
5. Toilets.	200	200
6. Team rooms, 50" × 72" lockers, 400 square feet each and benches in each.	2 of 800 each	
7. Office space for instructors including showers, toilets, and locker space.	600	600
8. Uniform drying and storage room. An equipment room approximately 15 × 15 for storage of equipment used either inside or outside.	300	100

The locker units shall consist of one single tier locker and one six-compartment, multiple tier locker. This combination unit to serve one student each period has an approximate dimension of 1 × 2 × 6 feet. Benches permanently fixed to the floor shall be located between rows of lockers. It should be indicated here, however, that the locker room may be expanded at some future date if the size of the total building exceeds 1,500 students."

In setting up design criteria for both the conventional gymnasium and the geodesic field house, the architects recognized the need for creating a structure, irrespective of type, which would be in harmony with the design of the balance of the school plant. This it was felt could be achieved, to a large degree, by using, in the physical education unit, the same basic materials of construction—brick, steel, and concrete, as had already been selected for the design elements of the main school structure.

Because of the complex nature of the geodesic dome structure, the architects retained the firm of Synergetics, Inc., Raleigh, North Carolina, as consultants for the design of the structural characteristics of the dome. This firm was established by R. Buckminster Fuller to carry out the design aspects of his geodesic structures. James W. Fitzgibbon and J.F. Barnwell of Synergetics, Inc., worked closely with McLeod and Ferrara and with J. Gibson Wilson, the architect's consulting structural engineer, in designing the geodesic structure for the field house.

The seemingly simple question of establishing the size of the dome structure was one of the first problems tackled by the architects and their consultants. The criteria established for the comparative study required that space and activity areas be as nearly identical as possible and that the total aggregate square feet of floor area be nearly the same.

The conventional gymnasium was designed as a two-floor structure, with playing areas above and showers and lockers below, and occupied an aggregate floor area for the two levels of 31,586 square feet. The problem of designing the geodesic field house to provide equivalent areas was complicated by the very fact that, while the gymnasium was a simple rectangle, the field house was circular in shape, thus requiring somewhat different planning arrangements to accommodate the same programmed activities. Similarly, the very size of the dome itself had a definite relationship to the total cost of the field house; consequently, a great many planning studies were required to achieve a fine economic balance between requirements, structure, site conditions, and building area. The geodesic field house as finally designed contains 35,800 square feet or some 4,200 square feet more than the gymnasium gross floor area.

Another matter which received some consideration in the early design stages was whether or not to provide a dirt floor in the field house. This is fairly common practice in many college field houses, and permits wider use of the facilities during winter months. However, since the Washington area climate allows for almost year-round use of outdoor athletic fields, the inclusion of a dirt floor in the field house was ruled out in favor of the usual wood playing floor.

From the many design studies and cost analyses made by Synergetics, Inc., for the dome superstructure, the most practical and economical type appeared to be the combination of a structural steel framing system, covered with a gypsum roof deck and composition roof covering. The structural steel framing was left exposed on the underside of the roof, thus giving a honeycomb effect to the dome ceiling. This arrangement, creating a whole series of coffers at the ceiling, together with the use of acoustical panelboard as forming for the gypsum deck, will help offset some of the acoustical difficulties inherent in a hemispherical shape.

One of the major problems faced by the architects and their consultants was found to be providing means for subdividing the large playing floor into two separate areas for simultaneous use by boys and girls. This is a problem not usually dealt with in a field house type of structure; however, since it was a program requirement and was already an integral part of the gymnasium design, it was necessary to effect a solution. Discussions with the physical education staff appeared to indicate that visual separation of boys' and girls' classes was the major problem, and that sound isolation between different groups in the large areas of a field house was not an overriding consideration.

Since the conventional gymnasium made use of a sectional, motorized, wood, folding partition, the architects' first research efforts were a wide exploration of the problem with manufacturers of this typical folding partition. It was hoped that by some modification the folding partition could be used in the field house; however, because of the structural problems involved in the high ceiling structure, but mainly because of the obstruction to spectator viewing caused by side-stacking the doors, this particular arrangement was abandoned. The solution finally adopted called for the use of a reinforced plastic divider which can be raised vertically by means of a motorized, automatic locking device. The divider curtain when raised into the dome is above the minimum clearance required for playing and above spectator sight lines. It is not expected that the fixed side guide rails will offer any obstruction to viewing.

Upon completion of the preliminary drawings, an accurate quantity survey and cost analyses were made for both the conventional gymnasium and the geodesic field house. In reporting the completion of the first stage of a comparative evaluation of the two designs, the architects indicated to the Board of Education and Educational Facilities Laboratories that, in their judgment, there was very little cost difference between the two types. In fact, it appeared, from their preliminary cost figures, that the conventional gymnasium might be from \$5,000 to \$10,000 cheaper than the geodesic dome. Both the Board of Education and EFL expressed willingness to continue the comparative analyses and authorized the architects to prepare working drawings and specifications for the two building types.

VS.

Comparison of bids

In order to obtain truly comparative bids on the gymnasium and field house, the project was subdivided into three separate bidding proposals, namely:

Proposal No. 1 A. The main portion of the school proper, excluding the gymnasium and field house.
B. Site work for this portion.

Proposal No. 2 A. The conventional gymnasium.
B. Site work for this unit.

Proposal No. 3 A. The geodesic field house.
B. Site work for this unit.

While this subdivision of bids was somewhat complex, a notice to the bidders apprised them of the necessity for separating the elements of bidding and sought their cooperation in carrying out the cost study. On September 27, 1960, bids were received from eight contractors, and the tabulation of bids for the conventional gymnasium and for the field house are listed as follows:

	Gymnasium	Field House
Victor R. Beauchamp	$603,000.	$616,000.
George Hyman Construction Company	$595,000.	$617,000.
American Construction	$586,000.	$651,000.
Coe Construction Co.	$593,000.	$611,000.
Norair Engineering Co.	$619,950.	$587,200.
J. F. Hughes Company	$650,000.	$630,000.
Gunnell Construction Company	$576,598.	$569,536.
Merando, Inc.	***$589,761.***	***$583,674.***

While the above tabulation indicates that Gunnell Construction Company submitted the low bid on the field house, the field house was only a part of a larger project and Merando, Inc., were the low bidders for the entire project. At a Board of Education meeting on October 3, 1960, the construction contract was awarded to Merando, Inc., and this award included the geodesic field house.

To carry the comparison of costs still farther, the following schedule indicates a breakdown of costs for the various subdivisions of work. This listing is based on the successful contractor's bid breakdown.

Item	Gymnasium	Field House
Building Excavating and Backfilling	$ 10,915.	$ 9,272.
Concrete	98,500.	94,450.
Masonry	71,000.	62,000.
Structural Steel	37,000.	64,100.
Ceramic Tile	13,700.	11,000.
Metal Windows, Curtain Walls, Screens, and Panels	20,000.	5,000.
Metal Doors and Frames	5,000.	6,000.
Miscellaneous Metals	7,400.	8,000.
Insulation, Roofing, and Sheet Metal	12,200.	46,778.
Calking, Weatherstripping, and Thresholds	1,300.	1,500.
Carpentry and Millwork	26,460.	24,189.
Acoustical Ceilings	7,750.	
Resilient Floors	3,250.	800.
Glass and Glazing	1,400.	450.
Furring, Lathing, Plastering, and Stucco	11,480.	4,920.
Painting	16,000.	20,310.
Toilet Partitions	1,075.	1,285.
Furnishings and Special Equipment	72,492.	60,106.
Plumbing, Heating, and Ventilating	112,000.	100,535.
Electrical	55,000.	57,200.
Miscellaneous	5,839.	5,779.
	$589,761.	$583,674.

Conclusions to be drawn from the comparison

In order to draw any valid conclusions from the comparative study, it is necessary to reexamine the original goals set down for the investigation. These goals, stated simply, were as follows:

1. Could the same *facilities be obtained at* less *cost?*

2. Could better *facilities be obtained at the* same *cost?*

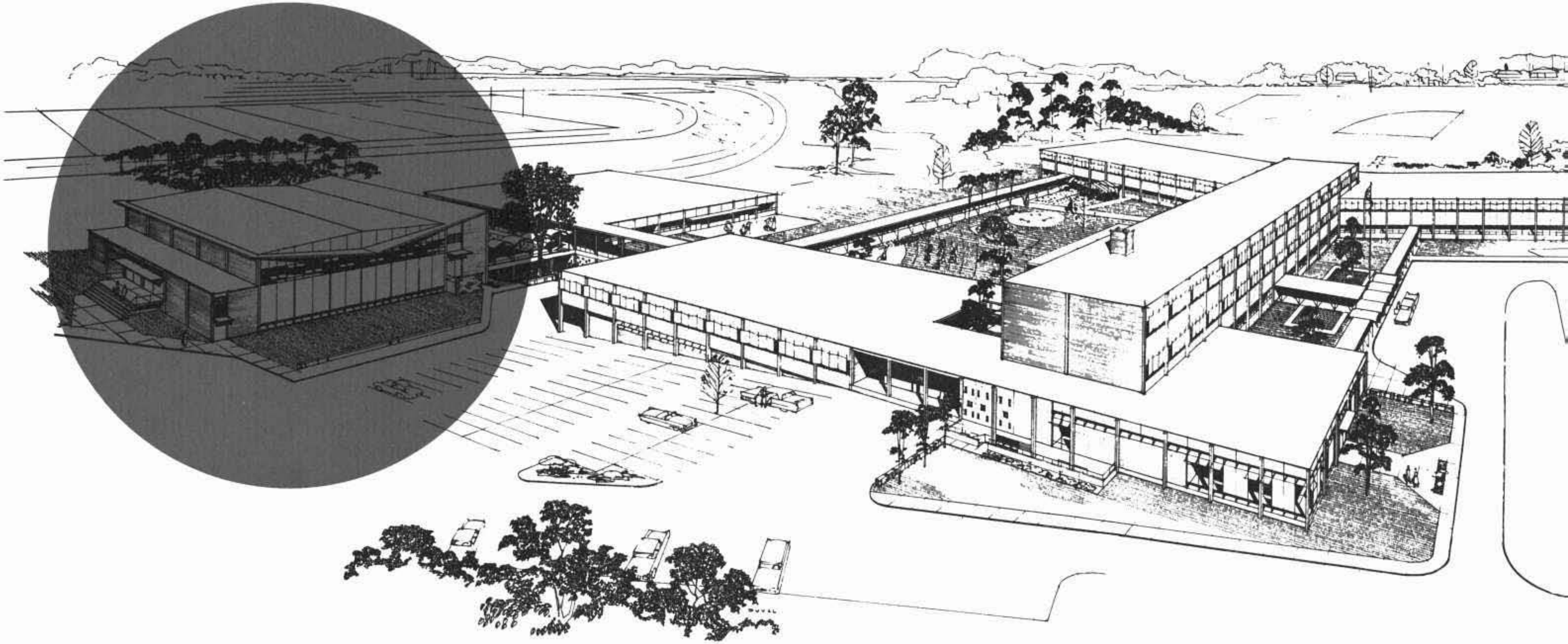
Insofar as the first of these goals is concerned, it would be a simple matter to state that, since the field house will contain some 4,000 more square feet in area, and will cost $6,087 less than the gymnasium, there is a clear advantage in favor of the field house. While these facts are essentially true, it is equally true that four of the eight bids indicated higher costs for the field house than for the gymnasium. In view of this, it might be better, before making any broad generalizations, to examine the results in terms of the second goal.

It was the Board of Education's hope that this new type of physical education facility would provide for a broader program of activities. They believe that the geodesic field house will accomplish this purpose. While the playing floor itself will be somewhat smaller in the field house than in the gymnasium, the large side and rear areas of the raised deck around the room will permit many and varied group activities to be carried on simultaneously. In the conventional gymnasium plan, of course, there were two auxiliary exercise rooms, but these were located on the lower floor level, and thus did not permit as flexible a program to be carried on without a certain amount of supervisory problems. Another consideration, in the physical education aspects, is the fact that the geodesic field house will provide for seating an extra 1,000 spectators at athletic events at no additional cost in terms of building.

It is, however, in thinking of the facility as an auditorium that the greatest advantages appear to be with the field house. For many years the school system has felt the lack of any single space in any school, either auditorium or gymnasium, which could serve for county-wide teacher conferences, summer workshops, and like activities. Similarly, for community purposes there is no large assembly space, public or private, which can accommodate 3,500 persons, the design capacity which the field house can seat when used for assembly or auditorium purposes. In addition to assembly, of course, the field house can serve as a center for book fairs, science exhibits, and many other county-wide school and community functions.

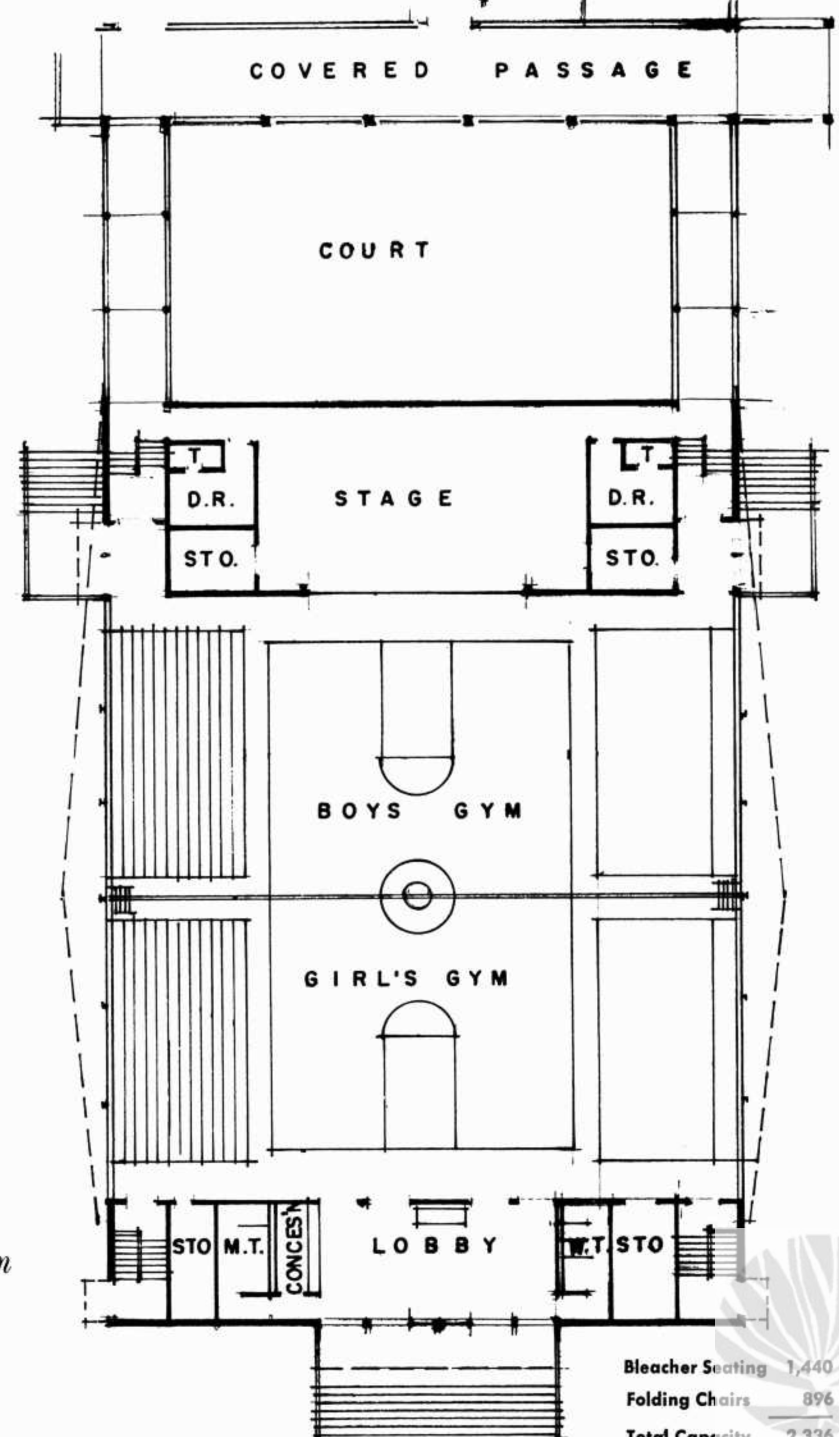
Taken together, the advantages with respect to both physical education and assembly are on the side of the geodesic field house. Even in the matter of cost comparison, while the differences are not as conclusive, it has been clearly established that the larger of the two structures, the field house, will cost somewhat less than the conventional gymnasium.

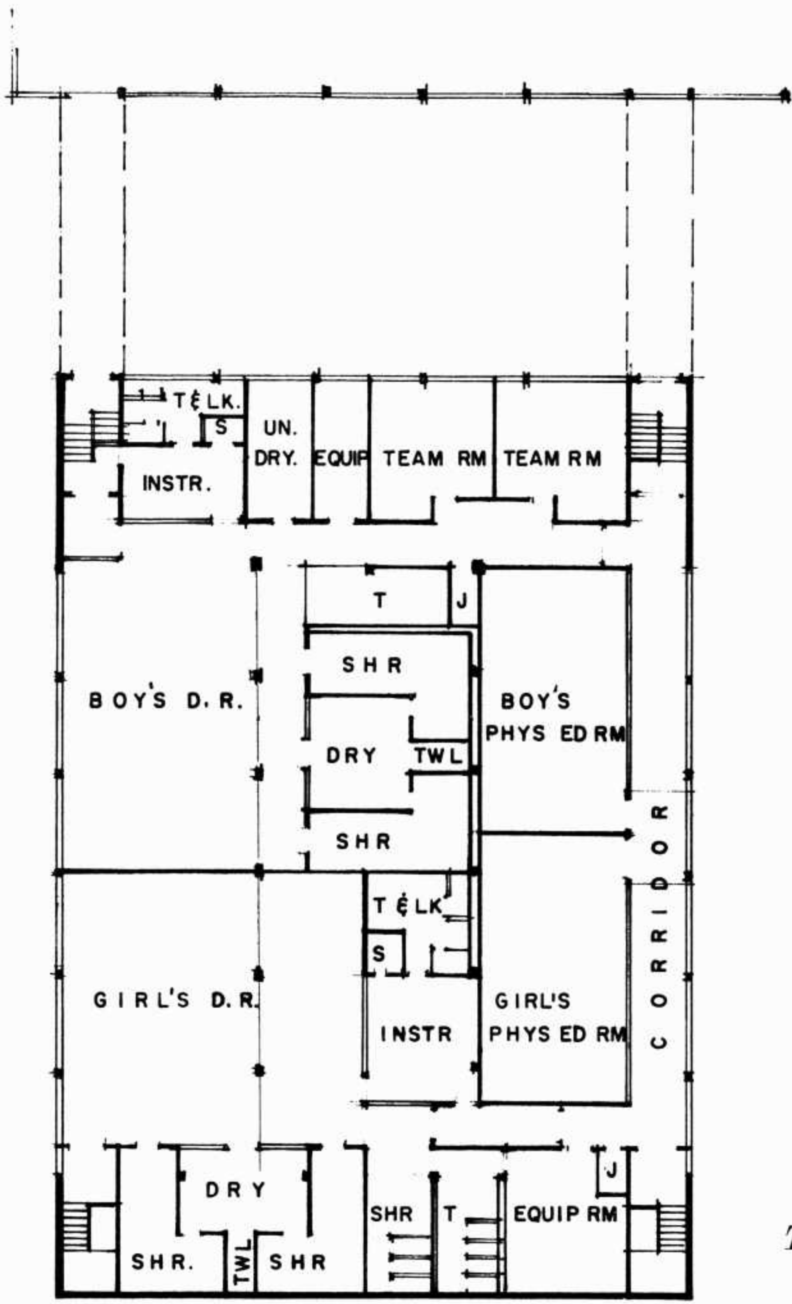
On the basis of the comparative study, it would appear that any school system seeking better ways to accommodate a physical education program might very well give consideration to the use of a geodesic structure.



The Gymnasium

First Floor Plan

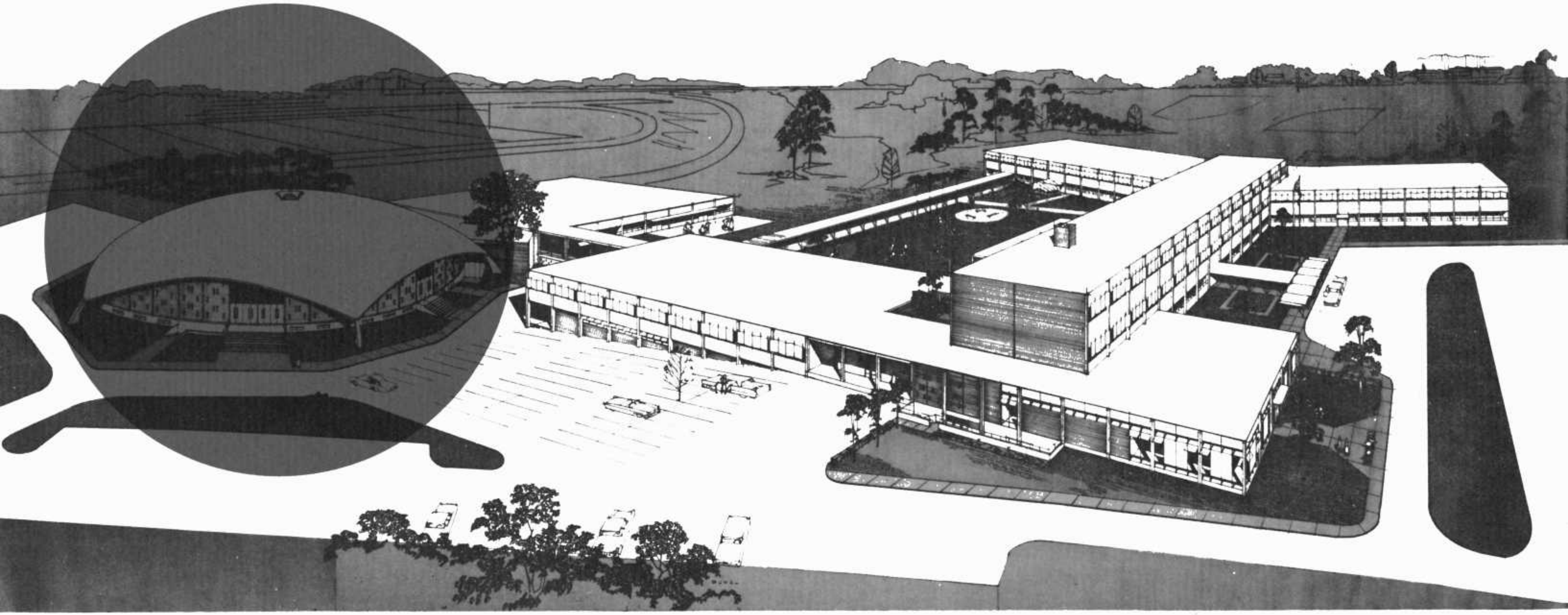




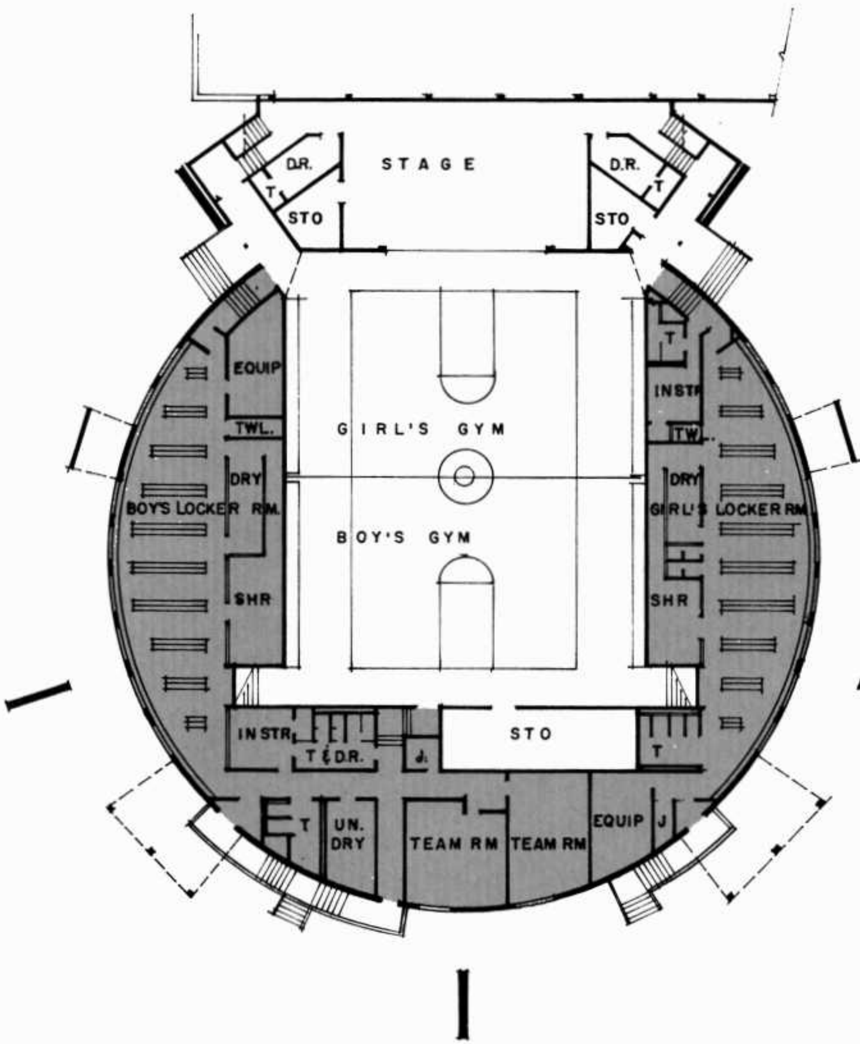
Basement Plan

The Gymnasium

Bleacher Seating	**1,440**
Folding Chairs	**896**
Total Capacity	**2,336**



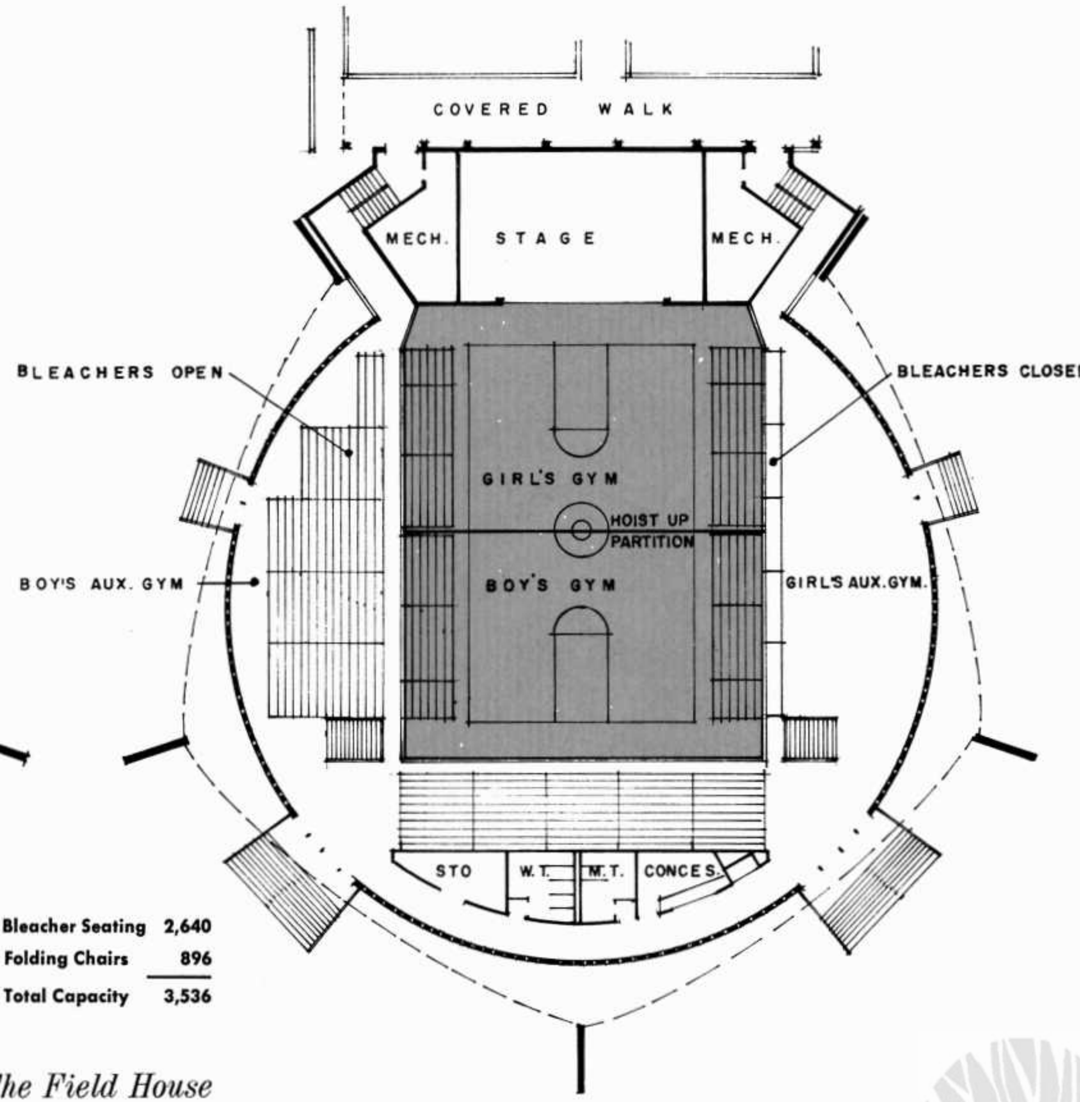
The Field House



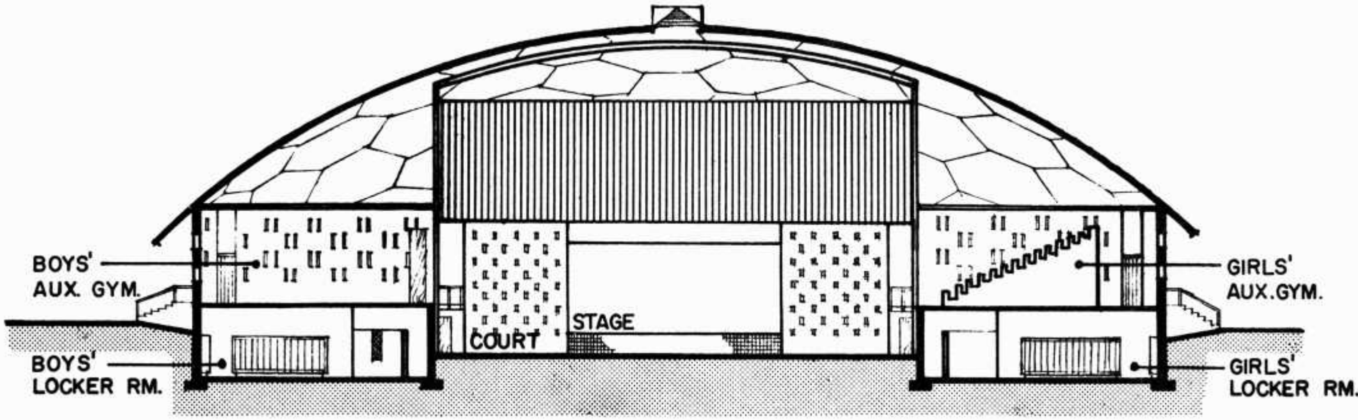
Basement Plan

Bleacher Seating	**2,640**
Folding Chairs	**896**
Total Capacity	**3,536**

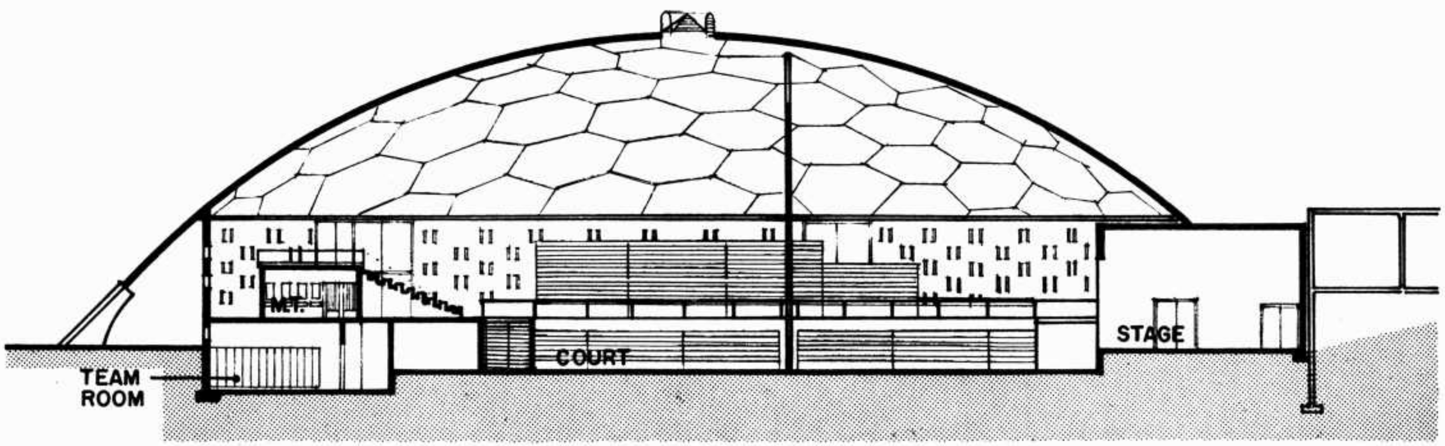
The Field House



First Floor Plan



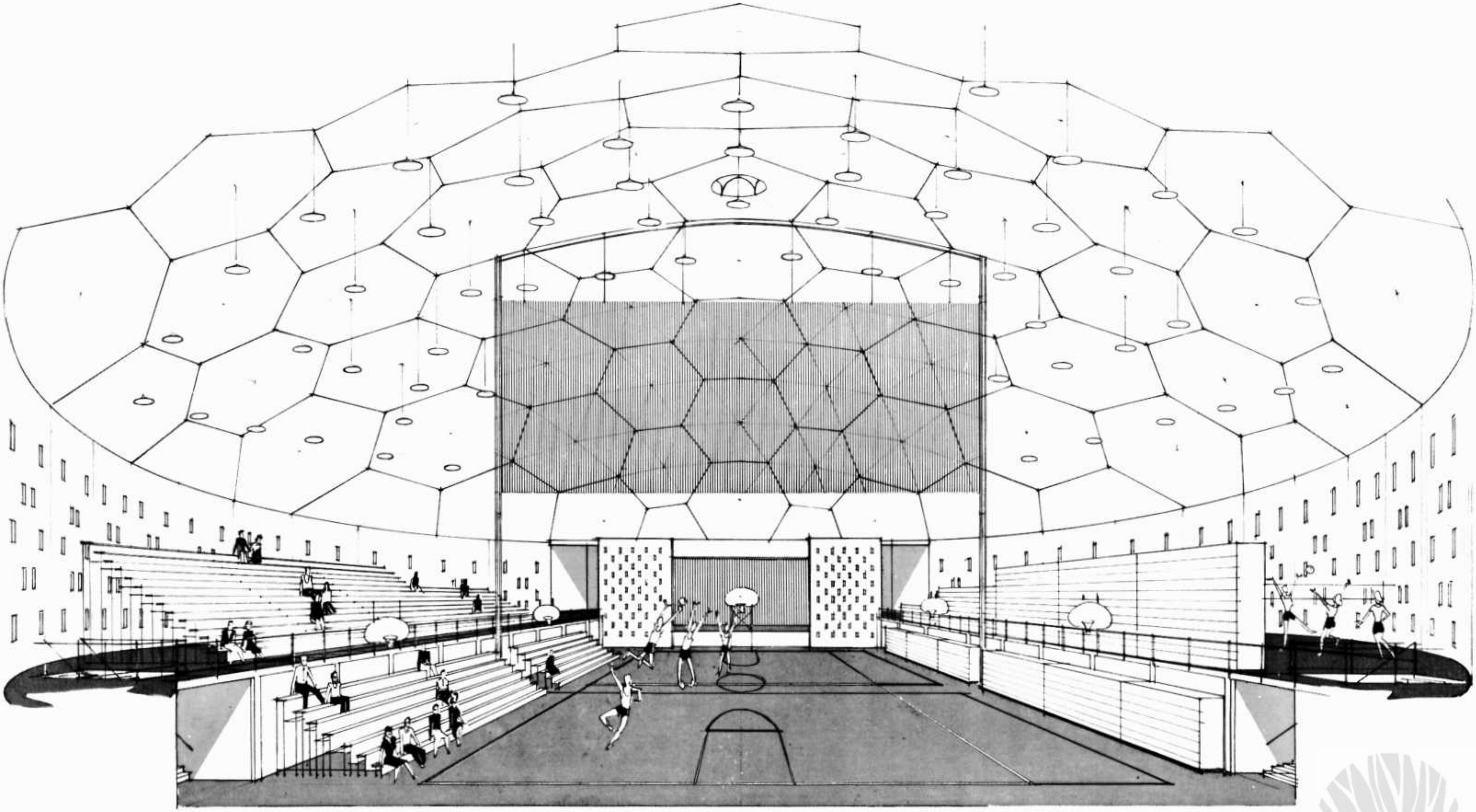
Longitudinal Section



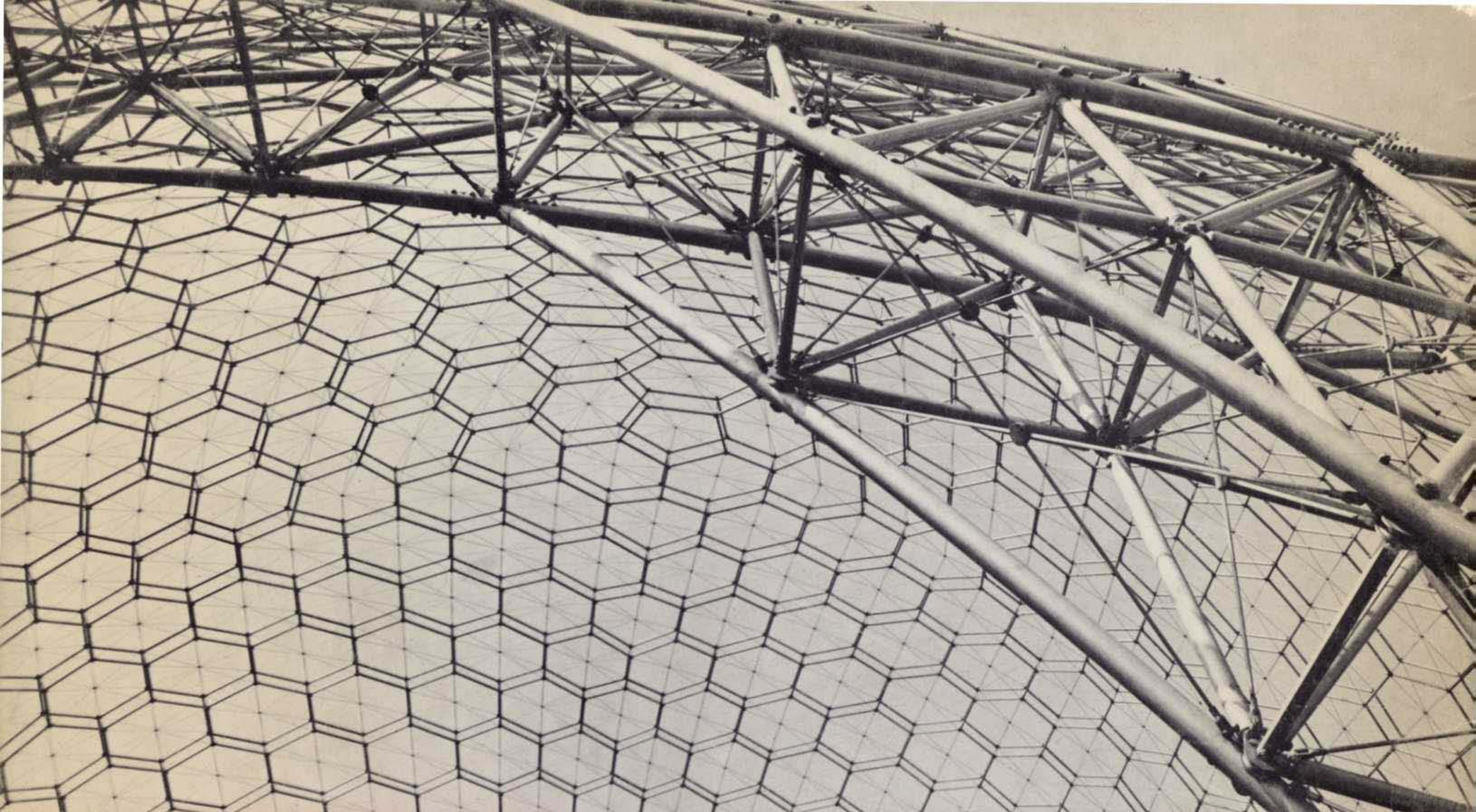
The Field House ***Cross Section***

The Field House

COVER PHOTOS BY BILL MARK
DESIGNED BY ROBERT SUTTER



Third Printing



CASE STUDIES 1 OF EDUCATIONAL FACILITIES

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