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BRITISH PREFABRICATED SCHOOL CONSTRUCTION.
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AT THE END OF WORLD WAR II, ENGLAND EXPERIENCED A SHORTAGE OF TRADITIONAL BUILDING MATERIALS WHILE HAVING TO FACE THE PROBLEM OF PROVIDING MORE THAN 1 MILLION PLACES FOR SCHOOL CHILDREN IN 7 YEARS. IN 1946, THE COUNTY OF HERTFORDSHIRE BEGAN USING PREFABRICATED STANDARDIZED MATERIALS FOR SCHOOL CONSTRUCTION TO MEET THIS NEED. STANDARDIZATION HAS SO LOWERED CONSTRUCTION COSTS THAT THE USE OF PREFABRICATED SYSTEMS HAS CONTINUED TO GROW, EVEN THOUGH SHORTAGES OF TRADITIONAL BUILDING MATERIALS NO LONGER EXIST. IN 1961 EDUCATIONAL FACILITIES LABORATORIES (EFL) BEGAN A STUDY OF THE ENGLISH EXPERIMENT TO DETERMINE THE FEASIBILITY OF APPLYING SIMILAR METHODS TO SCHOOL CONSTRUCTION IN THE UNITED STATES. THE SCHOOL CONSTRUCTION SYSTEMS DEVELOPMENT PROJECT (EFL) HAS UNDERTAKEN TO DESIGN A COMPLETE SET OF COMPONENTS FOR THE CONSTRUCTION OF SECONDARY SCHOOLS. EFL HOPES TO COORDINATE A NUMBER OF SCHOOL DISTRICTS IN ESTABLISHING A MARKET LARGE ENOUGH TO INTEREST INDUSTRY IN BIDDING FOR A CONTRACT TO PRODUCE PREFABRICATED MATERIALS MEETING STANDARDS SET BY THE SCHOOL SYSTEMS. A DETAILED DISCUSSION OF THE ENGLISH SCHOOLS, INCLUDING PHOTOGRAPHS AND DESIGNS, MAKES UP THE BODY OF THE REPORT. (AD)

SCHOOL CONSTRUCTION SYSTEMS DEVELOPMENT

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PREFACE

The report reviews recent developments in the design of English prefabricated school buildings which were seen and discussed during a trip to England in December, 1961. It also draws upon previous knowledge of this work which dates back to 1954 when the author, Ezra Ehrenkrantz, went to work at the Building Research Station, Garston, Hertfordshire, England, as a Fulbright Fellow.

The recent trip marks the beginning of a project (sponsored by Educational Facilities Laboratories) to determine the feasibility of applying the English approach to prefabricated school construction in the United States. The report therefore stresses those aspects of the English work which may hold useful precedents for work in the United States, and does not attempt to evaluate the school buildings from a purely aesthetic point of view. Two conflicting interests have focused EFL attention on the subject: (a) the requirement for design flexibility to house new educational methods, and (b) the desire to reduce costs through the use of stock plans. In addition, there is a trend toward the use of larger and more complicated building components. The trend will make it increasingly important to work with standard products. While it may be relatively simple to cut certain sheet materials with only a moderate degree of waste in terms of labor and material, it is extremely difficult to do this when the sheet is encased by an extruded aluminum section. The complexity of these products makes it almost impossible to alter them at the building site; and it becomes necessary for the architect who does not work with standard sizes to specify special sizes. This makes it impossible for industry to produce an efficient range of standard product sizes, which, in turn, raises the costs of the components. In other cases, the price of standard products is increased and the cost of special sizes is thereby subsidized in order to meet competition.

It is not surprising that people have, from time to time, thought of using stock plans for school construction. However, in a period of rapid change in educational programs and consequently in educational buildings, stock plans seem to offer little promise for the future.

The work done in England in using standard products for the design of individual school buildings seems to hold much more promise, both in terms of design freedom and cost reduction. The most important facet of this work is its orientation to the average-size components used in school construction such as windows, doors, and wall panels, rather than very large products or structural spans. Architects can then design schools on a grid dimension related closely to the function of the building, and can obtain considerable design flexibility within the framework of the grid. As the same components are used for a large number of buildings, it is possible to "program" their use and to obtain substantial price reductions through bulk purchase techniques. The work in England, which was initially begun because of post-war shortages of traditional building materials and labor, has developed over a period of approximately twelve years to a point where prefabricated school buildings are winning architectural design prizes both in England and abroad. Educational Facilities Laboratories has been interested in the English school experience because of the promise it holds for flexibility to be combined with the economies of standardization.

The School Construction Systems Development Project (EFL) has undertaken to design a complete set of components for the construction of secondary schools in the United States. It is likely that the buildings of the pilot project will be located entirely in California; the design and bidding procedures will have to conform to state legal requirements for school construction. School districts must be found which will employ the new system in one or more of their high schools. The schools of the project should have a completion date in 1966 or 1967.

The major aim of the EFL project is to obtain better value for our school building dollar through the mass purchase of components for more than one school at a time. An approach to the prefabrication of schools is envisaged here whereby a number of school districts maintain control of the system. Up to the present time in the United States, prefabricated systems have been industry centered, where one or more manufacturers develop a system and then market it.

In the project we will seek to work with a number of school districts which will present a large enough market to industry so that any desired building products can be ordered and made economically. In this way, the system will be controlled by the client.

As a result of preliminary discussions, it appears that approximately seven large high schools will be needed to provide a large enough market to interest industry in developing products specifically for the project. Once this market is developed, it will be possible to prepare performance specifications for the system. These specifications should go into considerable detail on both the educational and technical aspects of the buildings. The requirements should be described in such detail that bids may be taken on the basis of the performance specifications alone.

After the low bidders have been determined, the work on the actual components will begin. Each manufacturer will work to design and detail components that will be coordinated into the total system, taking advantage of the plant and technological know-how that he has at his disposal.

The components of each of the various manufacturers will all be coordinated by the EFL design team so that the result is a complete and coherent system.

By this procedure we will be able to develop a system that takes into account the client's wishes and, at the same time, can be produced effectively. The system itself must then have sufficient flexibility to meet the different design requirements of the individual school districts and their architects. In order for the system to be considered successful, it should provide for sufficient variety so that all the buildings constructed in the pilot program are recognized as individual buildings designed by particular architects for particular clients rather than buildings of a specific system designed by a number of different architects. This flexibility must be coupled with economically produced components that meet the school district's requirements.

The project is supervised by an Advisory Committee, representing state officials, architects, and educators. The current members are listed on page three of this report.

Additional information on the work in the United States can be obtained by writing to the offices in Palo Alto, California.

REPORT ON BRITISH PREFABRICATED SCHOOL CONSTRUCTION

Introduction

At the end of World War II, England was faced with the problem of having to provide over one million places for school children in seven years. This was the equivalent of more than 400 new schools per year. The reasons for this large demand were: war damage, increased birth rate, population shifts and the raising of the minimum school leaving age from 14 to 15.

However, the size of the job was not the only problem as there were acute shortages of building materials and labor. The available traditional materials were allocated basically to housing, making it necessary to develop new products and techniques to cope with the school building problem. With the large change over from war to peace-time production in industry, it was decided that the industrial potential of a number of manufacturers should be harnessed for the development of prefabricated school building systems.

The work on prefabricated school building systems was started by a development team of architects on the staff of the Hertfordshire County Council. The County of Hertfordshire lies immediately to the north of London, and within its boundaries a number of new towns have been sited to reduce the population pressures on London. The projected increase of population required the construction of 175 schools in 15 years to educate the growing population of the county. The H.C.C. architects resolved at an early stage to overcome the shortages of traditional building materials and on site labor by using a factory made building system. The first system was developed in 1946 and the results of this work in Hertfordshire were very successful.

In 1949, the Ministry of Education began to assist in the spread of this concept of development work. The problem of shortages of labor and materials were shortly compounded by a reduction in the financial allowances for each student place. The average cost per place in 1949 was £195 and £320 for primary and secondary schools, respectively. It was cut by necessity to £120 and £240 by 1951. A large portion of this reduction was taken up through reducing the area per place, however, a reduction in cost per square foot was also necessary. The Ministry of Education through its publications and development projects showed how it would be possible to provide good facilities for education in spite of the restrictions. Very careful attention was paid to cost controls and a system of cost analysis was developed to determine where the money was being spent. In all of the building systems which have been developed since, careful attention has been given to thorough costs studies and controls. Appendix 1 shows a Specimen Cost Analysis taken from the Ministry of Education's Building Bulletin No. 4, Cost Study.

The Ministry of Education originally sponsored four separate systems developed through the cooperation of different manufacturers. They were:

Hills, Brockhouse, B.A.C., and Intergrid.[1/] In 1957, B.A.C. went out of production, and the Ministry of Education assisted in the introduction of the Laingspan system, and is currently acting both as a catalyst and as an advisor in helping new development teams to get started.

At the time that the Ministry of Education began to assist in the development of these systems, the total school building program cost approximately £40 million per year. It was hoped that the systems would account for half of the construction with a market of £5 million for each system. This figure was reached for the first time last year by the CLASP system.

Figures for the number of schools constructed in England and Wales for the years 1950, 1955-1961 are given in Table 1, subdivided into three categories according to method of construction. These are: 1) Traditional Construction, 2) Prefabricated System, and 3) Hybrid, containing elements of 1 and 2. The percentage of construction in each category is shown at the bottom of Table 1. Table 2 contains a similar analysis by cost rather than by number of projects.

These two tables show that a larger percentage of the total volume of school construction was prefabricated in 1950 than in any succeeding year. Also that, after a good year in 1956-57, a low point was reached in 1957-58 from which time the use of prefabricated systems has been increasing. This general decline in the use of prefabricated systems may be attributed to the fact that, as other building materials became more readily available, some people decided to return to the use of more traditional methods. Another reason may lie in the fact that provision of new school places exceed the growth of school population for the first time in 1957, as shown in Figure 1. In some parts of the country this obviously reduced some of the urgency for providing new schools. As speed of construction is one of the undisputed advantages of prefabrication over traditional building methods, this may have reduced the requirement for prefabrication.

Since 1958-59, the use of prefabricated systems has been growing steadily although the shortages of traditional building materials no longer exist. This is because these systems have achieved considerable flexibility to cope with the varied design requirements, and they offer sufficient aesthetic flexibility to be used by private architects as well as various government agencies. In the last two years, buildings designed on two of these sys tems have won major international and national design awards. For this reason theere has been no reversion to the use of traditional methods for school construction. On the contrary, individuals who have been connected with the design of these systems have been recruited by the Ministries of Housing, Health, and the War Office to develop analogous systems for their own building types.

One factor which has obviously aided in the development of these prefabricated systems is the fact that schools are exempt from local bylaws or codes and school construction is subject only to a national code.

1/ For a total list of manufacturers, addresses and systems, see Appendix 2.

TABLE 1

SCHOOL BUILDING IN ENGLAND AND WALES

ANALYSIS BY NUMBERS OF CONSTRUCTIONAL ELEMENTS - 1950, 1955/56 to 1960/61

	1950	1955/57	1956/57	1957/58	1958/59	1959/60	1960/61	Totals
Traditional	242	324	375	146	294	252	356	1,747
Hybrid	240	330	247	91	221	169	228	1,286
Prefabricated	117	146	127	56	67	66	85	547
Totals	599	800	749	293	582	487	669	3,580
Timber (Included in Prefab. above)	-	55	64	21	23	23	30	216
Analysis By Percentages Based on Above Totals								
Traditional	40.4	40.5	50.1	49.8	50.5	51.7	53.2	48.8
Hybrid	40.1	41.3	33.0	31.1	38.0	34.7	34.1	35.9
Prefabricated	19.5	18.2	16.9	19.1	11.5	13.6	12.7	15.3
	- - - - - - - 100.0% - - - - - - - - - - -							
Timber (included in Prefab. above)	-	6.9	8.5	7.2	4.0	4.7	4.5	6.0

Notes:
1) 1959/60 does not include 30 projects for which there is no noting.
2) 1960/61 does not include about 65 projects for which there is no noting.
3) The end Totals include the 1955/56 to 1960/61 programs only.

TABLE 2

SCHOOL BUILDING IN ENGLAND AND WALES

ANALYSIS BY VALUE OF CONSTRUCTIONAL ELEMENTS - 1950, 1955/56 to 1960/61

	1950	1955/57	1956/57	1957/58	1958/59	1959/60	1960/61	Totals
				Value in 1,000,000s				
Traditional	13.95	28.28	34.35	10.44	20.52	19.31	32.38	145.26
Hybrid	20.63	36.96	26.64	9.77	24.09	16.72	29.88	144.06
Prefabricated	9.05	12.88	10.39	5.00	5.46	4.50	10.25	48.48
Totals	43.63	78.12	71.36	25.21	50.07	40.53	72.51	337.80
Timber (included in Prefab. above)	-	3.51	4.07	1.06	1.08	0.74	1.39	11.85
				Analysis By Percentages Based on Above Totals				
Traditional	32.0	36.2	48.1	41.4	41.0	47.6	44.7	43.0
Hybrid	47.3	47.3	37.3	38.8	48.1	41.3	41.2	42.6
Prefabricated	20.7	16.5	14.6	19.8	10.9	11.1	14.1	14.4
				- - - - 100.0% - - - -				
Timber (included in Prefab. above)		4.5	5.7	4.2	2.2	1.8	1.9	3.5

Notes:
1) 1959/60 does not include 30 projects for which there is no noting.
2) 1960/61 does not include about 65 projects for which there is no noting.
3) The end Totals include the 1955/56 to 1960/61 programs only.

INCREASE IN SCHOOL POPULATION SINCE JANUARY, 1946 IN THOUSANDS COMPARED WITH PROVISION OF NEW SCHOOL PLACES

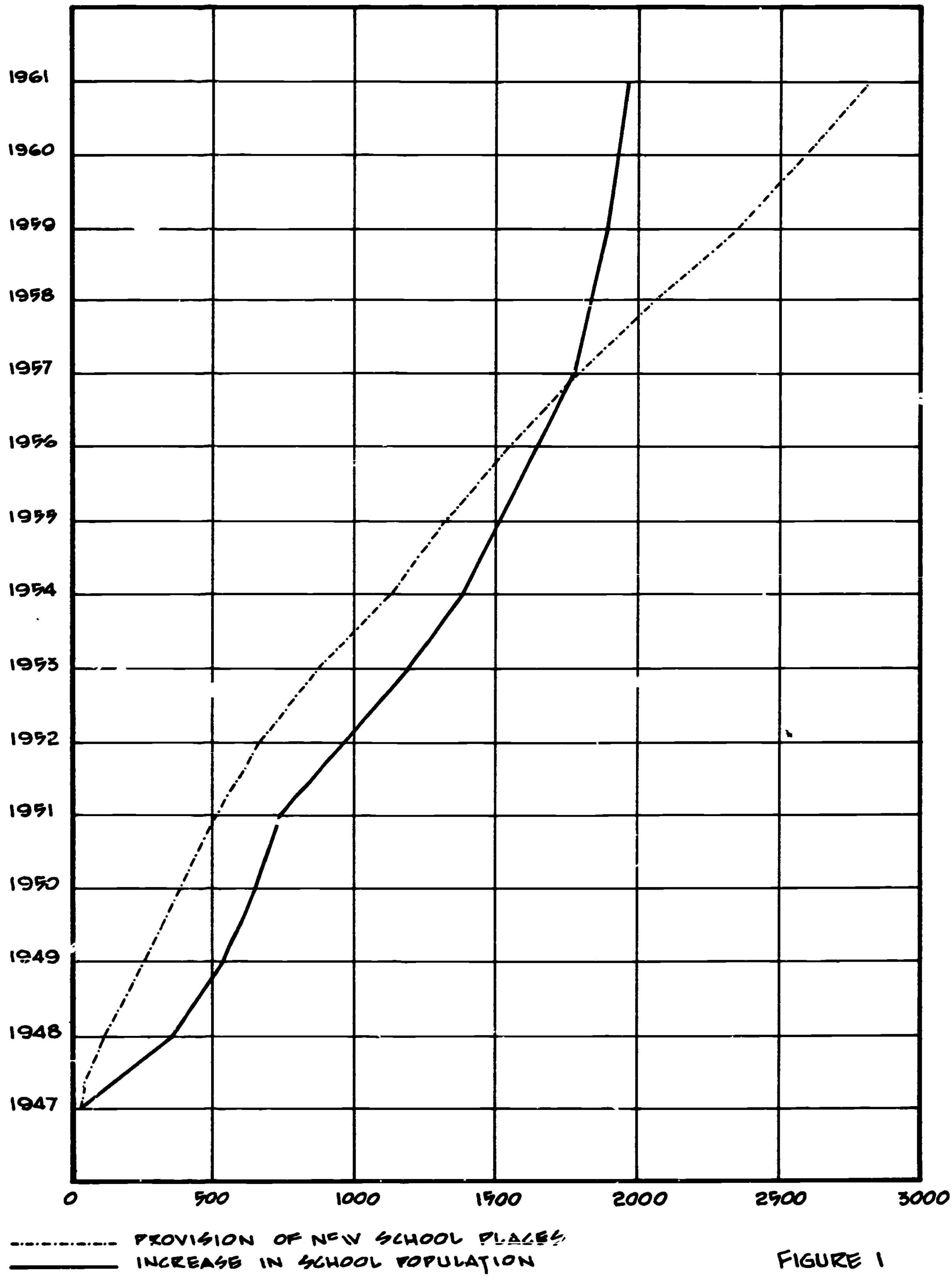


FIGURE 1

Hertfordshire

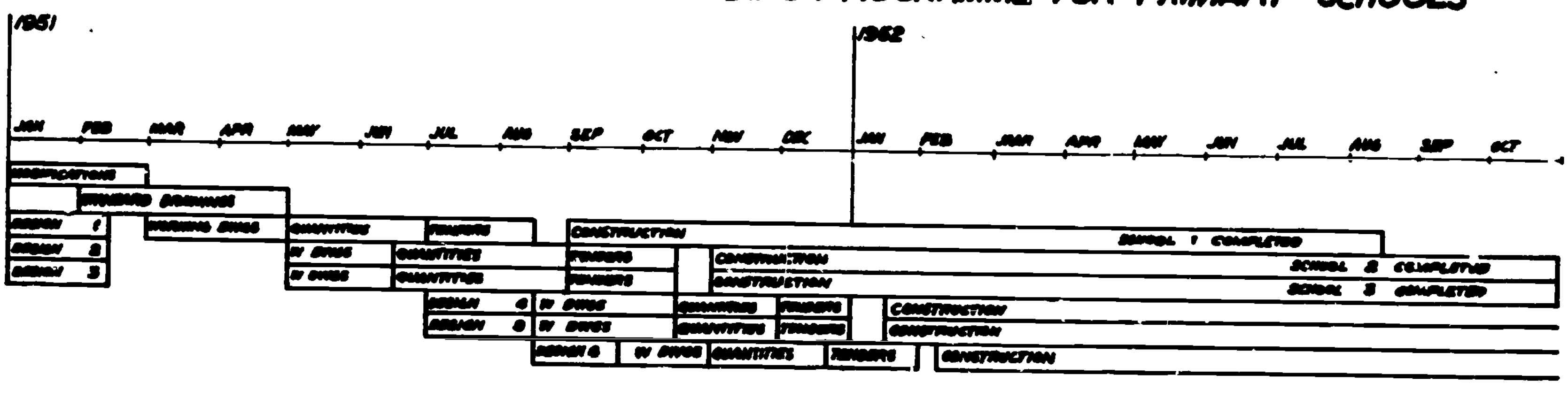
The main impetus for the entire prefabricated school building program in England was begun in the County of Hertfordshire which has an annual building program of about 12 schools. Sometime in 1962 their 200th prefabricated school will be constructed. About 85% of these school buildings were designed on an 8'3" grid which has been used since 1946. The actual system, however, has varied from year to year. The volume of construction in a given year is sufficient to permit industry to amortize its costs so that, in the first few years of the H. C. C. program, considerable modifications and revisions were made annually. Table 3 shows part of a typical year's primary school building program.

The overwhelming majority of the Hertfordshire County Council schools have been designed with a steel structural frame developed by the H. C. C. architects and Hills, Ltd. of West Bromwich. The price of the steel frame varies only with the tonnage and the cost for galvanizing. Hills pays for all the development work on the basis of a continuing contract from the late 40s. The structural system, once it has been designed, is fixed for a given period of time. The other components must be interchangeable and fit with the structural framework.

The initial work of the H. C. C. was related only to school construction, and in recent years it has been expanded to include colleges, police stations, municipal garages, etc. It has been found that the variety of requirements cannot be solved efficiently by a single structural system so the H. C. C. is currently developing three structural systems from steel, concrete, and traditional load bearing elements. Everything but the structural components will be interchangeable for bulk bidding. This will enable the County to take bids for a year's entire £5 million building program at one time.

TABLE 3

PART OF A TYPICAL YEAR'S BUILDING PROGRAMME FOR PRIMARY SCHOOLS



The light steel frame system which has been used for the design of the H.C.C. schools will be used for approximately £3.5 million construction; the concrete frame designed for heavy, multi-story urban buildings will be used for approximately £1 million construction; and the traditional load bearing methods will be used for small buildings and renovations at an approximate cost of £0.5 million. All of the other components, including windows, walls, floors, roofs, mechanical systems, etc. will fit the three structural systems.

This appears to be a step towards an extremely flexible concept of prefabrication where few things are fixed and everything is related, where the choice of material is left up to the designer, and is related to the requirements of the building. Ken Evans, the Deputy Chief Architect of the H.C.C. is very conscious of the implications of this work and speaks of the system as being spelled with a small 's'. This flexibility may be of considerable importance to us in the United States as few school authorities have a big enough building program to justify the design of their own system, so a number of separate groups will have to work together if they are to provide an economically feasible market for industry.

The structural grid of the new steel frame system is 10'8" (although columns may be placed 21'4" on center) and the component grid is 2'8" which is the smallest planning grid used in English school construction. Back in 1946, an 8'3" grid was recommended as a useful design grid for school construction. It was related to a classroom size of 24'9" which could be constructed using a 9" brick module or using 8' sheets of dry building materials with 9" columns. The dimension from inside of wall to inside of wall was exactly 24'0". In the middle 50s a 3'4" grid was used, particularly for secondary schools where plan requirements necessitated greater flexibility than was available with the larger 8'3" grid. The 3'4" dimension grid was used in a rather small number of H.C.C. schools and the 8'3" grid continued to be used for a major portion of the school building program until 1962. From now on, the new steel frame system with a 2'8" component grid will be used exclusively. This dimension offers considerably more flexibility than the 8'3" grid for interior planning although the minimum structural grid of 10'8" offers less design freedom. Actually the system is designed to permit interior planning on the basis of one-half grid dimension or 1'4". The use of the 2'8" grid is very economical, as three products of 2'8" may be cut from a sheet size of 8'0". When the 3'4" grid was used, 1'4" of material was wasted from every 8'0" sheet.

There has been some considerable development in the detailing of the various systems which have been used in Hertfordshire. Figure 2 shows this development from 1946-1954 with the most important system being the one developed in 1951 which has been in use with minor modifications until 1961.

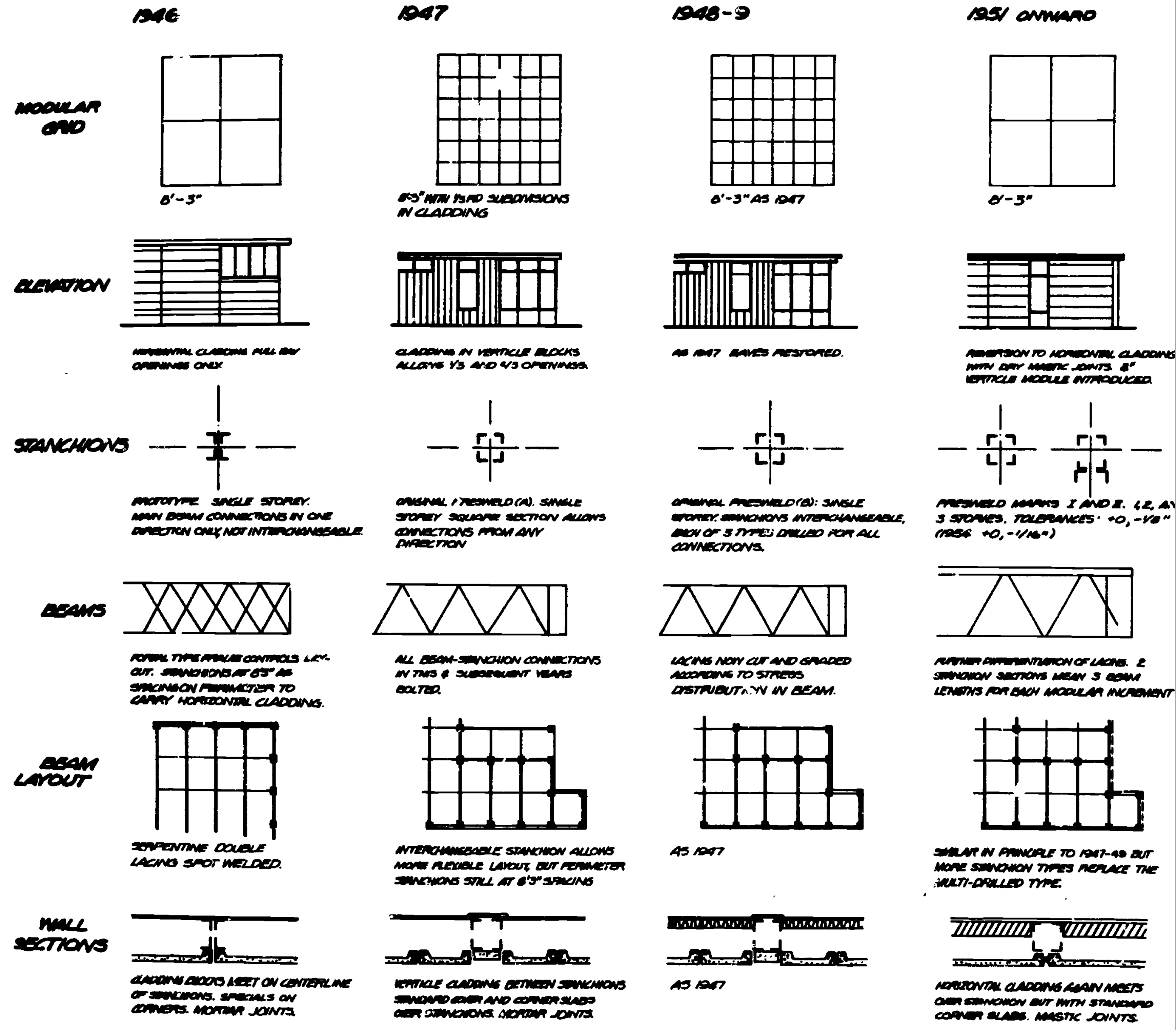
One of the interesting aspects of the new Hertfordshire system using the 2'8" grid is that it is the first system which does not have the columns fall in the line of the outside wall of the building. The columns normally fall 1'4" inside the wall of the structure although they may also come the same distance outside the wall. One of the main reasons for this departure was that the wall itself was freed from the structure of the building so that column size could vary with the height of the building, and the wall panels would not have to compensate for the thickness of the structural elements. By separating the exterior wall of the building from the structure, it becomes possible to have the same group of components work with the three different kinds of structural systems. A possible disadvantage of the use of this system is that the columns which fall within the rooms themselves may inhibit the use of a considerable portion of the interior space.

An important savings in the cost of building components is effected through the technique of bulk bidding. Competitive bids are taken for all standard components which will be used in the County's building program for a period of one or more years. In the Hertfordshire school building program this means approximately twelve schools a year, and under the new program it will involve £5 million worth of building. This enables the manufacturer to plan his production schedule over a long period of time, and supply the building products as they are needed within the County. This not only reduces costs but permits the H. C. C. architect to develop products which will suit the County's particular requirements. This technique of annual bids is used for all but two product types: the structural and heating systems, where nominated subcontractors supply the products. These contractors were chosen initially as a result of competitive bids, but were called upon to spend considerable sums of money to develop products in collaboration with the County Architect. In return for this expenditure on research and development, these two contractors were promised that their products would be used over an extended period of time. As was mentioned previously, the price of the Hills structural frame varies only with the cost of steel per ton, and on this index alone a large variety of structural systems have been developed since 1949. In the case of the heating products, Weatherfoil has been working with the County in a similar manner.

In the case of a number of other components which require development money in excess of what the County is able to pay but not enough to justify restricting the competitive bidding, the manufacturer who does the research is promised that his products will be used in two or three schools before the details and specifications are submitted for open bids. The manufacturer who developed the components thus has an opportunity to amortize his expenses on these schools and will then be in a position to place his bid with the advantage of having worked on the components.

In one interesting case, Crittal developed a new range of windows with the County Architect; and after the construction of the initial schools, the details were put out to bid. Another firm was the low bidder. The following year a third firm came up with the lowest bid; and in the third year Crittal was the low bidder, not having changed its price by one penny in any of the three bids. Apparently, from the experience that they gained while doing the development work, they learned how much it would cost to produce this range of windows.

DEVELOPMENT OF SYSTEMS IN RELATION TO MODULES



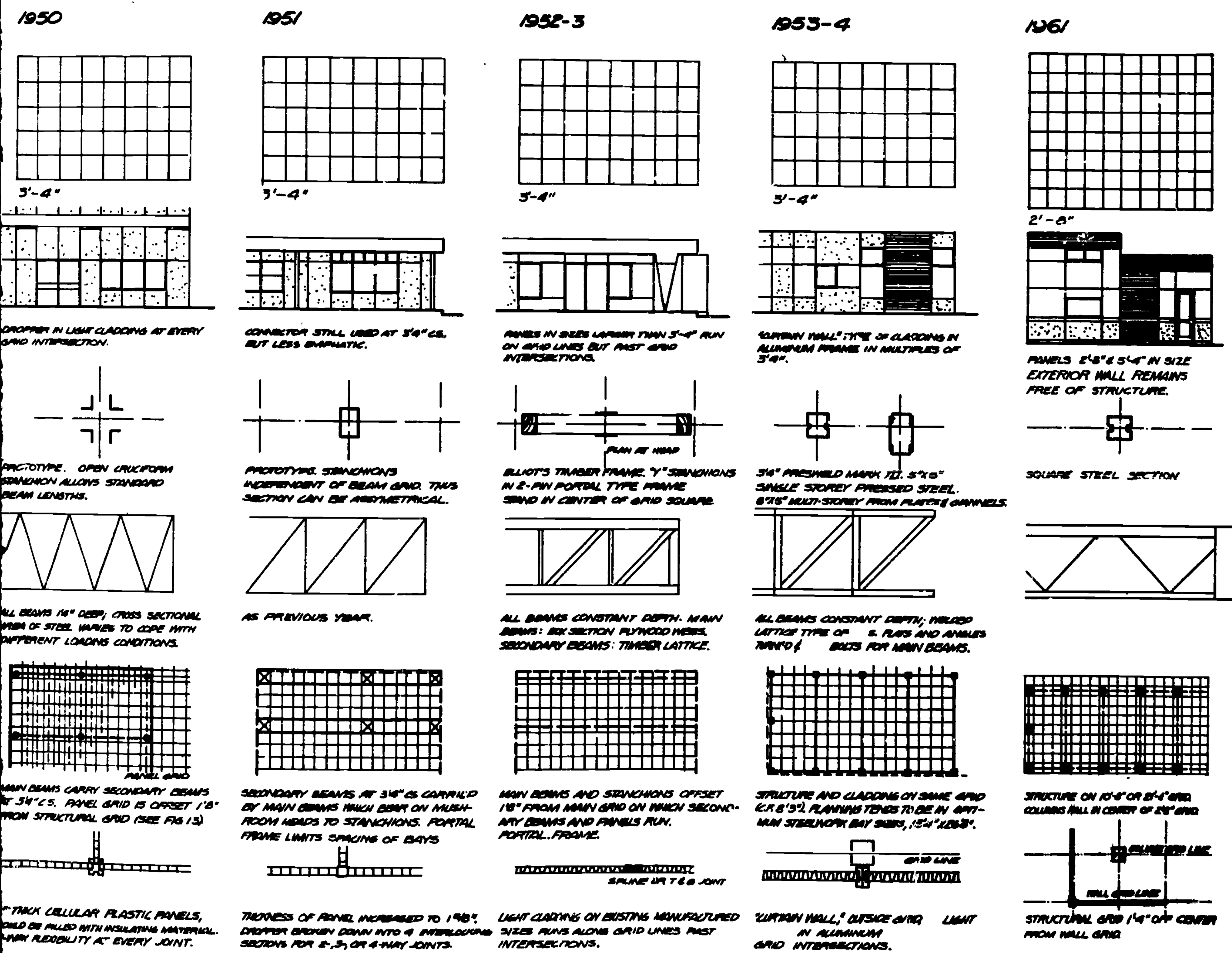
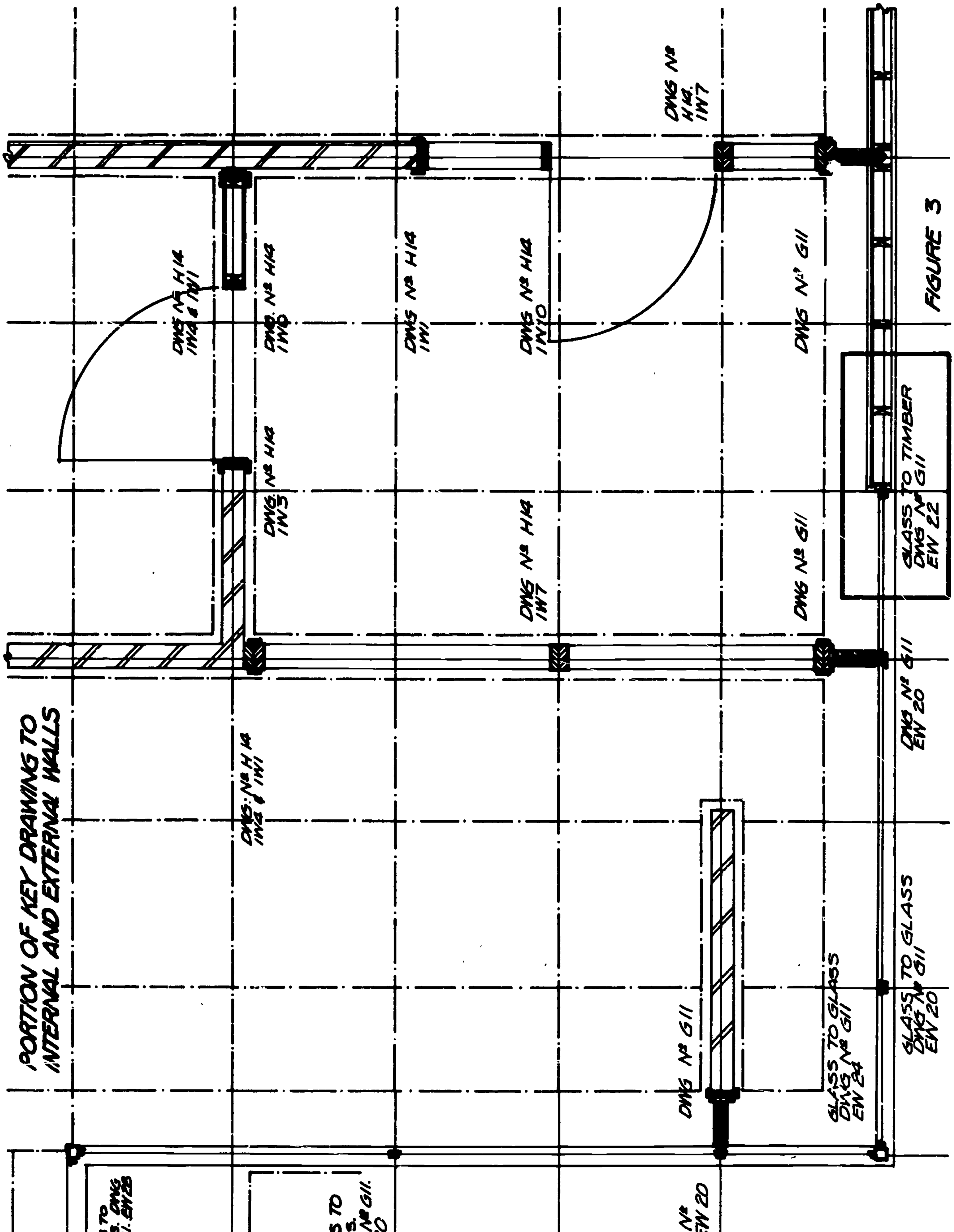

1950
1951
1952-3
1953-4
1961
3'-4"
3'-4"
3'-4"
3'-4"
2'-8"
DROPPER IN LIGHT CLADDING AT EVERY GRID INTERSECTION.
CONNECTOR STILL USED AT 3'4" CS. BUT LESS EMPHATIC.
PANELS IN SIZES LARGER THAN 3'-4" RUN ON GRID LINES BUT PAST GRID INTERSECTIONS.
"CURTAIN WALL" TYPE OF CLADDING IN ALUMINUM FRAME IN MULTIPLES OF 3'4".
PANELS 2'8" & 5'4" IN SIZE EXTERIOR WALL REMAINS FREE OF STRUCTURE.
PROTOTYPE. OPEN CRUCIFORM STANCHION ALLOWS STANDARD BEAM LENGTHS.
PROTOTYPE. STANCHIONS INDEPENDENT OF BEAM GRID. THUS SECTION CAN BE ASYMMETRICAL.
PLAN AT HEAD
ELLIOT'S TIMBER FRAME. "Y" STANCHIONS IN 2-PIN PORTAL TYPE FRAME STAND IN CENTER OF GRID SQUARE.
3¼" PRESWELD MARK III. 5"x5" SINGLE STOREY PRESSED STEEL. 6"x5" MULTI-STOREY FROM PLATES & CHANNELS.
SQUARE STEEL SECTION
ALL BEAMS 14" DEEP; CROSS SECTIONAL AREA OF STEEL VARIES TO COPE WITH DIFFERENT LOADING CONDITIONS.
AS PREVIOUS YEAR.
ALL BEAMS CONSTANT DEPTH. MAIN BEAMS: BOX SECTION PLYWOOD WEBS. SECONDARY BEAMS: TIMBER LATTICE.
ALL BEAMS CONSTANT DEPTH; WELDED LATTICE TYPE OF S. FLATS AND ANGLES BOLTS FOR MAIN BEAMS.
PANEL GRID
MAIN BEAMS CARRY SECONDARY BEAMS AT 3'4" CS. PANEL GRID IS OFFSET 1'8" FROM STRUCTURAL GRID (SEE FIG 13)
SECONDARY BEAMS AT 3'4" CS CARRIED BY MAIN BEAMS WHICH BEAR ON MUSHROOM HEADS TO STANCHIONS. PORTAL FRAME LIMITS SPACING OF BAYS
MAIN BEAMS AND STANCHIONS OFFSET 1'8" FROM MAIN GRID ON WHICH SECONDARY BEAMS AND PANELS RUN. PORTAL FRAME.
STRUCTURE AND CLADDING ON SAME GRID (C.F. 8'3"). PLANNING TENDS TO BE IN OPTIMUM STEELWORK BAY SIZES,
STRUCTURE ON 10'-8" OR 21'-4" GRID. COLUMNS FALL IN CENTER OF 2'8" GRID.
SPLINE OR T & G JOINT
GRID LINE
WALL GRID LINE
"THICK CELLULAR PLASTIC PANELS, COULD BE FILLED WITH INSULATING MATERIAL. FLEXIBILITY AT EVERY JOINT.
THICKNESS OF PANEL INCREASED TO 1⅜". DROPPER BROKEN DOWN INTO 4 INTERLOCKING SECTIONS FOR 2-, 3-, OR 4-WAY JOINTS.
LIGHT CLADDING ON EXISTING MANUFACTURED SIZES RUNS ALONG GRID LINES PAST INTERSECTIONS.
"CURTAIN WALL," OUTSIDE GRID. LIGHT IN ALUMINUM GRID INTERSECTIONS.
STRUCTURAL GRID 1'4" OFF CENTER FROM WALL GRID.

FIGURE 2

It may be interesting to note the way in which the Hertfordshire County Council developed the bidding procedures for the new concrete system. Initially, performance specifications were drawn up for the purpose of obtaining competitive bids on the structural system. These bids were related to unit costs and were not based on a completed design. The selected manufacturer then did the development work to design the system in accordance with the unit costs. The work was done in collaboration with the County Architect; and the resulting design takes into account the capabilities and procedures of the manufacturer's plant as well as the requirements of the architect. Normally, six bidders are required by County regulations for all projects, but in the case of the concrete system, the number was cut down to three as there were no others who had sufficient technical experience.

The Hertfordshire system consists of a series of drawings of a large number of components which may be combined in the design of a building. Each type of component will be supplied by a single manufacturer selected through competitive bidding. The drawings show all the conceivable ways in which the standard components may be used together. When the architect designs a building, he draws the site plan in the usual manner. The other drawings may be in a more or less simplified form, as all of the components are keyed to one another by a single coding system. Figure 3 shows a portion of the key drawing to Internal and External Walls. This drawing shows all the wall jointing conditions and indicates on what sheet the details will be found. Figure 4 shows the detail EW-22 on Drawing No. G-11 which is circled in Figure 3. By means of this type of reference system it is possible to specify the components for any portion of the building in a very simple manner, as may be seen by the elevation shown in Figure 5. The details describing how all of these parts go together are contained within the drawings of the system so that the designer of a specific building does not have to redo them for every job.

The number of available components which the designer may use is very considerable. As an example, the External Frame Range is shown in Figure 6. Photographs 1-5 illustrate the use of the 2'8" grid system in the design of St. Alban's College of Further Education.



PORTION OF KEY DRAWING TO INTERNAL AND EXTERNAL WALLS

FIGURE 3

AN EXTERNAL WALL DETAIL

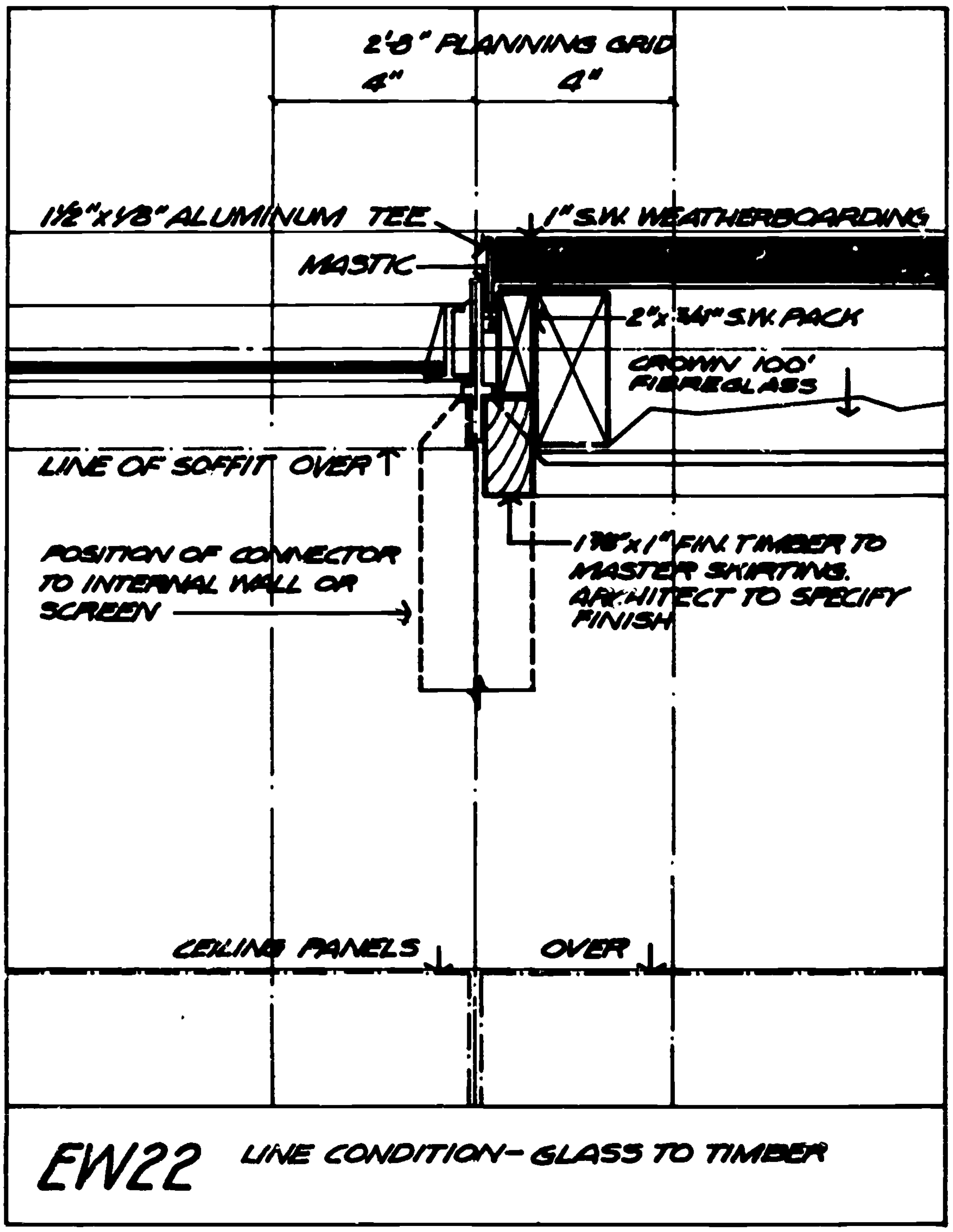
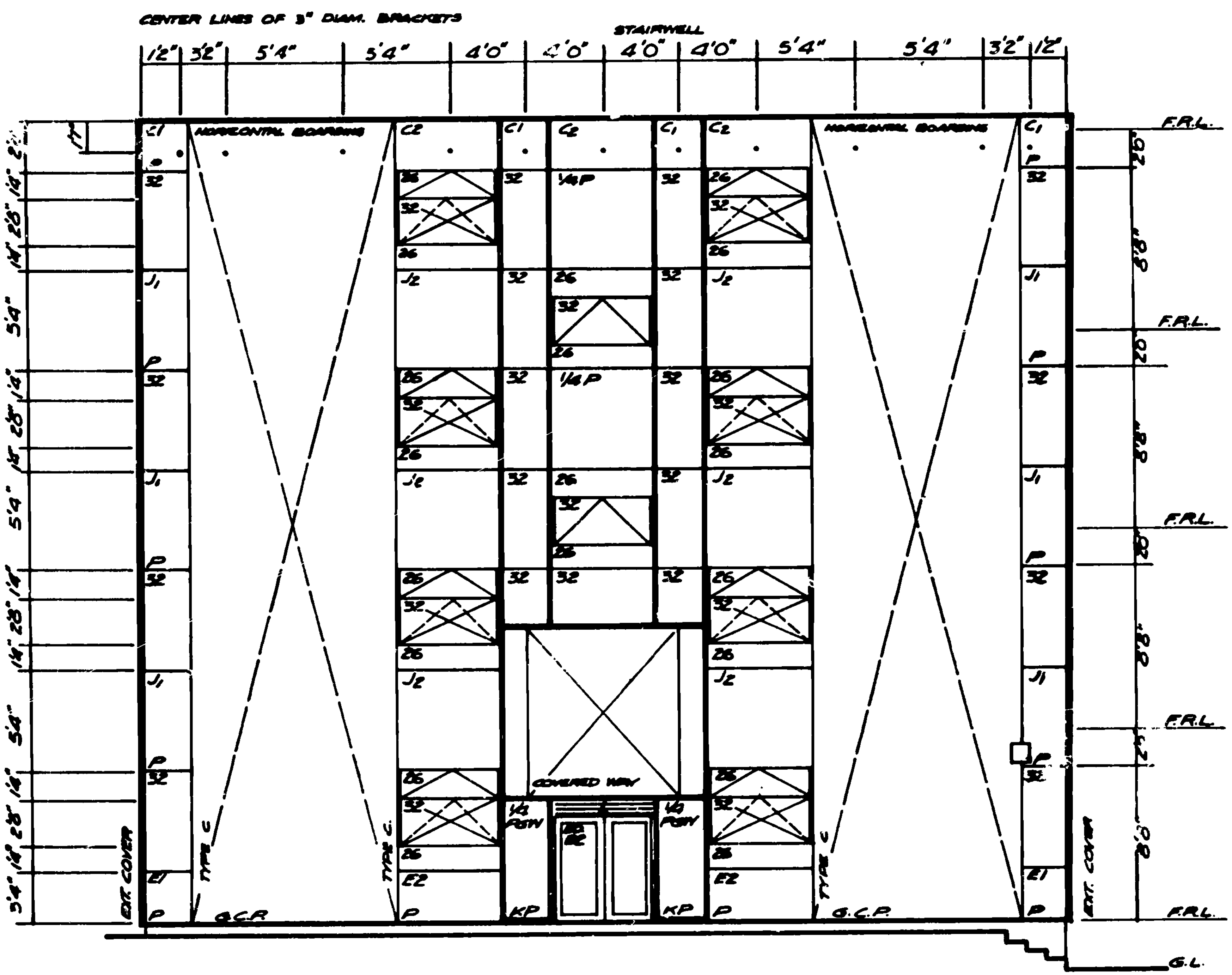


FIGURE 4

TYPICAL ELEVATION – ST. ALBAN'S COLLEGE OF FURTHER EDUCATION



SOUTH ELEVATION

FIGURE 5

NOTES

10.5.57 ELEVATIONS REVISED DUE TO ALTERATIONS TO PLAN.

SCHEDULE OF INSERT PANELS

	1	2
A		
B		
C	8	26
D		
E	4	78
F		
G		
H		
J	12	72
K		
L		
M		
N		
O		
P		
Q		
R		

K.P. – KICKING PLATE
L. – LOUVRES
P. – PANEL

TOP HUNG VENT

PROJECTED TOP HUNG VENT

GLASS WEIGHTS
26 – 26 Oz.
32 – 32 Oz.
1/4 PGW – 1/4" POLISHED GEORGIAN WIRED
OBS – OBSCURRED

PANEL SUPPLIER TO NOTE:
# INDICATES HOLES IN EXTERNAL WALLING TO TAKE 3" DIAM. BRACKET SUPPLIED & FIXED BY MESSRS. HILLS LTD. HABIPE HOLING IS IN PLASTIC PANELS. THIS IS TO BE PERFORMED BY MANUFACTURER 3 1/2" DIAM. WITH REINFORCED EDGE AND IN POSITIONS INDICATED ON ELEVATIONS.

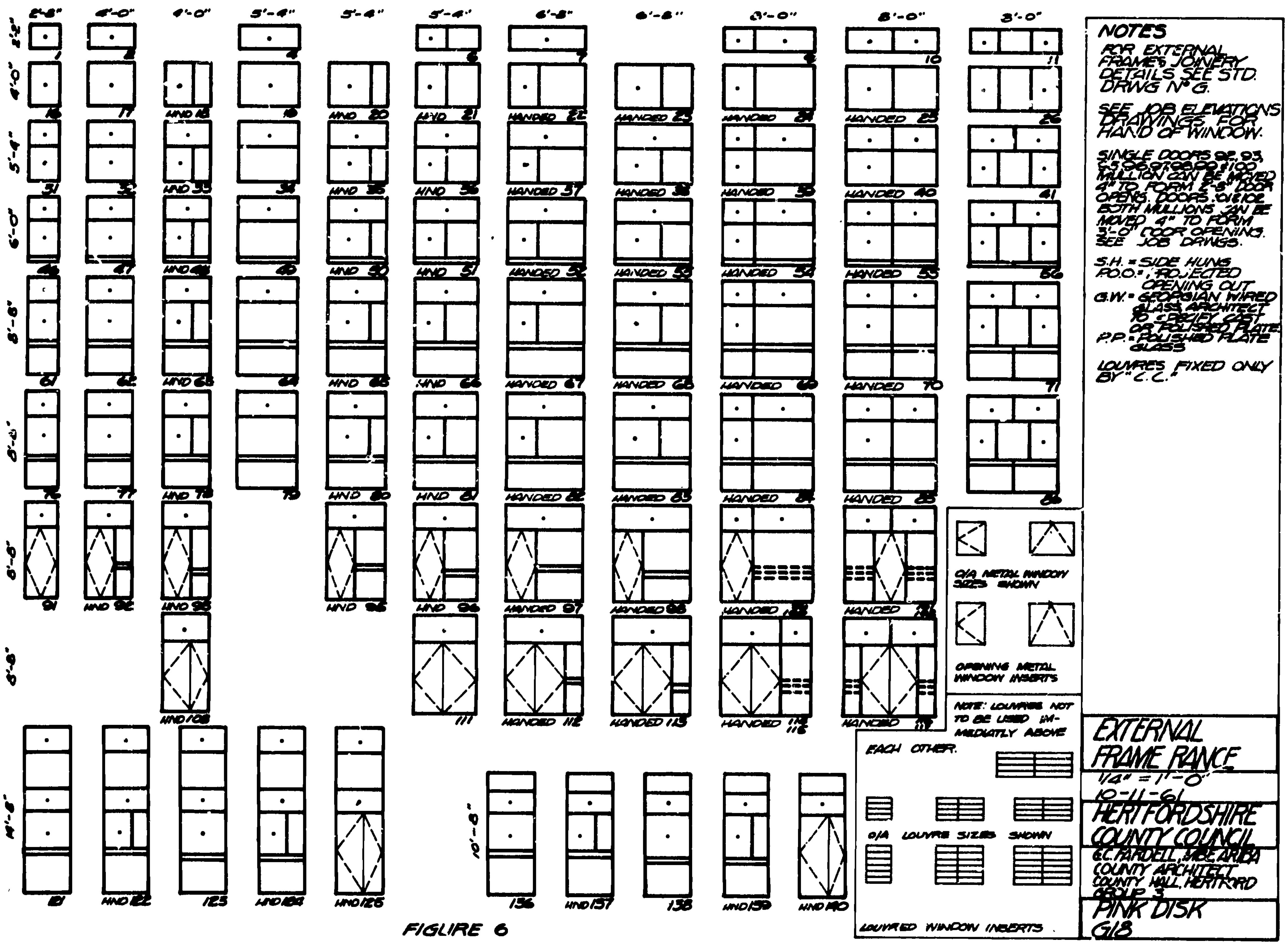
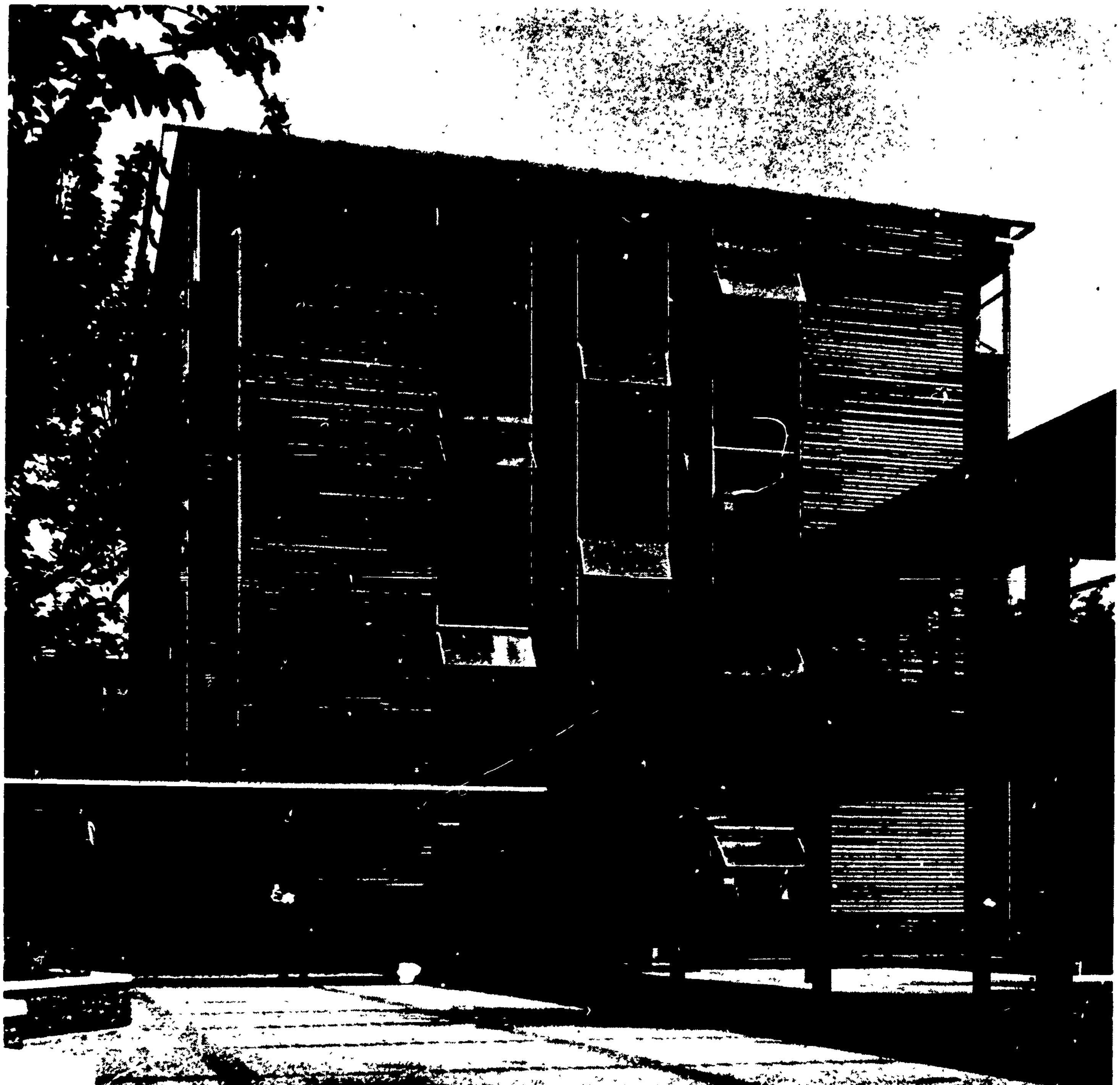
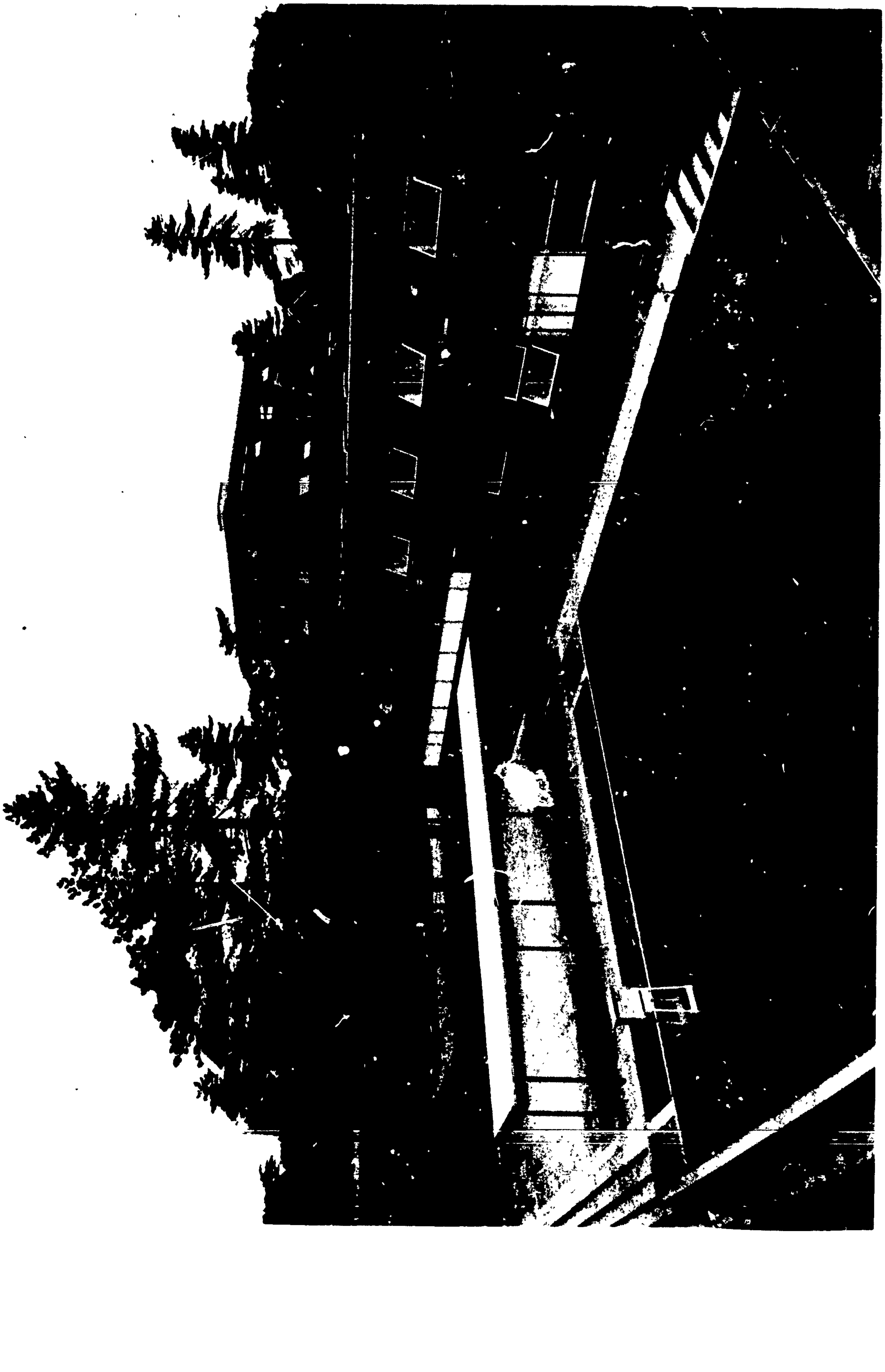

NOTES
FOR EXTERNAL FRAMES JOINERY DETAILS SEE STD. DRWG Nº G.
SEE JOB ELEVATIONS DRAWINGS FOR HAND OF WINDOW.
BOTH MULLIONS CAN BE MOVED 4" TO FORM 3'-0" DOOR OPENING. SEE JOB DRWGS.
S.H. = SIDE HUNG
P.O.O. = PROJECTED OPENING OUT
G.W. = GEORGIAN WIRED GLASS ARCHITECT TO SPECIFY CAST OR POLISHED PLATE
P.P. = POLISHED PLATE GLASS
LOUVRES FIXED ONLY BY "C.C."
O/A METAL WINDOW SIZES SHOWN
OPENING METAL WINDOW INSERTS
NOTE: LOUVRES NOT TO BE USED IMMEDIATLY ABOVE EACH OTHER.
O/A LOUVRE SIZES SHOWN
LOUVRED WINDOW INSERTS
EXTERNAL FRAME RANGE
1/4" = 1'-0"
10-11-61
HERTFORDSHIRE COUNTY COUNCIL
COUNTY ARCHITECT
COUNTY HALL, HERTFORD
GROUP 3
PINK DISK
G18

FIGURE 6





CLASP

In 1955, the Nottingham County Council was faced with a shortage of school places which could not be supplied through traditional planning and construction procedures. In addition, up to 10 per cent of the cost of schools was being spent to prevent damage due to mining subsidence. The effects of subsidence on buildings may be likened to a slow earthquake, and the precautions taken using traditional construction were frequently unsuccessful.

In order to gain time for the design of a system which would cope with these problems, it was decided that the 1956-57 building program would be constructed using one of the existing proprietary systems. A study of the building pattern within the County was made, and it was noted that a severe shortage of skilled labor existed. After the study a decision was reached: it would not be possible to rely on traditional construction; pre-stressed or pre-cast concrete construction was too rigid for use in areas liable to mining subsidence; timber systems were limited in that they were unsuitable for more than two story construction; and steel provided the best opportunity for success of the program.

It appeared that the requirements of the County could best be met by a system of construction based on a pin-jointed steel frame with the maximum use of factory made components. There was no existing structural system which met the requirements but one of the Ministry of Education's development projects at Belper using a steel frame manufactured by Brockhouse appeared to contain most of the desired elements. The County Architect suggested that it would be desirable to begin with this system and modify it rather than to start from scratch. In January, 1956, the development work began and eight men did the drawings in a period of about eight months. It is interesting to note that new men recently out of school were found more effective than more experienced ones who did not have experience working on the design of building systems. In the 1957-58 building program, eleven schools and two other jobs were started at a cost of £800,000. This volume of work made it possible for industry to cover the cost of new molds, jigs, and tools to make new parts. Brockhouse, Ltd., who did the development work on the structural system, was guaranteed a minimum market of 400 tons of steel to be used in this program in order to be reimbursed for its costs. The development work included the construction and testing of full scale mockups.

The experience gained by this program showed that a volume of 400 tons of steel was not enough to offer the full benefits of the available manufacturing capacity, so a Consortium was proposed whereby a number of authorities joined together to take advantage of the potential offered by a larger building program. In 1958-59 the building program called for 31 new schools at a cost of £2,870,000. The 1962-63 building program for the Consortium, which is called CLASP (Consortium of Local Authorities Special Program) is for £10,000,000. Brockhouse is still the supplier of the steel frame and continues to do development work to improve the system. The relationship between manufacturer and architect, in this case, is of a professional nature. The 1962-63 building program will consist of 90 projects - Table 4 - or an average of one start every four days. At this point, it becomes necessary to reconsider the design of the components as the increased volume makes new manufacturing techniques economical. Brockhouse looks forward to the development of a system of improved components which will have general appeal for the entire building industry.

In England, batch production of a range of steel components becomes economical at the time when 500 tons of steel are needed each year according to Mr. F.W.L. Heathcote of Brockhouse. It is possible to introduce mass production techniques at the time that production calls for 2,000 tons per year. This is not done early in the development of a system, however, as the investment in plant by industry is much greater than for batch production and the freedom for modifying the system is reduced considerably.

The system is designed so that the horizontal and vertical modules are related to the stair treads and risers. This enables the half landings to be readily accommodated when they appear in the exterior facade of the building. Columns are located in the exterior wall of the building and 4 basic panel sizes are used. These are: 3'4", 3'0", 2'8", and 2'4". In the case of the CLASP system, it was found that the depth of the beams should be 1/12th of the span which would give the most economical use of the light steel sections. If one wished to span a distance of 72 feet, the structural element should be 6 feet deep. In developing the system it was found that 60 per cent of the structural cost was for the beams and 15 per cent for the columns with the remainder required for base plates, jointing elements, etc. It was felt that the volume of production required by the Consortium was sufficient to allow for a considerable variety of beam and column types and sizes, and that it would be much more wasteful and costly to over-standardize providing a smaller group of elements to do the same job. The use of a very limited number of products to solve a wide variety of design conditions results in the use of heavier and more complex elements in cases where cheaper ones would suffice. This quickly dissipates the savings of mass production.

The CLASP system permits design of buildings up to three stories high using column sections of the same external dimensions. Those for one or two story buildings are made from cold rolled steel and the three story columns are hot rolled. Columns are made to multiples of 2'0" and are stocked in lengths of 8, 10, 12, 14, 16, 20, and 22 feet. The beams range in size from 6'8" to 53'4". A few of the standard connections of the beams and columns are shown in Figure 7 and the diagonal bracing members are shown in photograph 6. Beams of the same depth are used for both floors and roof, but the spacing is 3'4" for the floor and 6'8" or 10'0" for the roof.

The exterior wall components may be selected from a variety of different materials which have been coordinated to fit with the structural system and include: concrete and vitreous enamel panels, wood siding, various tile and window elements. The interior partitions are shown in the isometric drawing, Figure 8.

The roof uses four sizes of prefabricated timber panels: 3'4" x 6'8", 3'4" x 10'0", 6'8" x 6'8", and 6'8" x 10'0", and a range of skylight sizes is avail-

TABLE 4

C.L.A.S.P. 1962-63

PROJECT	[illegible]	[illegible]	[illegible]	[illegible]	1962 A	M	J	J	A	S	O	N	D	1963 J	F	M	A	M	J	NOTES	
COVENTRY																					
[illegible]																					H
[illegible]	[illegible]																				H
[illegible]																					H
[illegible]			[illegible]	[illegible]																	H
GATESHEAD																					
[illegible]	[illegible]	[illegible]																			H
DURHAM																					
[illegible]	[illegible]	[illegible]																			H
[illegible]	[illegible]	[illegible]																			H
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[illegible]	[illegible]	[illegible]																			H
[illegible]	[illegible]	[illegible]																			H
[illegible]	[illegible]	[illegible]																			H
[illegible]	[illegible]	[illegible]																			H
[illegible]	[illegible]	7500																			H
[illegible]	[illegible]	7500																			H
[illegible]	[illegible]	[illegible]																			H
NOTTS																					
[illegible]	[illegible]	[illegible]																			H
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[illegible]	[illegible]		[illegible]	M																	G
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[illegible]	[illegible]			M																	H
[illegible]	[illegible]																				H
[illegible]	[illegible]	[illegible]																			H
[illegible]	[illegible]																				H
[illegible]	[illegible]	[illegible]		M																	H
WARWICKS																					
[illegible]			[illegible]																		H
[illegible]			[illegible]																		H
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[illegible]			[illegible]																		H
[illegible]			[illegible]																		H
[illegible]			[illegible]																		H

PROJECT	[illegible]	[illegible]	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	NOTES	
WAR OFFICE																			
[illegible]	[illegible]																	[illegible]	F
[illegible]		[illegible]																"	F
[illegible]	[illegible]																	"	F
[illegible]	[illegible]																	"	F
[illegible] J.L.U.																		[illegible]	D
[illegible]	[illegible]																	"	F
[illegible] J.L.U.	[illegible]																	"	F
[illegible] J.L.U.	[illegible]																	"	F
[illegible]																		[illegible]	D
[illegible]	[illegible]																	"	F
[illegible] R.M.A.																		[illegible]	D
[illegible]	[illegible]																	"	F
[illegible]	[illegible]																	"	F
[illegible]	[illegible]																	"	F
[illegible]	[illegible]																	"	F
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[illegible]		[illegible]																"	F
[illegible]		[illegible]																"	F
W. RIDING																			
[illegible]	[illegible]																		H
[illegible]	[illegible]																		H
[illegible]	[illegible]																		H
[illegible]																		[illegible]	B
[illegible]																		[illegible]	B
[illegible]		[illegible]																	H
[illegible]	[illegible]																		H
[illegible]	[illegible]																		H
[illegible]	[illegible]																		H
GLAMORGAN																			
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[illegible]	[illegible]																		H
DERBYSHIRE																			
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LEICESTER																			
[illegible]	[illegible]																		H
[illegible]		[illegible]																	G
[illegible]																			H
[illegible]																			H
HOSTEL		[illegible] M																	G
HOSTEL		[illegible] M																	G
[illegible]		[illegible]																	H
MIN. OF EDUC.																			
[illegible]		[illegible]																	H
[illegible]		[illegible]																	H
[illegible]		[illegible]																	H
[illegible]		[illegible]																	H

able which will work with these panels. The ceiling is suspended with two different types of ceiling components to relate to fire code requirements. The units are 3'4" square with extra sizes of 3'4" x 3'0", and 3'0" x 3'0" to handle edge conditions. Heat is supplied by a unit heater designed by Weatherfoil which is one of the two nominated contractors working with the CLASP system, Brockhouse being the other.

The nature of the CLASP system and its application may best be illustrated by a series of drawings and photographs. As in the case of the Hertfordshire system, drawings are prepared which indicate how all the various components of the system may be used together. In designing a building it is possible to key the working drawings for a particular job to the standard drawings. A special effort is made not to repeat drawings and considerable use is made of preparing reproduceables from master drawings. An example of scheduling the working drawings is shown in Figure 9 where four reproduceables are made from the master drawing as soon as the grid is laid out. At a later stage, eight negatives are made. These reproduceables are then completed as individual drawings and, in certain cases, copies are made at specific stages for other drawings. Figure 10 shows a portion of the Ground Floor Plan of the Blidworth Secondary Modern School. Figure 11 shows a portion of the site slab drawing. This drawing corresponds to (5 Holes in Slab, Plinths) in Figure 9. Figure 12 indicated which baseplates should be used to support the structure and corresponds (to 21 Baseplates) in Figure 9. Figure 13 contains the structural layout and corresponds to (G 6 Steelwork) in Figure 9. Figure 14 shows the roof layout and related to (10 Roofdeck) in Figure 9. The fact that the grid is drawn only once, for all of these drawings, before other information is put on the master drawing indicates a considerable saving in the drafting time required to complete the working drawings.

All of the code symbols are then backed up by standard coding and detail sheets. Figure 15 shows the coding sheet which includes the foundation plates. For each of these coding sheets there are many detail sheets. Figure 16 shows a detail for the patented rocker baseplate called for in Figure 12. Figure 17 shows a portion of an elevation sheet which is coded in a similar manner to that of the HCC seen in Figure 5. Photographs 6 and 7 show some of the CLASP schools.

C.L.A.S.P. SYSTEM
HEADER TYPES

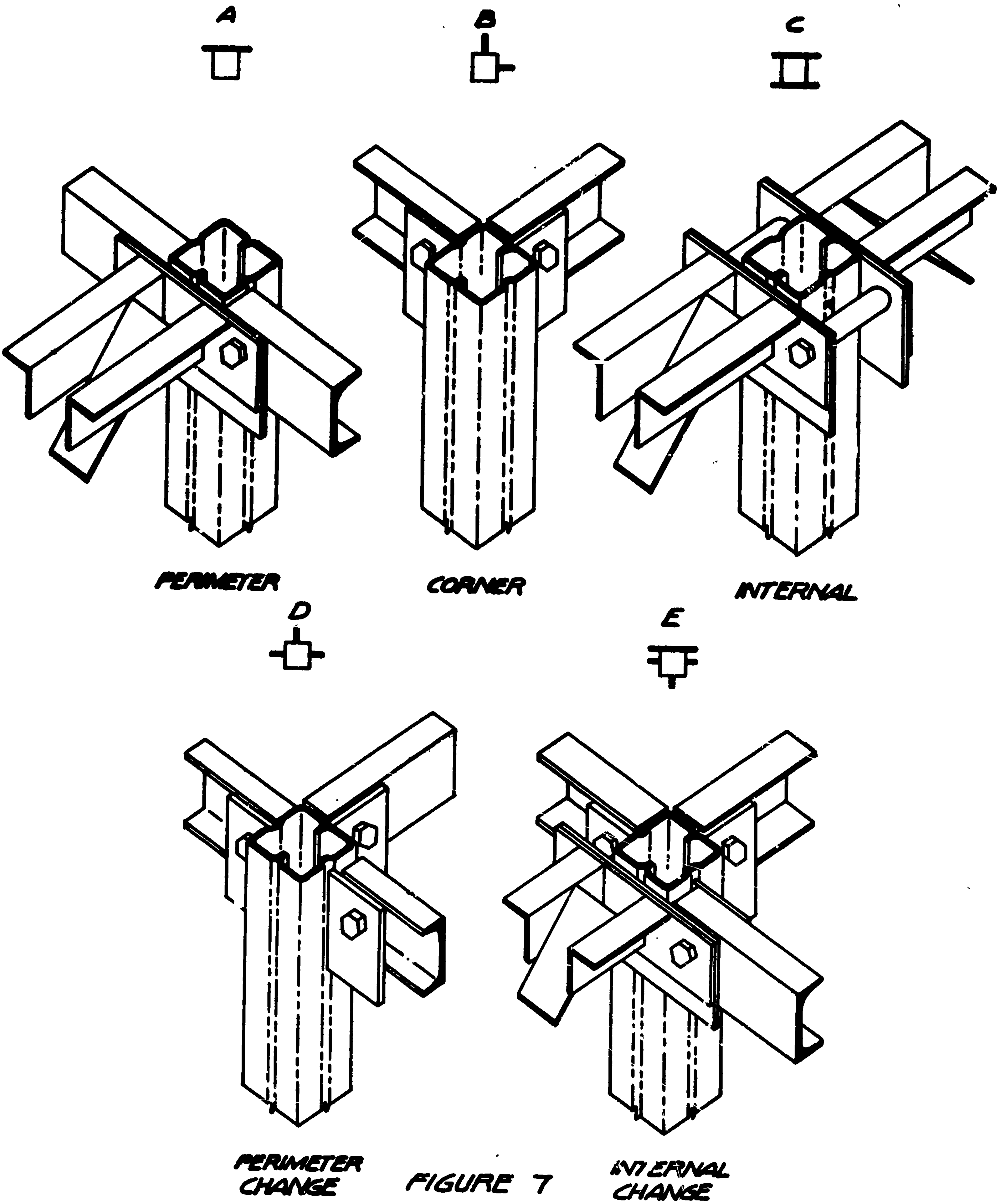
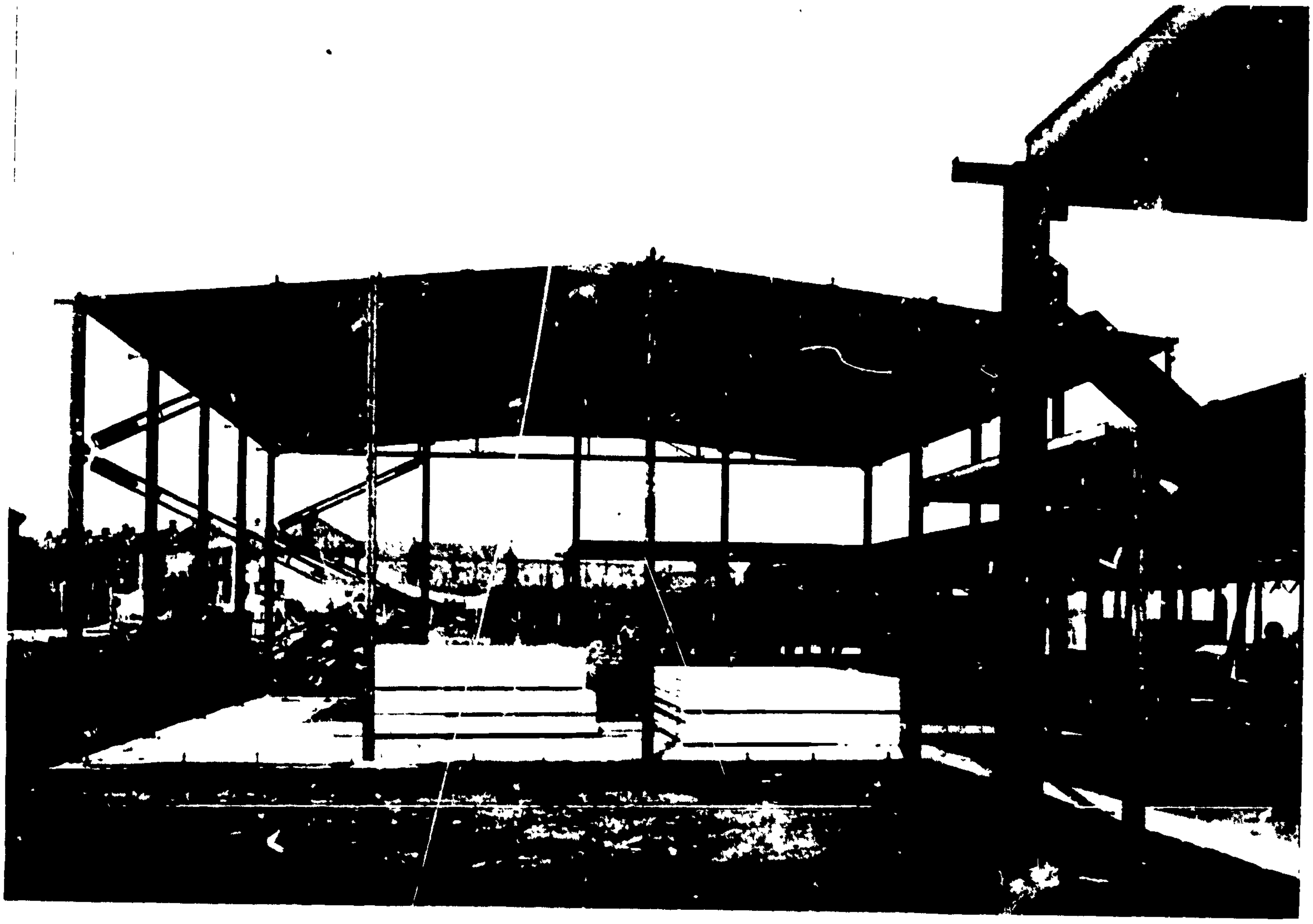
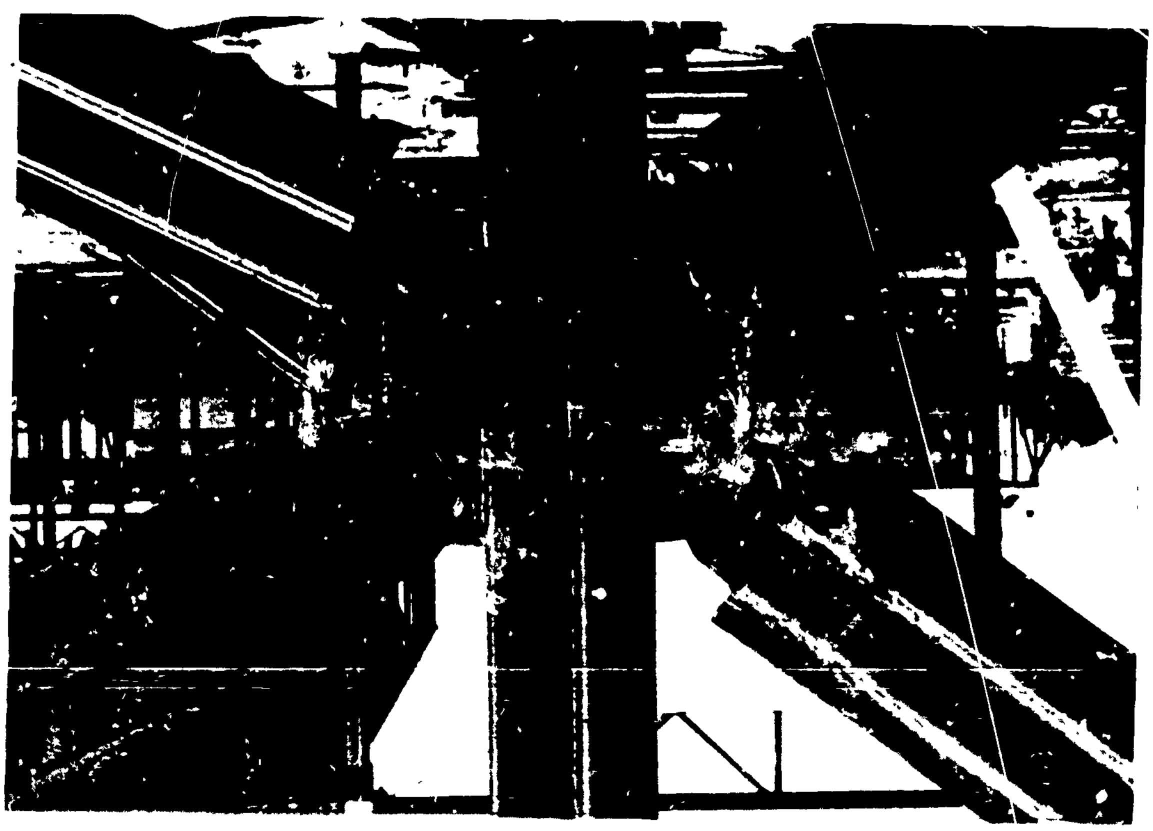


FIGURE 7





C.L.A.S.P. SYSTEM INTERIOR PARTITIONS

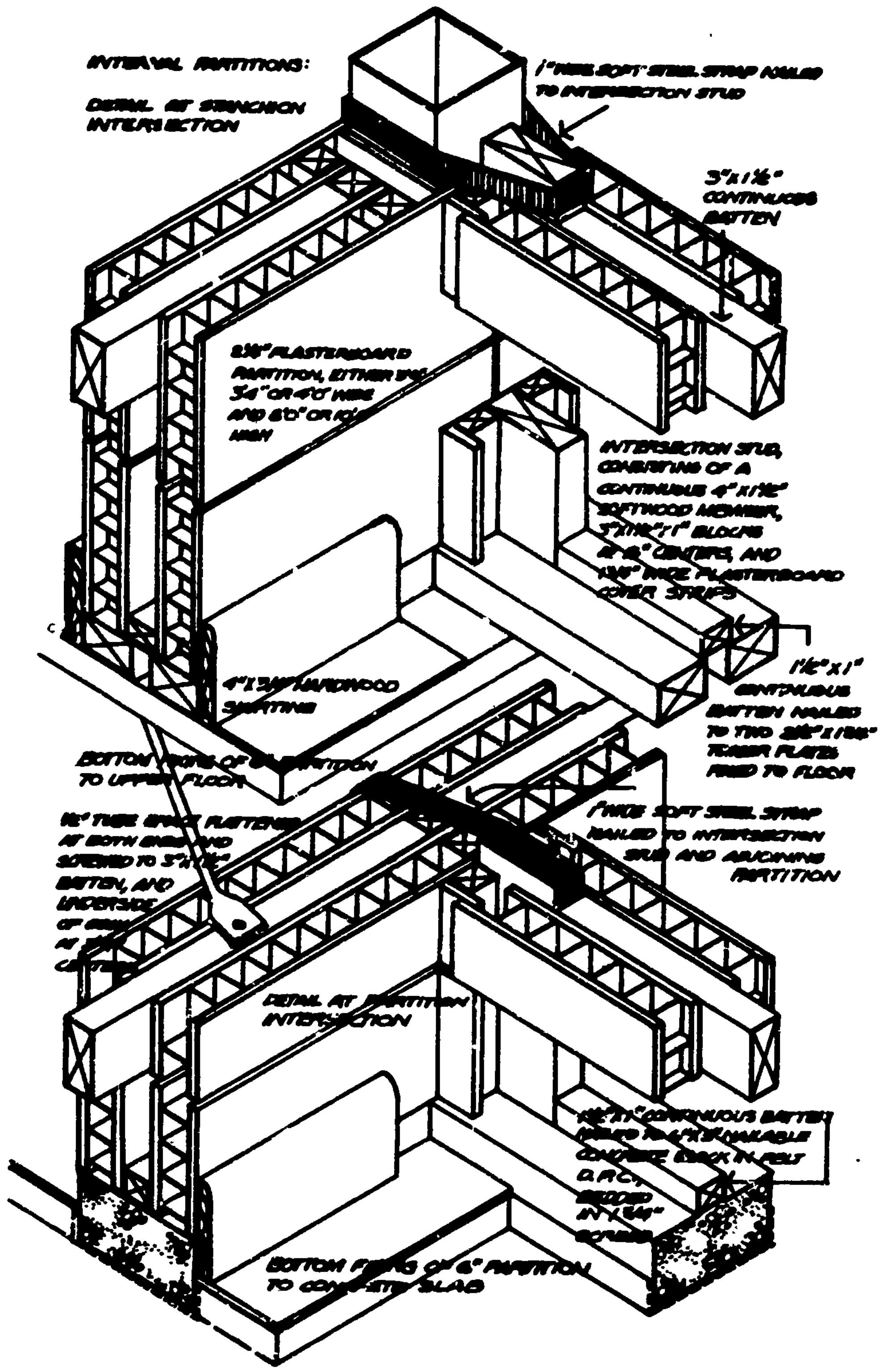


FIGURE 8

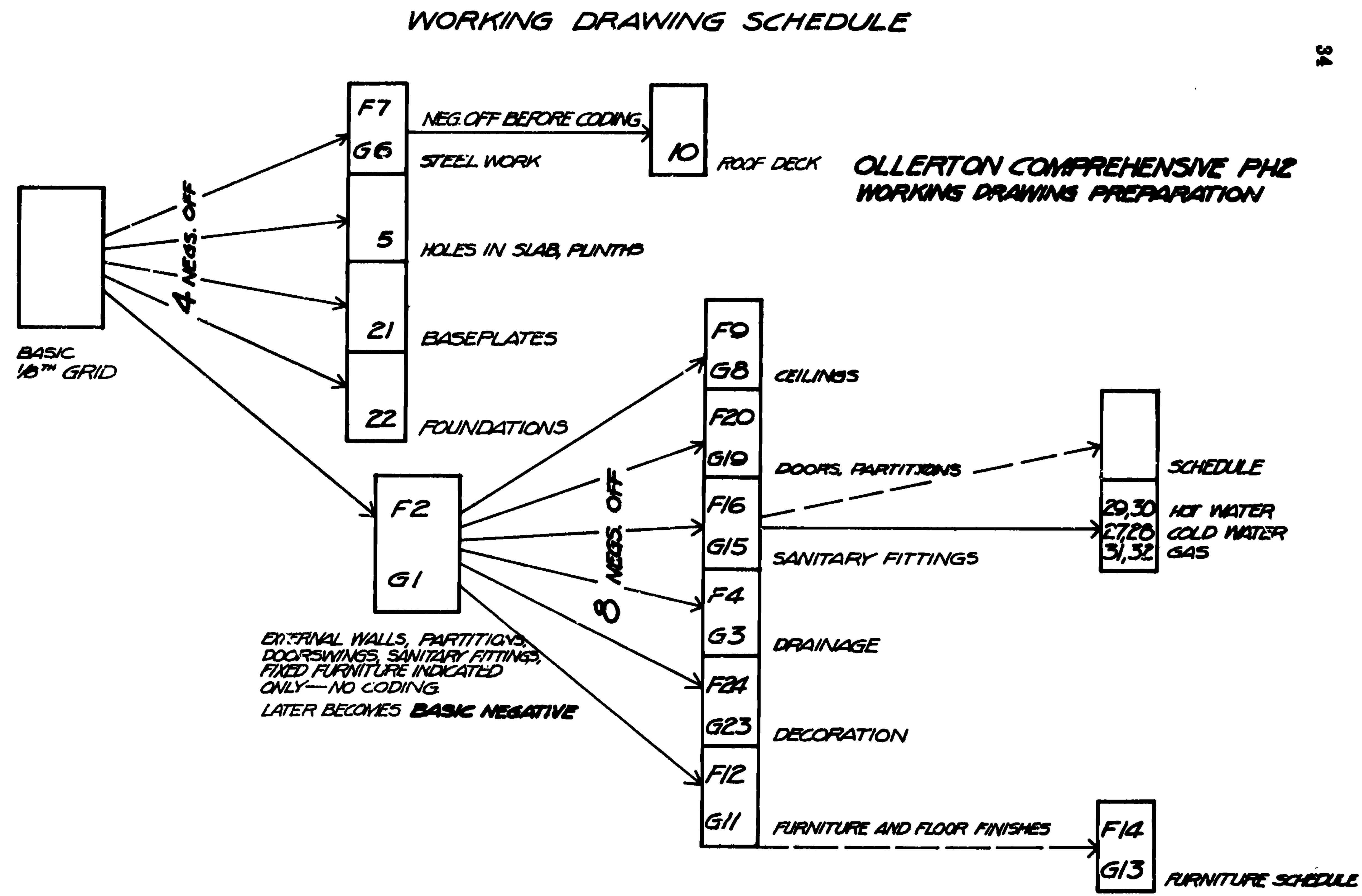
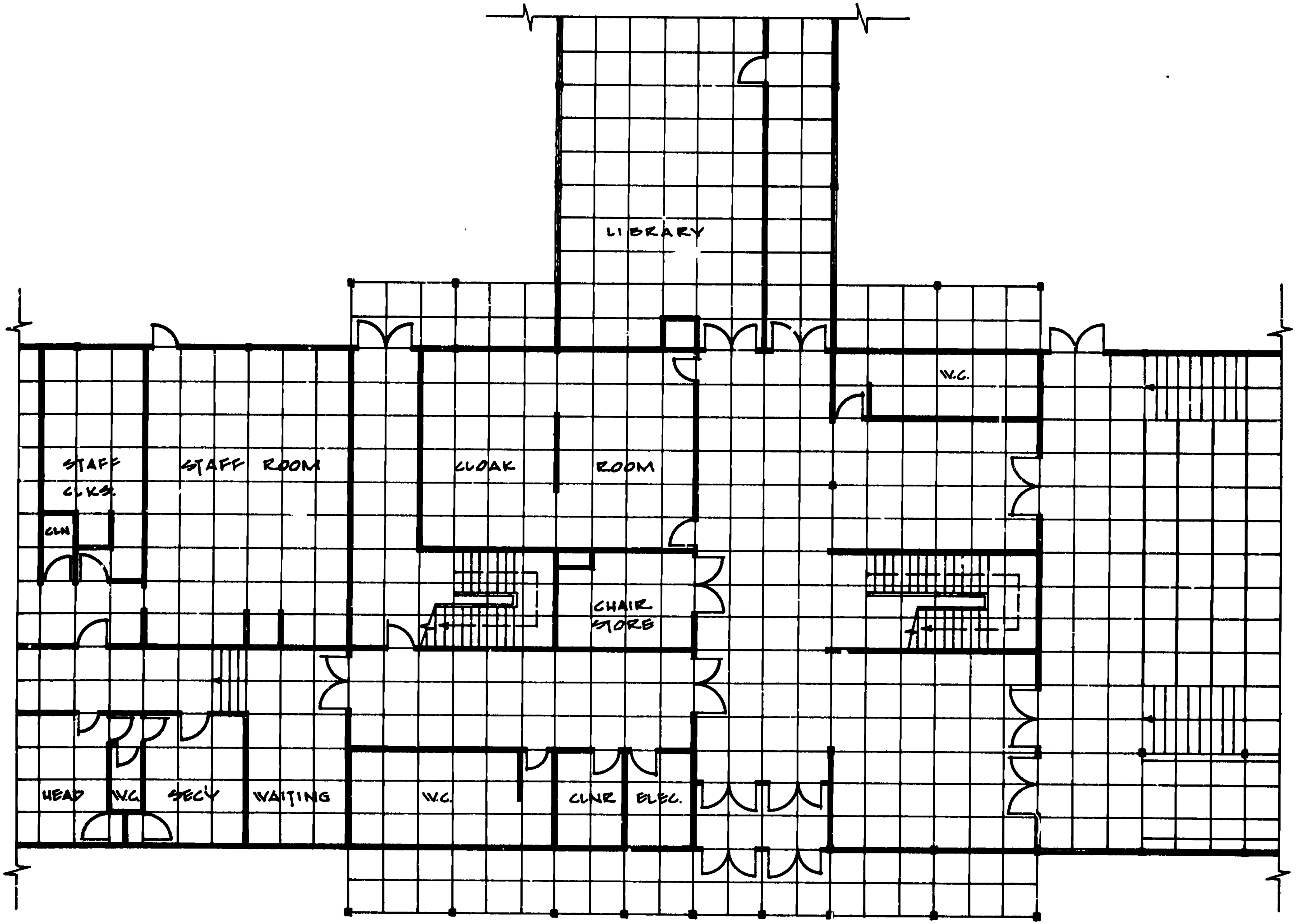

WORKING DRAWING SCHEDULE
OLLERTON COMPREHENSIVE PH2
WORKING DRAWING PREPARATION
BASIC
1/8TH GRID
4 NEGS. OFF
F7
G6
NEG. OFF BEFORE CODING
STEEL WORK
10
ROOF DECK
5
HOLES IN SLAB, PLINTHS
21
BASEPLATES
22
FOUNDATIONS
F2
G1
EXTERNAL WALLS, PARTITIONS, DOORSWINGS, SANITARY FITTINGS, FIXED FURNITURE INDICATED ONLY—NO CODING.
LATER BECOMES BASIC NEGATIVE
8 NEGS. OFF
F9
G8
CEILINGS
F20
G19
DOORS, PARTITIONS
F16
G15
SANITARY FITTINGS
F4
G3
DRAINAGE
F24
G23
DECORATION
F12
G11
FURNITURE AND FLOOR FINISHES
SCHEDULE
29,30
27,28
31,32
HOT WATER
COLD WATER
GAS
F14
G13
FURNITURE SCHEDULE

FIGURE 9

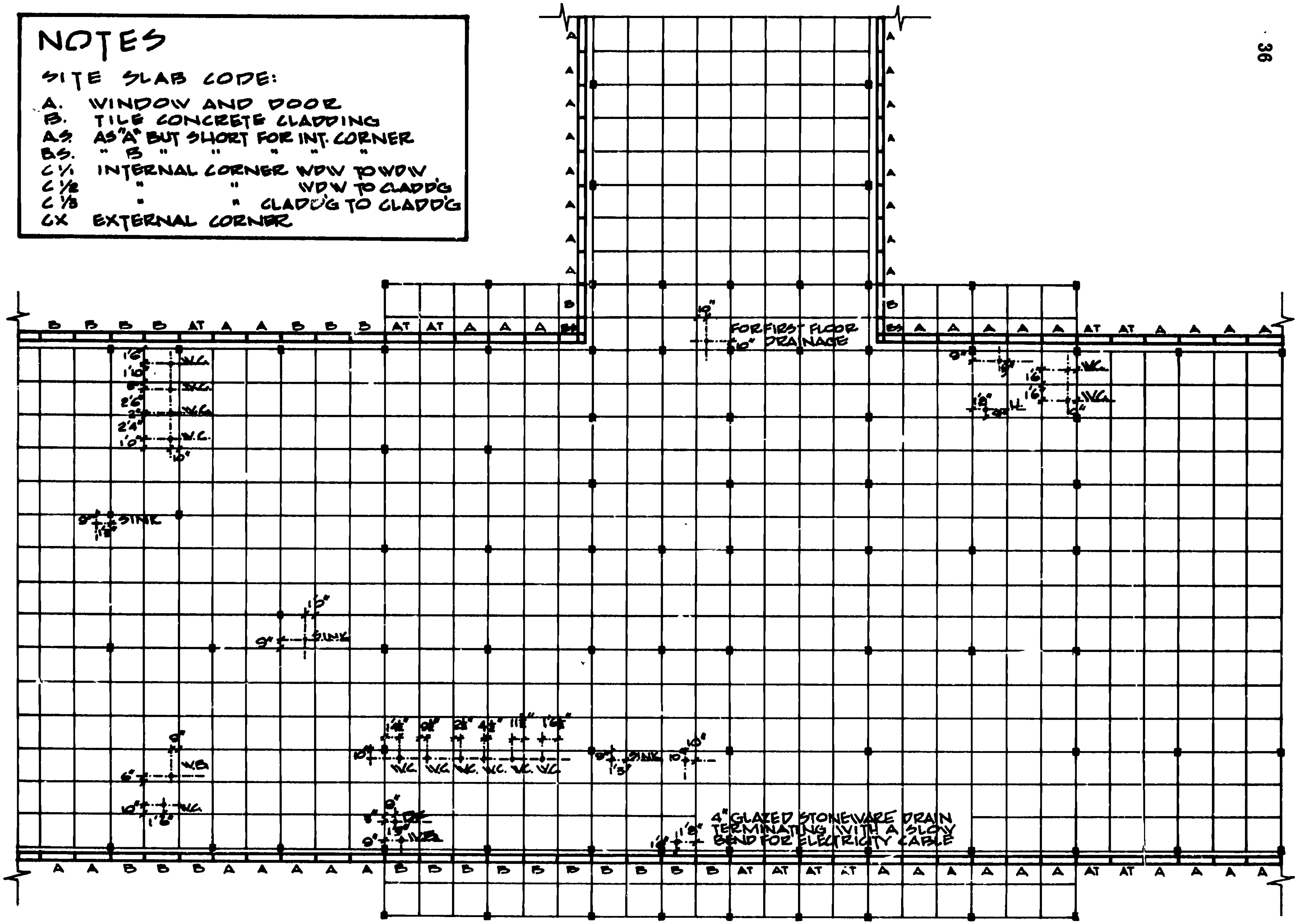


PORTION OF GROUND FLOOR PLAN FIGURE 10

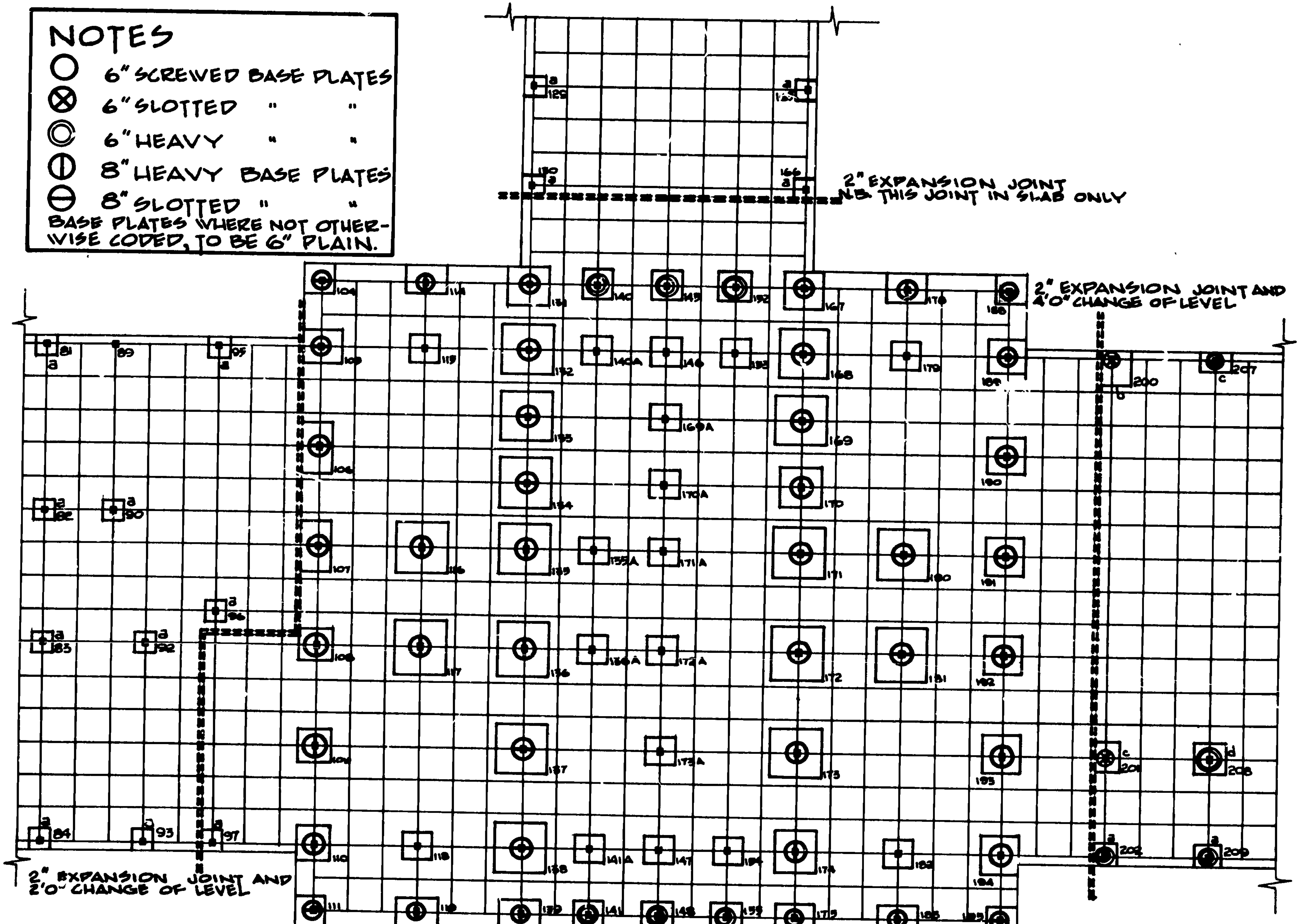
NOTES

SITE SLAB CODE:

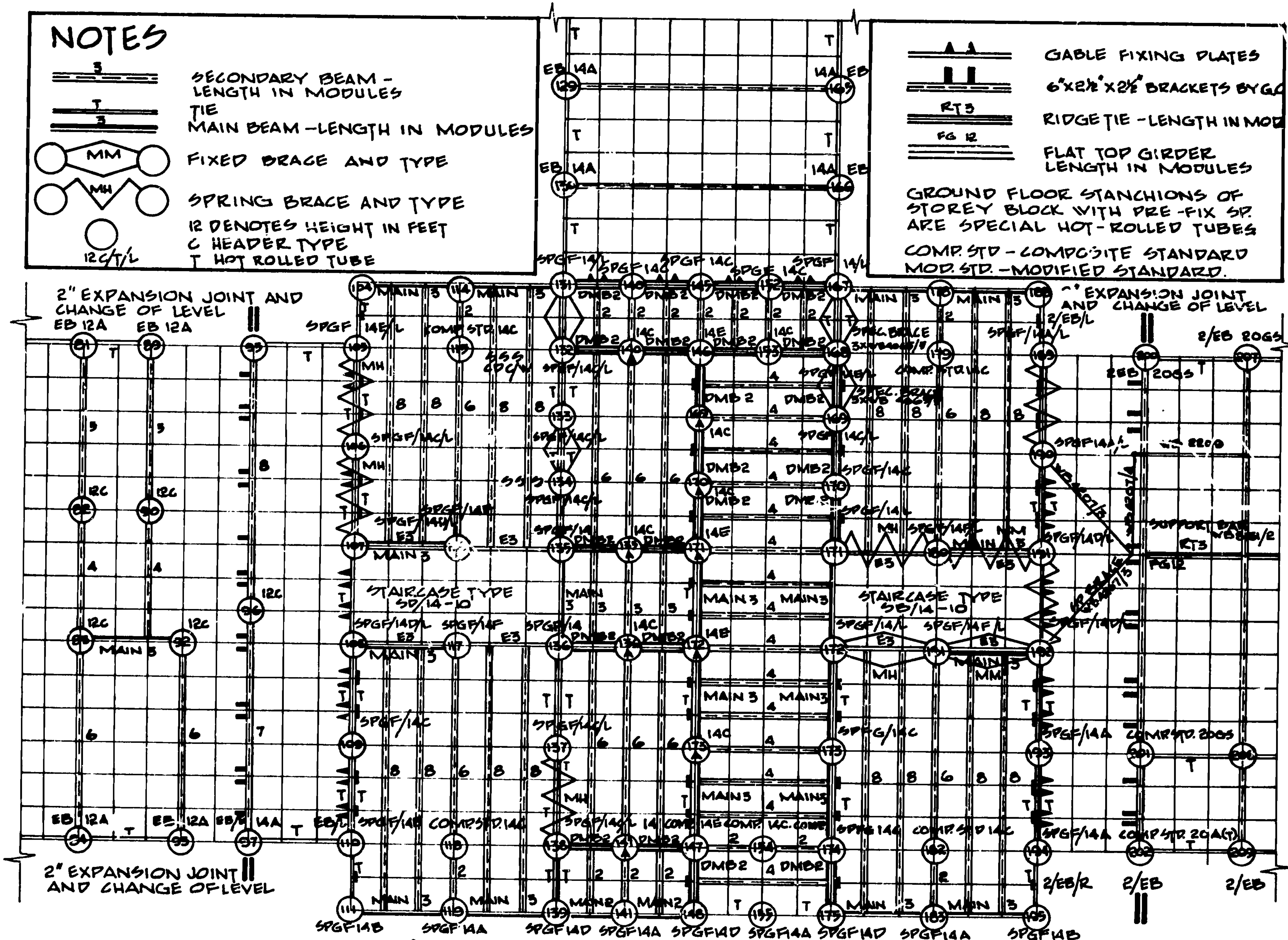
A. WINDOW AND DOOR
B. TILE CONCRETE CLADDING
AS. AS "A" BUT SHORT FOR INT. CORNER
BS. " B " " " "
C 1/1 INTERNAL CORNER WDW TO WDW
C 1/2 " " WDW TO CLADD'G
C 1/3 " " CLADD'G TO CLADD'G
CX EXTERNAL CORNER



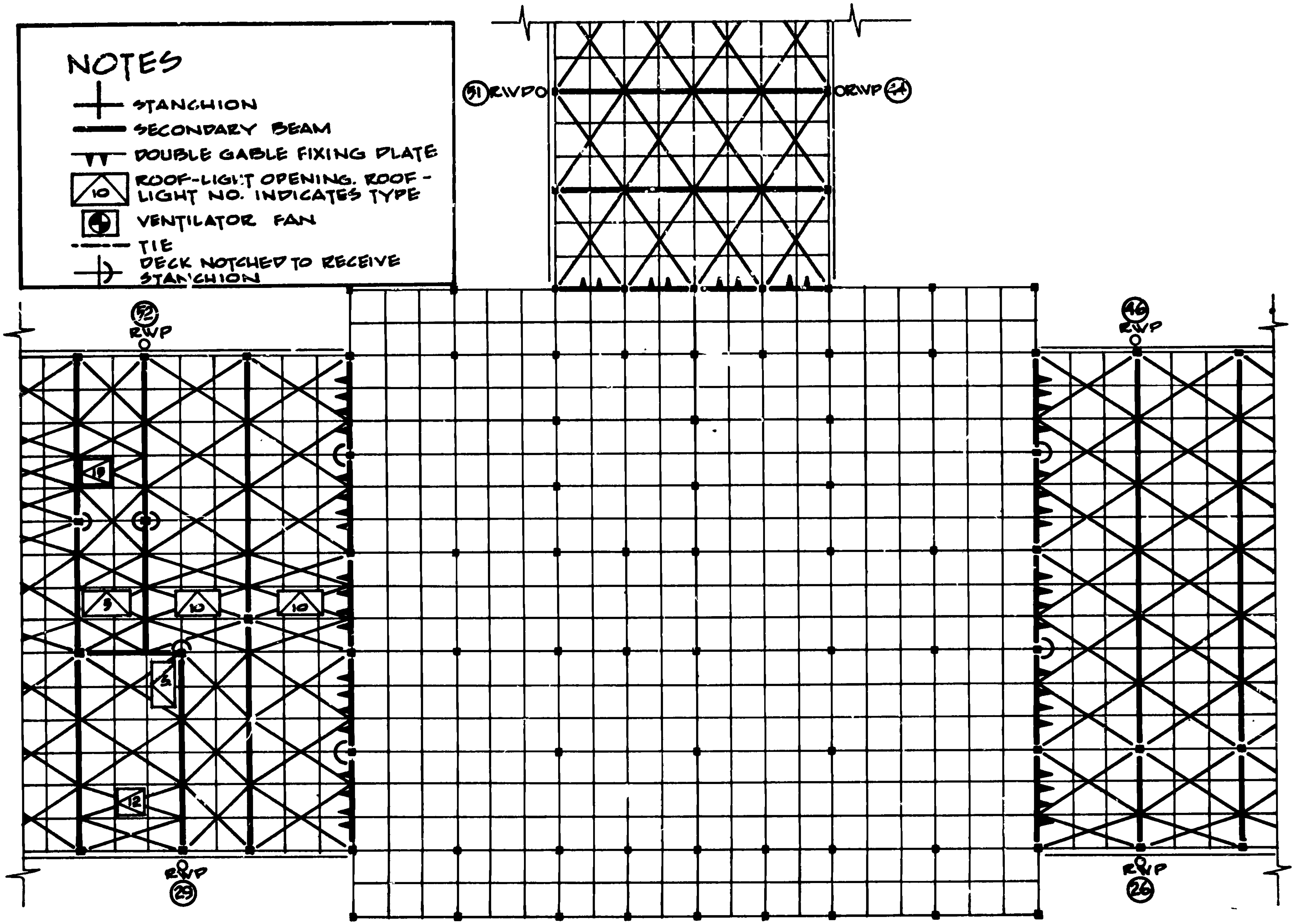
PORTION OF SITE SLAB DRAWING FIGURE 11



PORTION OF BASEPLATE LAYOUT DRAWING FIGURE 12



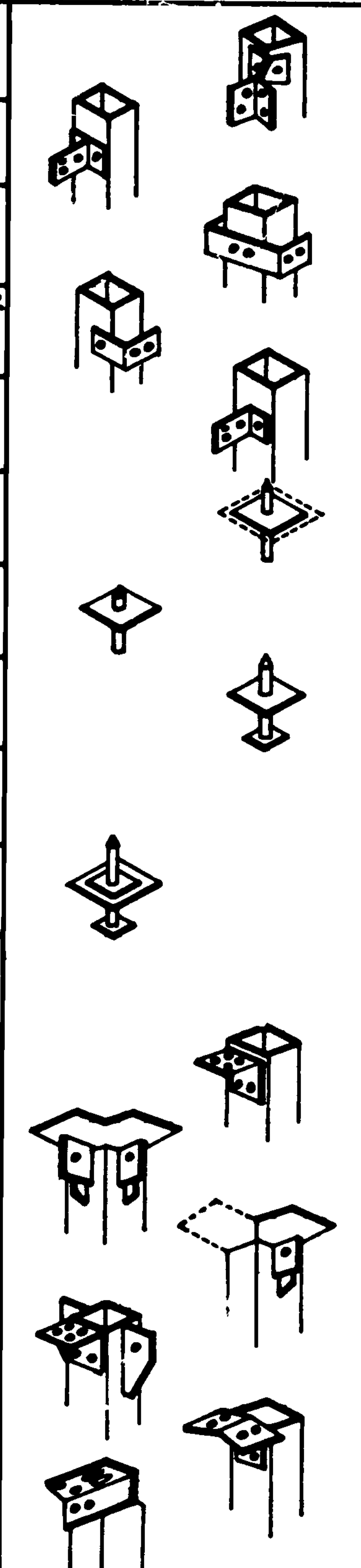
PORTION OF STRUCTURAL LAYOUT DRAWING FIGURE 13

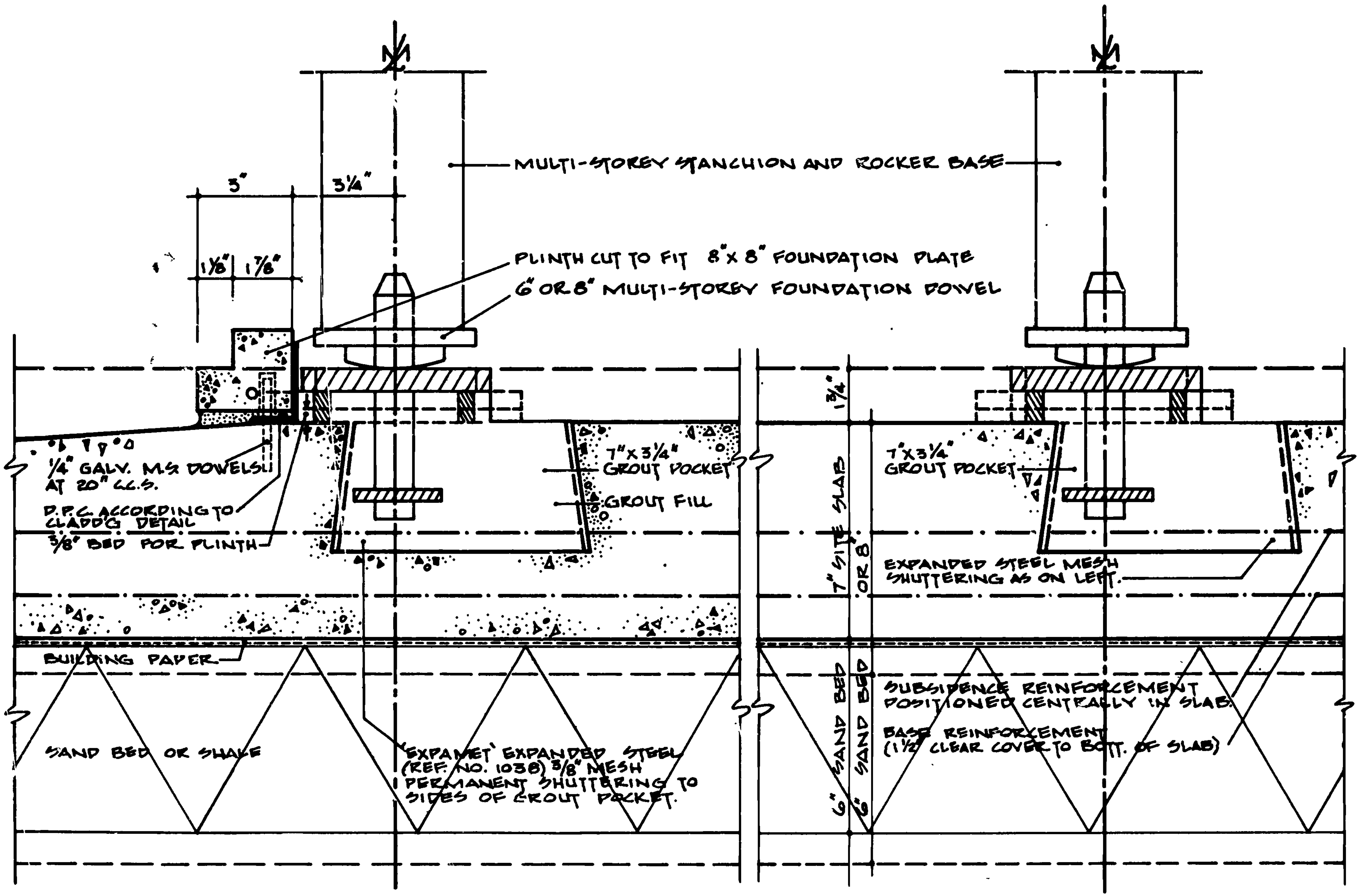


PORTION OF ROOF LAYOUT DRAWING FIGURE 14

	TITLE	BROCKHOUSE DWG. NO.	DESCRIPTION	FUNCTION AND LOCATION
FIXINGS TO STANCHIONS	INTERNAL CORNER CLEAT	WB 3247	1 1/2" DEEP X 9 3/8" SPLAYED ANGLE CLEAT OUT OF 1 1/2" X 3/16" X 5 5/8" M.S FLAT 1 NO. 13/32" DIA. HOLE FOR FIXING TO STANCHION. 2 NO. 1/4" DIA. HOLES FOR WOOD SCREW FIXING TO CORNER UNIT.	AT WINDOW TO WINDOW INTERNAL CORNER CONDITION FIXING BOXING TO CORNER STANCHION. CLEATS FIXED IN PAIRS.
	DOOR FIXING TEE	WB 8578	3 1/2" X 4 1/2" X 2 1/2" T SECTION CLEAT MADE FROM 2 NO. 12 GAUGE ANGLES. HORIZONTAL SLOT DRILLED 2 1/2" APART FOR 2 NO. 3/8" ST. BOLTS TO OUTER FACE OF STANCHION.	AT JAMBS OF DOORS ON FACE OF PERIMETER STANCHIONS. ALSO USED FOR FIXING EXTERNAL CORNER TIMBER UNIT.
	DOUBLE FRAME CLEAT	WB 3220	9" LONG X 2" DEEP AND 3" LEG. 1/4" FLAT 2 NO. 7/32" HOLES IN EACH LEG FOR FRAME FIXING AND 2 NO. 3/8" HOLES FOR FIXING TO STANCHIONS.	FIXING FRAMES TO STANCHIONS AT NORMAL CONDITIONS.
	FRAME CLEAT	WB 3219	3" X 2 1/2" X 3/16" ANGLE 3" DEEP 3/8" DIA. HOLE ON 3" LEG FOR FIXING TO STANCHION AND 2 NO. 17/64" DIA. HOLES FOR WOOD SCREW FIXING TO CLADDING FRAME.	FIXING CLADDING FRAME TO PERIMETER STANCHION AT INTERNAL AND EXTERNAL CORNER AND WINDOW ABUTMENTS.
	WINDOW FIXING ANGLE	WB 2492	4 1/4" X 1 13/16" X 2 1/2" DEEP ANGLE FORMED FROM COLD ROLLED STEEL. DRILLINGS AS FOR DOOR FIXING CLEAT D F T.	AT JAMBS OF WINDOWS ON FACE OF PERIMETER STANCHION. ALSO USED FOR FIXING EXTERNAL CORNER UNITS, REVERSABLE.
FOUNDATION PLATES	6" PLAIN	WB 8015	6 1/2" LONG, 1" DIA. DOWEL WITH 2 1/8" DIA. BASE PLATE AND 6" SQUARE BEARING PLATE	DOWEL GROUTED INTO SLAB FOR SINGLE STOREY STANCHIONS WITH LOADS LESS THAN 3 TONS.
	6" SCREW'D	WB 8017	9 1/2" LONG DOWEL THREADED ABOVE 6" SQUARE BEARING PLATE.	AS ABOVE, BUT FOR BOLTING DOWN EXTERNAL CORNER STANCHIONS AND SINGLE STOREY STCHN WITH BRACING. DO NOT USE ON STCHN. SUPPORTING 12 1.MOD. GIRDERS OR LOADS OVER 3 TONS.
	6" HEAVY	WB 8153	8" LONG, 1 1/2" DIA. DOWEL WITH 3" SQUARE BASE PLATE AND 6" SQUARE ROCKER PLATE.	FOR MULTI-STOREY STANCHIONS: LOAD UP TO 6 TONS.
	6" SLOTT'D	WB 8154	8 3/4" LONG DOWEL WITH SLOT FOR COTTER PIN ABOVE ROCKER PLATE.	FOR MULTI-STOREY STANCHIONS: LOAD UP TO 6 TONS AT CORNERS AND STANCHIONS AT ALL WIND BRACING CONDITION.
	8" HEAVY	WB 8155	8" LONG X 1 1/4" DIA. DOWEL WITH 3" SQUARE BASE PLATE AND 5" SQUARE PLATE ON 8" SQUARE ROCKER PLATES.	FOR MULTI-STOREY STANCHIONS: LOAD OVER 6 TONS.
	8" SLOTT'D	WB 8156	8 3/4" LONG DOWEL WITH SLOT FOR COTTER PIN ABOVE BEARING PLATE.	FOR MULTI-STOREY STANCHIONS: AT CORNERS AND STANCHIONS AT ALL BRACING CONDITIONS.
EAVES BRACKETS	PLAIN	WB 3036	1/4" M.S. FOLDED PLATE DRILLED FOR 2 NO. 3/8" P.K. BOLTS FIXING TO STANCHION AND HOLED FOR 4 - 3/8" BOLTS FOR GUTTER FIXING.	FOR SUPPORTING COMBINED EAVES GUTTER UNIT FIXED FLUSH AT HEAD OF PERIMETER STANCHIONS FOR STRAIGHT RUN CONDITIONS.
	INTERNAL CORNER	WB 8743	1/4" M.S. PLATE DRILLED FOR 8 - 3/8" BOLTS AS GUTTER FIXING WITH TWO FIXING LUGS FOR ATTACHMENT TO STANCHION HEADER LUGS AND TWO DROPPER CONNECTION LUGS.	SUPPORT FOR EAVES BRACKET AT INTERNAL CORNER BOLTED TO STANCHION LUGS BY 1" BOLTS, ALSO PROVIDES FIXING AT HEAD FOR DROPPERS.
	INTERNAL CORNER STOP ENDS L AND RH	WB 8839 WB 8840	1/4" M.S. PLATE DRILLED FOR 4 - 3/8" BOLTS AS GUTTER FIXING WITH ONE FIXING LUG FOR ATTACHMENT TO STANCHION HEADER LUGS AND ONE DROPPER CONNECTION LUG, RIGHT AND LEFT HAND TYPES.	DITTO. AT STOP END WHERE LOW EAVES RUN INTO HIGH BLOCK.
	GABLE BRACKETS	WB 3039 WB 3040	1/4" M.S. FOLDED PLATE DRILLED FOR 2 - 3/8" P.K. BOLTS FOR FIXING TO STANCHION AND HOLED FOR 4 - 3/8" BOLTS FOR GUTTER FIXING	FOR SUPPORTING EAVES GUTTER UNIT ON SLOPING GABLE RIGHT OR LEFT HAND, ACCORDING TO SLOPE.
	GABLE RIDGE BRACKET	WB 3041	1/4" M.S. FOLDED PLATE WELDED TO 1/4" BACK PLATE TO FORM RIDGE DRILLED FOR 2 - 3/8" P.K. BOLTS FOR FIXING TO STANCHION AND HOLED FOR 4 - 3/8" BOLTS FOR GUTTER FIXING.	FOR SUPPORTING EAVES GUTTER UNIT AT RIDGE OF SLOPING GABLES.
	EXPANSION BRACKET L AND RH	WB 3037 WB 3038	1/4" M.S. FOLDED PLATE WITH HOLES, 2 - 3/8" P.K. BOLTS FOR FIXING TO STANCHION AND 2 - 3/8" FOR GUTTER FIXING.	SAME AS EB PLAIN BUT SLOTTED TO TAKE SLIDDING JOINT AT EXPANSION POINT.

DIAGRAM





DETAIL OF BASEPLATE FIGURE 16

TYPICAL ELEVATIONS - C.L.A.S.P. SYSTEM

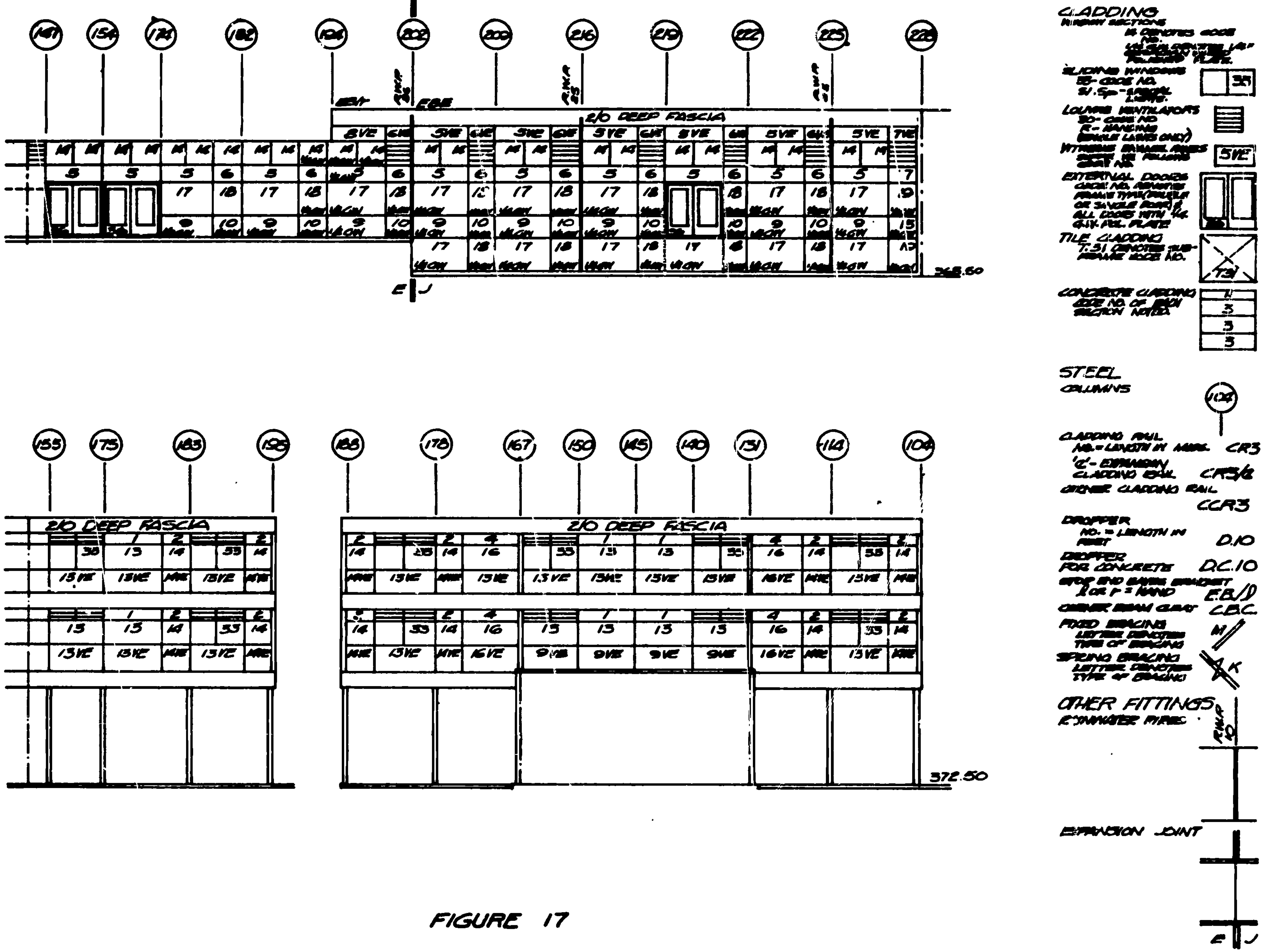
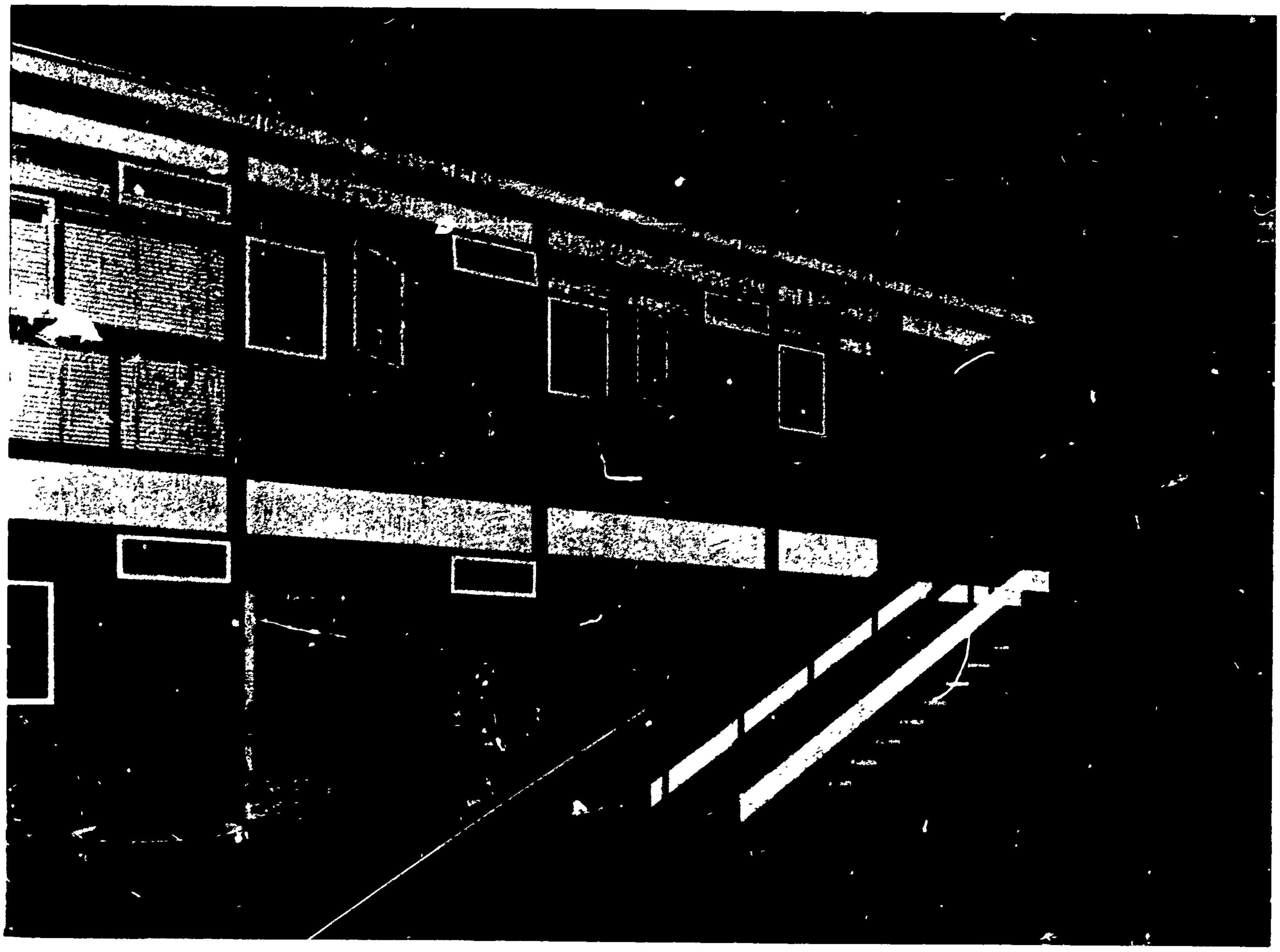
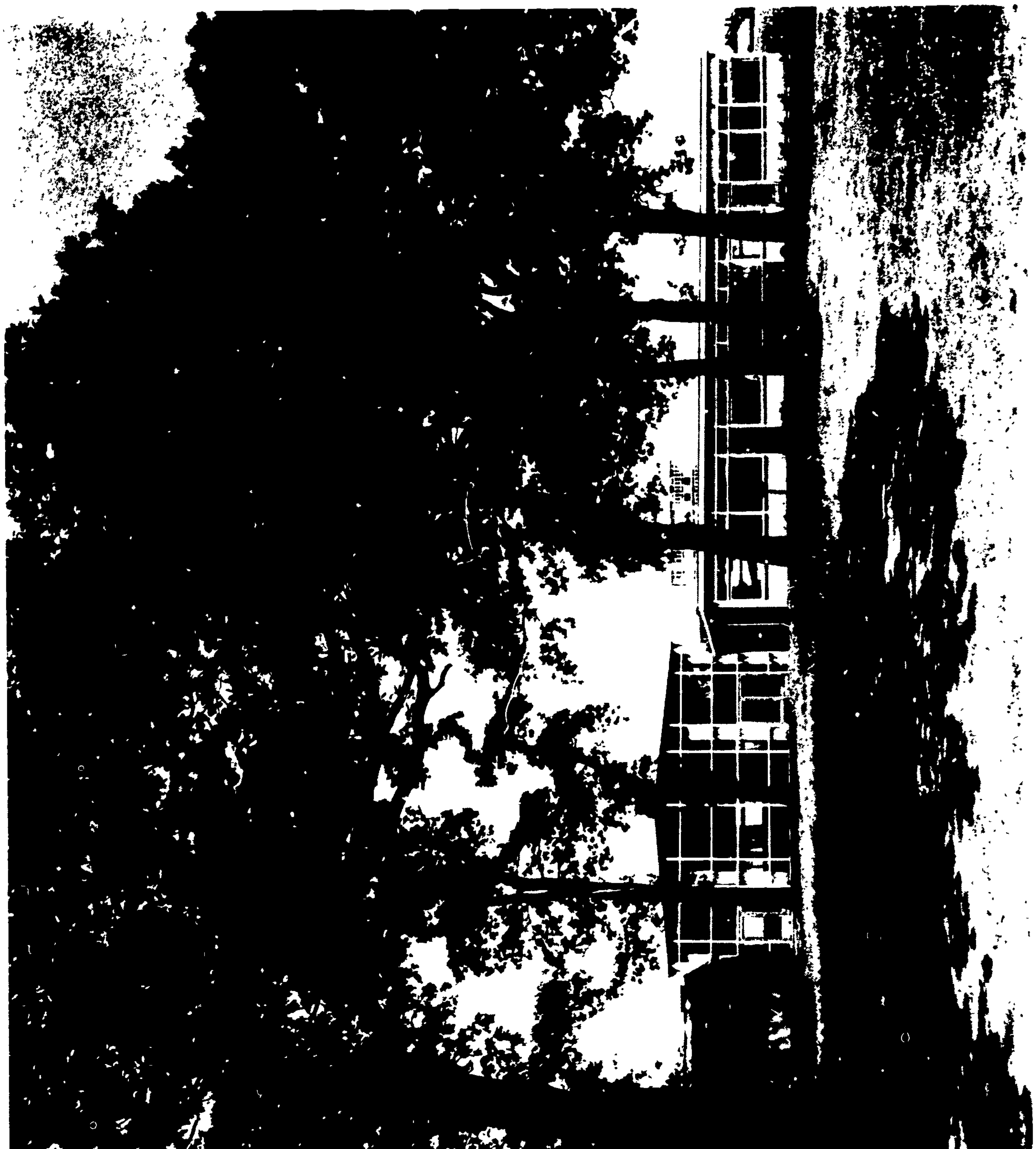
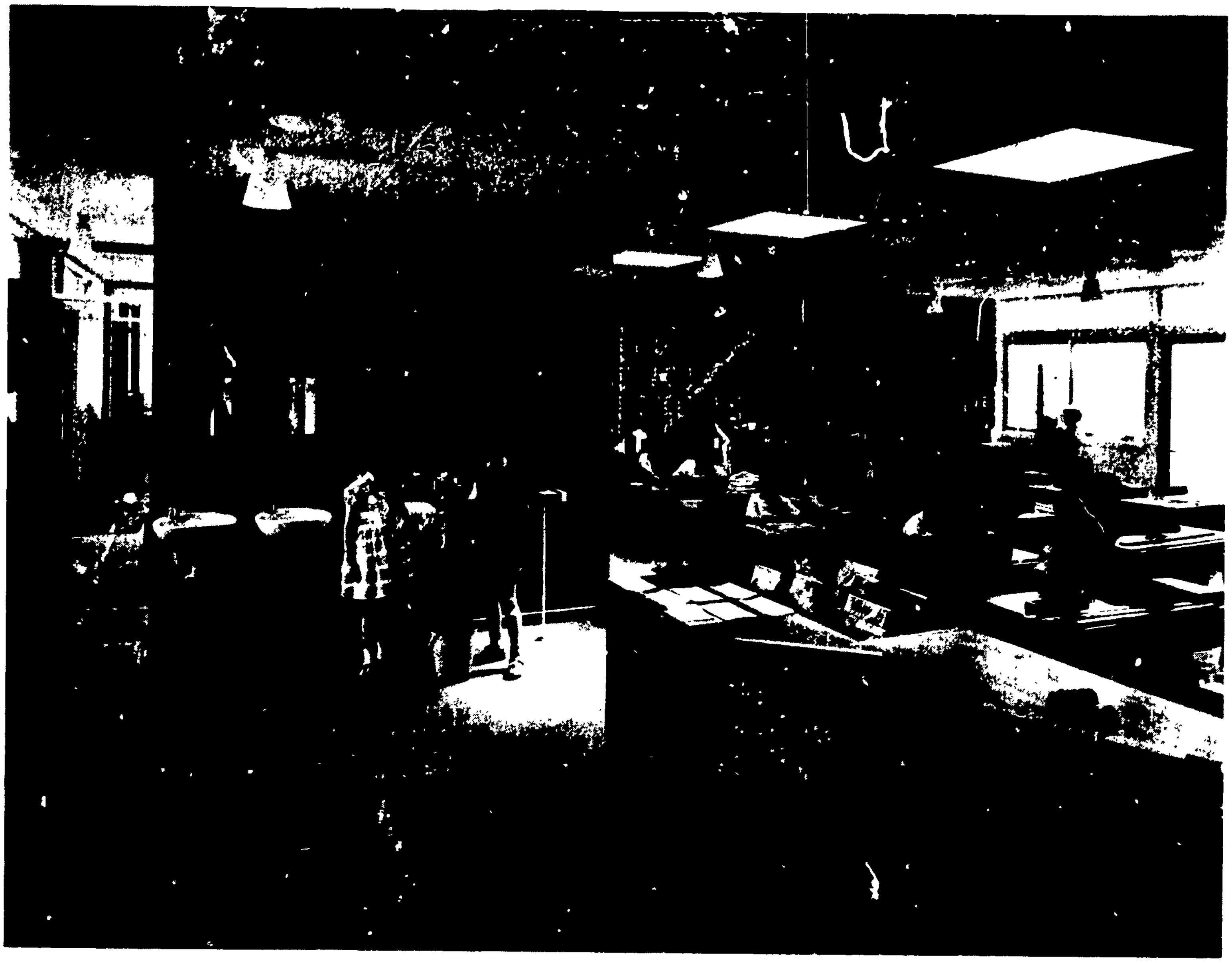


FIGURE 17







The organization of the Consortium is most interesting. A fund for continuing development work is maintained through the contribution of 1/4 of 1% of the cost of each project by Consortium members. This covers the cost of redesigning and modifying components and of taking yearly bids for each of the system's many components except for the structure and the heating system where prices are negotiated. The Consortium works with a large group of manufacturers who submit bids for specific components used within the total building system. On the basis of these bids a short list of manufacturers is selected who will work to the CLASP specifications and, as approved manufacturers, they are assured that where their products are specified in a design no other may be used. The bidding is done after the components are developed, but before the schools are designed.

It frequently happens that a number of manufacturers act as subcontractors and, not only make the components, but install them. The general contractor in this case does not have the opportunity to choose his own subcontractors. As far as CLASP is concerned, this enables the Consortium to get the best price on each portion of the work before the individual design project goes out for the general contractor's bid.

The program is administered by a committee which includes the top officials of each of the thirteen participating Authorities. The Chief Architect of each Authority is represented by one or more men who comprise the working committee for the Consortium.

The cost of the components is being steadily reduced. Table 5 gives some indication of the trend of prices for components used by the Consortium at a time when there has been a general upward trend in the price of building components. The cost of the steel frame was reduced from 8s. 9-3/4d. per square foot in 1957-58 to 7s. 11-1/2d. in 1961-62, a saving of 10%. In the case of metal windows a saving of about 23% was found. Figures 18 and 19 compare the cost of CLASP schools with the national average and show that relatively more teaching area is provided in CLASP schools. At the same time the quality of the finishes is better than average so that the savings in cost can in no way be attributed to cheaper construction. In addition, construction time is reduced considerably. A survey has shown that it takes 4.39 months to provide 100 school places using CLASP, and 6.33 months as an average for other types of construction.

The fact that prices are fixed by yearly bids for a very large proportion of the components makes it possible for potential general contractors to bid closely on the job effecting an additional saving. The contractors work with the quantity surveyor's cost figures for each school, adding additional sums for site development, contingency, and profit. In a number of cases this method enables the contractors to bid for school work on a long-term basis. This procedure is known as serial contracting and the low bidder is given the option to build a series of schools which are scheduled over a two or three year period so that when he completes one he can start on the next. The ability to schedule work crews over long periods of time using the same component system provides a considerable saving on labor which results in lower bids by contractors. The first time this

TABLE 5

Savings to the Consortium as a Result of the Purchasing Procedure

		Notts. Pilot Program	Consortium Programmes		
		1957-58	1958-59	1959-60	1960-61
Concrete Cladding	Type 1 unit size 9 ft. 11 3/4 in. x 1 ft. 5 1/8 in.	76s. 2d. plus 4% increased costs	66s. 0d.	71s. 0d.	66s. 0d.
Concrete Plinth Unit	Type A unit 3'3 3/16" long	13s. 10d. plus 4% increased costs	8s. 9d.	9s. 0d.	7s. 3d.
Upper Floor Covering	Price per sq. yard	45s. 9d.	43s. 11d.	38s. 9d.	38s. 2d.
Metal Roof Lights	Total of one ea. of 4 types	£42 9s. 9d.	£31 2s. 0d.	£29 4s. 6d.	£30 13s. 11d.
Vitreous Enamel Panels	Price per sq. ft. on typical panel	8s. 11d. plus 5% increased costs	7s. 9d.	6s. 7d.	6s. 4d.
Internal Flush Doors	Price per sq. ft.	7s. 5d.	6s. 5d.	6s. 1d.	5s. 11d.

approach was tried, it resulted in a bid which was 8% below the estimated quantity-surveyor's figure--which is very considerable when such a large percentage of the building material costs are fixed.

Since the Milan Triennale, where a CLASP school won first prize, there has been considerable interest in the system on the continent. This year there will be £8,000,000 worth of school buildings constructed in Italy and Germany on the CLASP system, for which royalties will be paid to the Consortium.

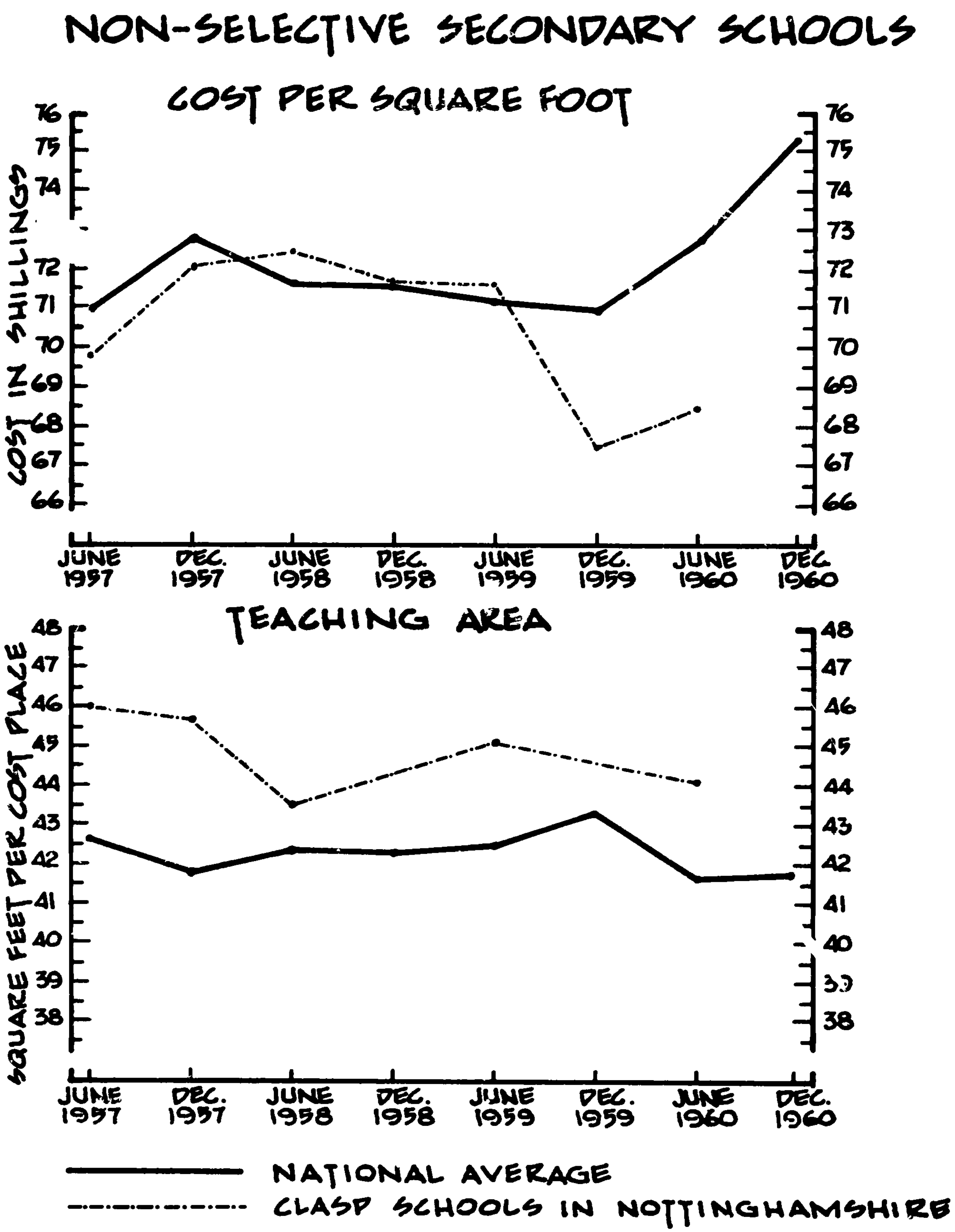


FIGURE 18

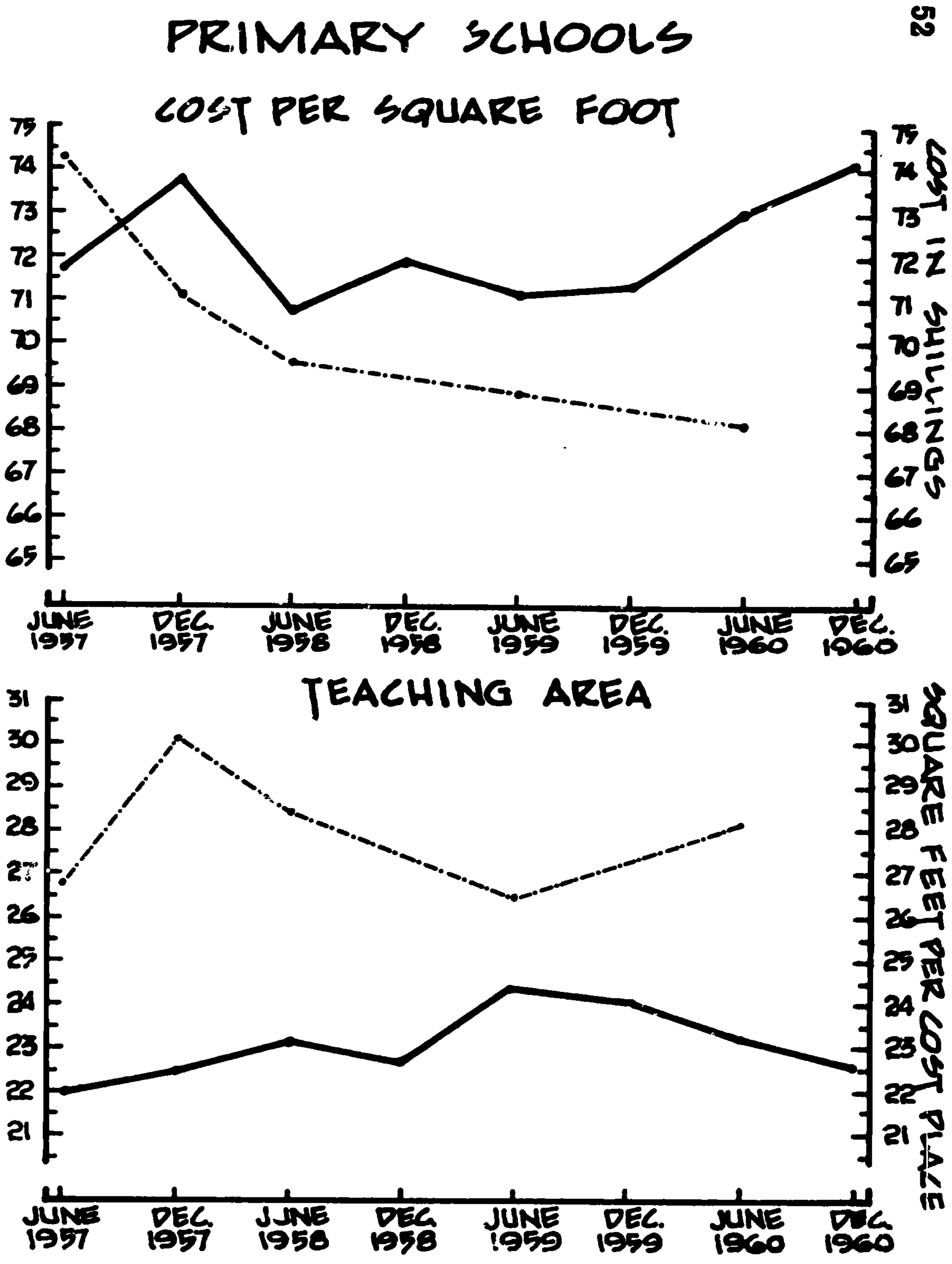


FIGURE 19

LAINGSPAN

This system, which is the property of a private contractor, John Laing and Son, Ltd., was developed in association with the development group of the Ministry of Education, Architects and Building Branch with a private consulting engineer, A. J. Harris. The prototype school was built at Arnold using a pre-stressed and post-tensioned concrete system. The Ministry of Education describes the system as follows:

"General Description 1/

The structure consists of pre-cast concrete components, some of which are pre-tensioned and some post-tensioned. The dimensions were chosen to allow freedom of planning on a 3 ft. 4 in. square grid with a 10 in. vertical grid--these dimensions be subject to certain maximum spans and heights. It is suitabl building up to four stories.

Flexibility and location of all elements is made possible by the careful profiling of structural parts, and this also allows the design and fixings of these elements to be greatly simplified.

Freedom for the passage of services is main d both ho zontally through the ceiling space and vertically ough the standard service ducts in partitions.

A brief, setting out the structural and dimensional requirements which the system would have to satisfy, was first drawn up. While it did not postulate a system profoundly different from several others at present available, it is perhaps worth quoting since it provides a useful stick for comparison with other systems. 2/

Within the over-riding requirement that it should be competitive with other systems, in speed of construction, and with both these and conventional methods in the matter of cost, the system was required to:

(1) exploit the techniques of pre-stressing to the full in order to economise on the consumption of steel and to achieve the utmost lightness and elegance of construction;
(2) be suitable for school construction up to four stories;

1/ Building Bulletin No. 17, Ministry of Education, London, England, pp 45-48.
2/ Similar briefs were developed prior to the design of most of the systems discussed in this report.

(3) be an open frame, i.e., not relying on load-bearing walls;
(4) allow 3 ft. 4 in.* planning flexibility in both directions and allow internal partitions to be placed at 3 ft. 4 in. intervals in both directions;
(5) allow changes of ceiling heights, change of floor level, junctions and clerestory windows all in 10 in. increments (using standard components);
(6) permit free spans of up to 33 ft. 4 in. for floors and 46 ft. 8 in. for roofs (including halls and gymnasia) using the same range of components--neither of these maximum spans to be limited by a maximum dimension in the other direction.
(7) consist of pre-cast components of such a size and weight that they could easily be handled by one or two men or a light mobile crane--all units to be as large as possible within these terms in order to reduce site jointing to a minimum.
(8) provide a range of light-weight cladding components with the use of concrete reduced to a structural necessity.
(9) provide a full and standard range of windows, doors and top lights, which (as with the cladding) would be dimensioned as to eliminate special conditions at internal or external corners;
(10) be erected without the use of scaffolding;
(11) allow free passage for all services between ceilings and the floor or roof above, thus eliminating expensive and inflexible floor ducts and crawlways (this dimension to be 1 ft. 8 in. regardless of span);
(12) allow column spacings of 3 ft. 4 in., 6 ft. 8 in. and 10 ft. with the possibility of staggering the columns. Column sections to be standard;
(13) provide demountable ceiling panels for easy access to all services;
(14) provide vertical ducts in partitions for small service drops;
(15) provide a thermal resistance of 0.2 for walls and roof;
(16) allows roof lights to be placed, either singly or in groups, at any point;
(17) provide standard partition components with a high level of sound insulation between rooms (40 to 45 decibel reduction between teaching spaces);. . . . ."

The system used in the development project at Arnold satisfied the conditions of the brief and a portion of this system is now being used in the design of a growing number of schools and other buildings. LAINGSPAN is a system of component parts for the structural frame and external wall. The interior products and service systems, however, are supplied by other manufacturers as

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* All the modular and sub-modular dimensions given are nominal.

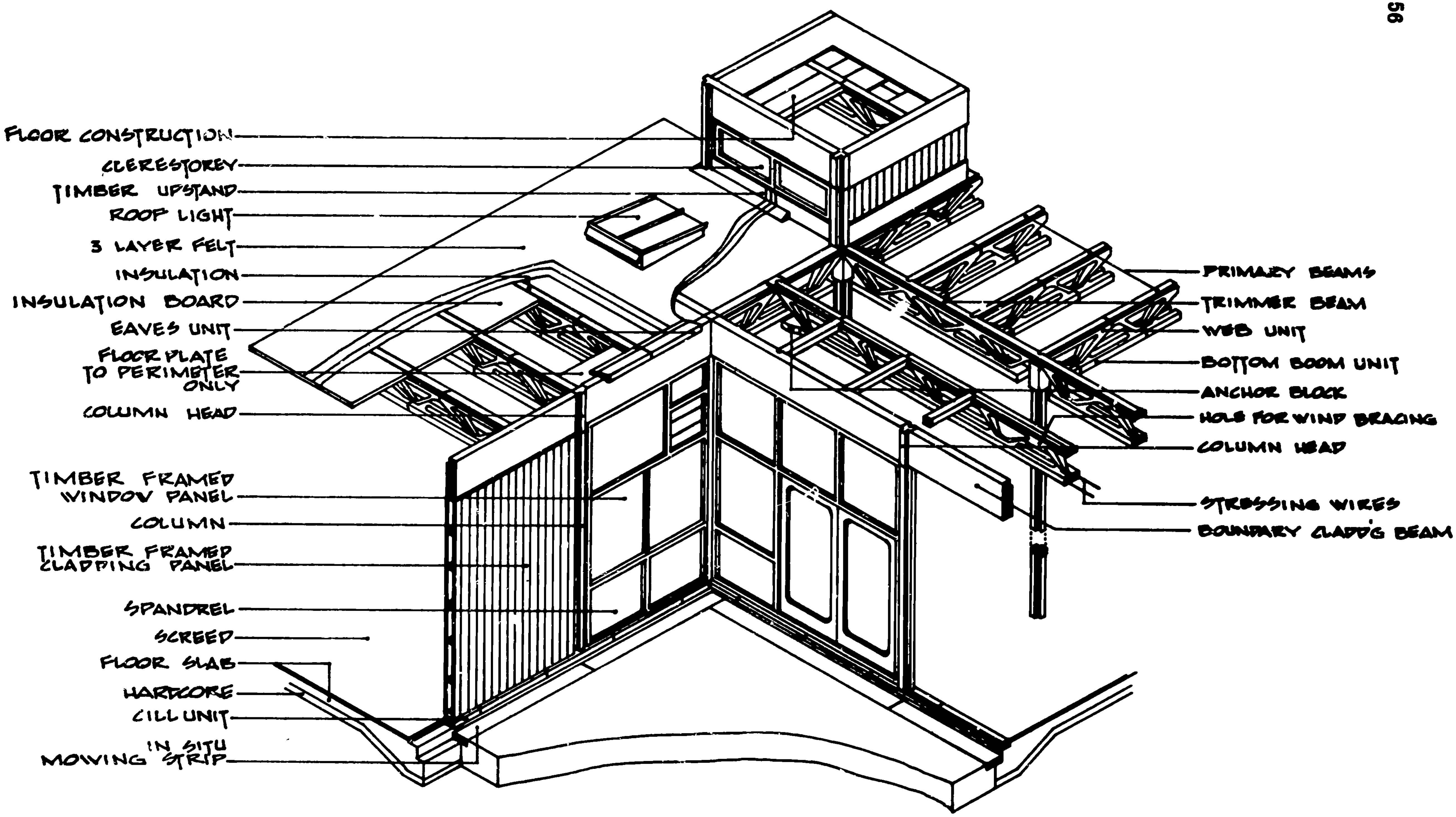
specified by the architect.

The structural and cladding system are best illustrated in Figure 20. The beams are made of a number of small units which are assembled together at the building site and strung up and stressed by cables. The small units can be handled by two men and the beams may reach a maximum of 60 feet. The most interesting aspect of this system is the use of a number of different column heads which may be joined to the column shafts to accommodate a variety of beam intersections. In the case of a clerestory window condition, four pieces may be tied together to develop a single column which has two column heads. The fact that these heads are separated from the rest of the column enables the shafts to be produced in uniform fashion with the sizes varying according to the 10" vertical module. Figure 21 shows three of the column heads. Considerable interest in this approach has been expressed by the designers of other systems, and it will probably be tried in a steel system before long. The problem of stocking the components is simplified considerably by separating the heads and column shafts. The normal stock list of about fifty pieces is shown in Table 6. If it is necessary to combine heads and columns, the stock list would probably be increased tenfold.

The wall panels consist of prefabricated units which require the minimum of finishing on site. They are simply fixed in standard rebates on the columns.

The use of the system is extremely simple due to the fact that the entire structural system is shown on a single sheet, Figure 22. Each item is related to detail and assembly drawing sheets by code numbers. Photographs 17-22 show some of the LAINGSPAN schools.

THE LAINGSPAN SYSTEM



ISOMETRIC OF STRUCTURE FIGURE 20

TABLE 6

SUGGESTED LIST OF STANDARD UNITS FOR STOCKPILING BY TRENT CONCRETE, LTD.

CILLS	XCC	100
	XF	200
	XFS	10
	XS	20
	XER	10
	XEL	10
	XIR	10
	XIL	10
	XLR	10
	XLL	10
COLUMNS	CC9	10
	CC10	70
	CC11	200
	CC12	20
	CC13	10
	CS9	5
	CS10	70
	CS11	70
	CS12	20
	CS13	5
COLUMN HEADS	HBE	50
	HBN	300
	HBB	10
	HBI	10
	HBTP	10
	HBBP	5
	HI	30
	HBNP	5
BOUNDARY	BRB2	100
	BRB3	150
	B2	50
	B3	75
TRIMMER	TB2	20
	TB3	20
	RTB2	20
	RTB3	20

(continued)

TABLE 6

W.B. AND FLOOR SLABS	WB	100
	F	2,000
	FS	300
EAVES UNITS	EGS	500
	EGE	30
	EGI	10
PRIMARY FLOOR BEAMS	PE	200
	PI	500
	PB2	20
	PB4	200
	PB8	200
	PBI	1,000
PRIMARY ROOF BEAMS	PRI	200
	PR2	200
	PR3	200
	PR4	200
	PR5	150
	PR6	150
	PR7	50
	PR8	20
	PBRI	100

STANDARD DATA FOR BOUNDARY, PRIMARY & TRIMMER BEAMS

PRECAST BOUNDARY ROOF BEAM UNITS

MK	DRAWINGS	DESCRIPTION	DRG NO	ASSY DRG	REMARKS
BRB1, BRB1F, BRB2, BRB2F, BRB3, BRB3F, BRB4, BRB4F	END VIEW; EXTERNAL ELEVATIONS	BRB(1-4) = BOUNDARY ROOF BEAM 1,2,3 OR 4 MODULES LONG. BRB(1-4)F = AS ABOVE BUT WITH FLASHING FOR 1'8" CHANGE OF LEVEL.	PC58, PC57, PC59, PC60	AY18	BOUNDARY BEAMS AND COLUMN HEADS ARE SCHEDULED TOGETHER AS COMPLETE BEAMS. WHERE COLUMN HEADS ARE COMMON TO TWO BEAMS THEY ARE REFERRED TO WITH THE BEAM IN DIRECTION OF HEAD LETTERING. APPLIES ALSO TO SCHEDULING OF TRIMMER BEAMS

PRECAST BOUNDARY FLOOR BEAM UNITS

MK	DRAWINGS	DESCRIPTION	DRG NO	ASSY DRG	REMARKS
B1 B1F ([illegible])	END VIEW. FLOOR BOUNDARY BEAMS ARE 1,2,3 OR 4 MODULES LONG.	B(1-4) = BOUNDARY FLOOR BEAM 1,2,3	PC27	AY2	THE BOUNDARY BEAMS ARE TO BE SCHEDULED AS ABOVE.
B2 B2F ([illegible])	N.B. 4 MODULE BEAMS ARE NON-STRUCTURAL.	OR 4 MODULES LONG.	PC8	AY2	
B3 B3F ([illegible])		B(1-4)F = AS ABOVE, BUT WITH FLASHING	PC7	AY2	
B4 B4F ([illegible])		GROOVE FOR 1'8" CHANGE OF LEVEL.	PC28	AY2	

PRECAST BOUNDARY (SPECIAL FOR SERVICES) ROOF & FLOOR BEAM UNITS

MK	DRAWINGS	DESCRIPTION		DRG NO	ASSY DRG	REMARKS
BS1 ([illegible])	END VIEW SECTION; EXTERNAL ELEVATION	BS1	BOUNDARY BEAM WITH HOLES FOR SERVICES EITHER 1,2 OR 3 MODS. LONG.	PC27	AY2	
BS2 ([illegible])	NOTE: 3 MODULE BEAM HAS 8 NO. HOLES POSITIONED ABOUT AS ON TWO MOD. BEAM ABOVE 1 MOD. BEAM HAS 2 NO HOLES	BS2		PC38	AY2	
BS3 ([illegible])		BS3		PC34	AY2	
BRBS1 ([illegible])		BRBS1		PC58	AY18	
BRBS2 ([illegible])		BRBS2		PC75	AY18	
[illegible] ([illegible])		BRBS3		PC76	AY18	

PRECAST PRIMARY FLOOR BEAM UNITS

MK	DRAWINGS	DESCRIPTION	DRG NO	ASSY DRG	REMARKS	
PE ([illegible])	PE PL PL PE	P = PRIMARY; E = END UNIT	PC1	AY48	FROM 4 MOD. (13'-4") TO 10 MODS. (33'-4").	FLR. BEAMS ARE AT 1 MOD. (13'-4") C/C
PL ([illegible])	PBL PBL PBL	L = INTERMEDIATE UNIT; B = BOOM	PC2	AY48	CARRYING 5" THERMALITE PARTITIONS. MAX SPAN IS 9 MODS (30'-0")	
PB2, PB4, PB6 ([illegible])	PB2, PB4, PB6 } ELEVATION OF 4 MODULE (13'-4") SPAN BEAM.	2, 4, 6 } NO. WIRES IN UNIT	PC5	AY48		
PB1 ([illegible])			PC4	AY48	THESE ARE SCHEDULED AS INDIVIDUAL UNITS.	

PRECAST PRIMARY ROOF BEAM UNITS

MK	DESCRIPTION	DRG NO.	ASSY DRG	REMARKS	
PB2, PB4, PB6	PBRL PBRL. ELEVATION OF 15 MODULE (50'-0") SPAN BEAM. PRIMARY ROOF BEAM END BLOCK TO BOTTOM BOOM.	PC3, PC77	AY18, 20R1	PBE. THESE ARE SCHEDULED AS COMPLETED BEAMS I.E. RP/7 = 7 MOD. ROOF PRIMARY BEAM.	ROOF BEAMS ARE AT 2 MODULES (26'-8") C/C
PR1-8, 115 TO 120 LR	PRIMARY ROOF BEAM WEB ELEMENTS	PC55, 62, PC78	AY18, 20R1		
PBRL, PBL ([illegible])	PRIMARY BEAM INTERMEDIATE BOTT. BOOM ON 4 TO 12 MOD. BEAM. PRIMARY ROOF BEAM INTERMEDIATE BOTT. ON 13, 14 & 15 MODULE BEAM.	PC4, PC64	AY48, AY48		

PRECAST FLOOR TRIMMER BEAM UNITS

BEAM TYPE	ELEVATIONS	DESCRIPTION	DRG NO	ASSY DRG	REMARKS	
TB1 ([illegible])	TB1	T = TRIMMER; B = BEAM; 1 = ONE MODULE	PC20		PRECAST 1 MOD. UNIT TO TAKE FLOOR SLAB ON BOTH SIDES.	FIN JOINT SEATING ON COLUMN HEADS.
TB2 ([illegible])	TB2	T = TRIMMER; B = BEAM; 2 = TWO MOD.	PC5		PRECAST ONE PIECE 2 AND 3 MOD. UNITS TO CARRY PRIMARY BEAMS ON BOTH SIDES.	
TB3 ([illegible])	TB3	T = TRIMMER; B = BEAM; 3 = THREE MOD.	PC6			

PRECAST ROOF TRIMMER BEAM UNITS

BEAM TYPE	DRAWINGS	DESCRIPTION	DRG NO.	ASSY DRG	REMARKS	
RTB1 ([illegible]), RTB2 ([illegible]), RTB3 ([illegible])	END VIEW; ELEVATIONS	R = ROOF; T = TRIMMER; B = BEAM; 1 = ONE MOD.; 2 = TWO MOD.; 3 = THREE MOD.	PC68, PC67, PC69	AY18, AY18, AY18	1 NO. 10 1/2" x 3 1/2" SERV. HOLE IN RTB1	STRESSED THROUGH COLUMN HEADS

COLUMN BRACING UNIT

MK	DRAWINGS	DESCRIPTION	DRG NO.	ASSY DRG	REMARKS
BU3 ([illegible])		B = COLUMN BRACING; U = UNIT; 3 = THREE MOD.	PC78	AY23	STRESSED THROUGH CA COLUMNS & BCH COLUMN HEAD.

STANDARD DATA FOR COLUMNS, COLUMN HE[ADS …]

PRECAST COLUMN HEAD U[NITS]

MK	PLAN	DESCRIPTION
HBE, HBEF (32)	BOUNDARY BEAM; BOUNDARY BEAM	H = HEAD; B = BOUNDARY BEAM; E = EXTERNAL ANGLE; F = FLASHING
HBN, HBNF (33)	BOUNDARY BEAM OR ROOF TRIMMER; FLOOR TRIMMER OR PRIM. BEAM; BOUNDARY BEAM OR ROOF TRIMMER	H = HEAD; B = BOUNDARY BEAM; N = NORMAL; F = FLASHING
HBB, HBBF (31)	BOUNDARY BEAM; BOUNDARY BEAM OR ROOF TRIMMER; BOUNDARY BEAM	H = HEAD; B = BOUNDARY BM; B = BOUNDARY BEAM; F = FLASHING
HBI (31)	BOUNDARY BEAM; FLR. TRIMMER OR PRIM. BEAM; FLR. TRIMMER OR PRIM. BEAM; BOUNDARY BEAM	H = HEAD; B = BOUNDARY; I = INTERNAL ANGLE
HBTP (39)	FLR. TRIMMER OR PRIMARY BEAM; FLR. TRIMMER OR PRIM. BEAM; FLR. TRIMMER OR PRIM. BEAM; ROOF TRIMMER OR BOUND. BEAM	H = HEAD; B = BOUNDARY BEAM; T = TRIMMER (FLR. TPE)
HBXL (37)	BOUNDARY BEAM; FLR. TRIMMER OR PRIM. BEAM; FLR. TRIMMER OR PRIM. BEAM	H = HEAD; B = BOUNDARY BEAM; X = EXPANSION JNT; L = LEFT
HBXR (37)	FLR. TRIMMER OR PRIMARY BEAM.; FLR. TRIMMER OR PRIM. BEAM; BOUNDARY BEAM	H = HEAD; B = BOUNDARY BEAM; X = EXPANSION JNT.; R = RIGHT
HBBP (31)	BOUNDARY BEAM OR ROOF TRIMMER; BOUNDARY BEAM OR ROOF TRIMMER; PRIMARY OR FLOOR TRIMMER BEAM; BOUNDARY BEAM OR ROOF TRIMMER	H = HEAD; B = BOUNDARY BM.; B = BOUND. BEAM; P = PRIMARY BEAM
HI (47)	FLR. TRIMMER OR PRIMARY BEAM.; FLR. TRIMMER OR PRIM. BEAM; FLR. TRIMMER OR PRIM. BEAM; FLR. TRIMMER OR PRIM. BEAM	H = HEAD; I = INTERNAL
HBNP (30)	BOUNDARY OR ROOF TRIMMER; FLR. TRIMMER OR PRIM. BEAM; BOUNDARY OR ROOF TRIMMER; FLR. TRIMMER OR PRIM. BEAM	H = HEAD; B = BOUNDARY; N = NORMAL; P = PRIMARY
BCH (23)	BU3; BU3	B = BRACING; C = COLUMN; H = HEAD

PRECAST COLUMN U[NITS]

MK.	SECTION	DESCRIPTION
CC1 to CC18 (27) / FT. RUN.		C = COLUMN; C = CRUCIFORM
CS1 to CS20 (37) / FT. RUN.		C = COLUMN; S = SQUARE
CA 12 & UP →	(39) / FT. RUN.	C = COLUMN; A = ASSEMBLY

PRECAST WIND BRACE & SL[AB …]

MK	DRAWING		DESCRIPTION
WB (31)	ELEVATION		W = WIND; B = BRACING
F (62)	ELEVATION; PLAN	FLOOR PLAN; 'F' UNITS; 'WB' UNITS; 'FS' UNIT	F = FLOOR SLAB
FS. (36)	ELEVATION; PLAN		F = FLOOR SLAB; S = SPEC. SIZE

N HEADS, WIND BRACE & FLOOR SLAB

AD UNITS

N	DRG NO	ASSY DRG	REMARKS	
BEAM ANGLE	PC	AY2	2 ANCHORAGES	FLASH'G TYPE COLUMN HEADS ONLY AT CHANGE OF LEVEL OF 1/2"
BEAM	PC2	AY2	NO ANCHORAGES	
Y BM BEAM	PC	AY2	1 ANCHORAGE	
Y ANGLE	PC5	AY2	2 ANCHORAGES	
Y BEAM (R TPE)	PC1	AY2	1 ANCHORAGE	
Y BEAM JNT	PC5	AY2	1 ANCHORAGE	
BEAM JNT	PC	AY2	1 ANCHORAGE	
Y BM BEAM BEAM	PC		1 ANCHORAGE USED ONLY ON ROOFS	
	PC7	AY2	NO ANCHORAGE OR STRESSING DUCTS. USED INTERNALLY ON FLOORS.	
Y	PC6		NO ANCHORAGE - MAINLY USED ON ROOFS.	
	PC2	AY25	ONLY USED WHEN CORNER COLUMN IS BRACED IN TWO DIRECTIONS	

IN UNITS

N	DRG NO	ASSY DRG	REMARKS	
M	PC9	AY2	CCFI (1 to 20) - CRUCIFORM COLUMN, INTERNAL FLASH'G CCFE (1 to 20) - CRUCIFORM COLUMN, EXTERNAL FLASH'G	COLUMN LENGTHS ARE MODULE LENGTH + 1/2"
	PC9	AY2		
Y	PC0			

SLAB UNITS

ON	DRG NO	ASSY DRG	REMARKS
	PC4	AY5	ARE SHOWN ON SCHEDULES WITH A SOLID BLACK LINE NORMALLY SPAN BETWEEN BOUNDARY AND PRIMARY BEAMS.
LAB	PC7	AY6	SHOWN ON SCHEDULES WITH AN OPEN RECTANGLE.
LAB E	PC7	AY6	SHOWN ON SCHEDULES WITH ONE DIAGONAL.

STANDARD DATA FOR SILL & EAVES UNITS

PRECAST SILL UNITS

MK	PLAN	DESCRIPTION		DRG NO	ASSY DRG	REMARKS
XCC (55)			X = SILL C = COLUMN C = CENTRAL	PC18	AY7	COLUMN RESTS ON CENTER OF UNIT
XF (99)			X = SILL F = FILLER	PC18	AY7	INTERMEDIATE UNIT ON WHICH NO COLUMN RESTS.
XFS (76)			X = SILL F = FILLER S = SPECIAL	PC18	AY7	INTERMEDIATE UNIT FOR USE AT EXTERNAL ANGLES ONLY.
XS (23)			X = SILL S = SHORT	PC18	AY7	SHORT FILLER UNIT FOR EXTERNAL ANGLES ONLY.
XER (57)		TYPICAL SECTION THROUGH SILLS	X = SILL E = EXTERNAL R = RIGHT	PC18	AY7	EXTERNAL CORNER COLUMN BEARING UNIT TO RIGHT OF COLUMN.
				PC18	AY7	AS ABOVE, BUT USED AT CHANGE OF LEVEL.
XEL (52)		TYPICAL SECTION UNDER COLUMN	X = SILL E = EXTERNAL L = LEFT	PC18	AY7	AS FOR 'XER', BUT UNIT TO LEFT OF COLUMN.
				PC18	AY7	
XIR (52)			X = SILL I = INTERNAL R = RIGHT	PC18	AY7	INTERNAL CORNER COLUMN BEARING UNIT TO RT. OF COL
XIL (52)			X = SILL I = INTERNAL L = LEFT	PC18	AY7	INTERNAL CORNER COLUMN BEARING UNIT TO LT. OF COL
XLR (26)			X = SILL L = LEVEL R = RIGHT	PC18	AY7	CHANGE OF LEVEL UNIT TO RIGHT OF COLUMN.
XLL (26)			X = SILL L = LEVEL L = LEFT	PC18	AY7	CHANGE OF LEVEL UNIT TO LEFT OF UNIT. COLUMN.
XXR (40)			X = SILL X = EXP. JOINT R = RIGHT	PC18	AY7	COLUMN BEARING EXPANSION JOINT UNIT TO RIGHT OF COLUMN.
XXL (40)			X = SILL X = EXP. JOINT L = LEFT	PC18	AY7	AS FOR 'XXR', BUT UNIT TO LEFT OF COLUMN.

TOP OF SILL UNITS ARE 1/2" BELOW M.L. LEVELS ARE MARKED AGAINST SILL UNITS WHERE OTHER THAN M.L. +1/2"

PRECAST EAVES UNITS

MK	PLAN	DESCRIPTION		DRG NO	ASSY DRG	REMARKS
EGS (190)			E = EAVES G = GLINEX S = STAND. UNIT	PC62	AY22	JOINTS TO STANDARD UNITS ARE AT HALF MODULES.
EGE (174)		TYPICAL SECTION	E = EAVES G = GLINEX E = EXT. ANGLE	PC62	AY22	EXTERNAL CORNER UNIT WITH JOINTS AT HALF MODS
EGI ([illegible])			E = EAVES G = GLINEX I = INTERNAL	PC62	AY22	INTERNAL CORNER UNIT WITH JOINTS AT HALF MOD
EGCC ([illegible])			E = EAVES G = GLINEX C CHG. OF LEVEL C AT BOTH ENDS	PC62	AY	THESE UNITS ARE USED ONLY BETWEEN TWO CHANGES OF LEVEL OCCURRING 6'-8" APART.
EGCR EGCL (210)	EGCR EGCL		E = EAVES G = GLINEX C = CHG. OF LEVEL R = RIGHT L = LEFT	PC62	AY22	THESE UNITS ARE USED AT CHANGES OF LEVEL ON LT. & RT. OF COL. AS INDICATED JOINTS OCCUR AT COL. ON ONE END & HALF MOD. LINE AT OTHER
EGXR EGXL ([illegible])	EGXR EGXL		E = EAVES G = GLINEX E = EXP. JOINT R = RIGHT L = LEFT	PC62	AY22	THESE UNITS ARE USED AT EXPANSION JOINTS.
EGCER EGCEL (80)	EGXER EGCEL		E = EAVES G = GLINEX C = CHG. OF LEVEL E = EXT. JOINT R = RIGHT L = LEFT	PC63	AY	THESE HANDED UNITS CAN ONLY BE USED WHERE A CHG. OF LEVEL OCCURS ONE MOD. AWAY FROM AN EXTERNAL CORNER.
EGCIR EGCIL ([illegible])	EGCIR EGCIL		E = EAVES G = GLINEX C = CHG. OF LEVEL I = INT. ANGLE R = RIGHT L = LEFT	PC63	AY	SAME AS ABOVE, EXCEPT FROM AN INTERNAL CORNER.

ALL EAVES UNITS TO BE BOLTED DOWN TO ROOF BOUNDARY BEAMS

NOTES

1. ALL VIEWINGS ARE FROM THE OUTSIDE OF THE BUILDING.
2. MODULE LENGTH HORIZONTAL = 3'-4". MODULE LENGTH VERTICAL = 10".
3. STAIRCASES
   a. STANDARD STAIRCASE WELLS ARE 5 MODS. (16'-8") x 3 MODS. (10'-0").
   b. STAND'D RISERS ARE 5". STAND'D TREADS ARE 10 1/2".
   c. LIMITING HEIGHTS FOR STAND'D STAIRCASE FROM FLR. TO HALF LANDING ARE 5'-0", 5'-5" OR 5'-10".
   d. FOR DETAILS: PC 19-22 AND AY3.
4. THERE ARE ENOUGH ADDITIONAL UNITS FOR SPEC. PURPOSES.
5. (50) INDICATES WT. OF UNIT IN POUNDS.

LOADING
FLOORS - 60#/SQ.FT. + CEILINGS, FINISHES AND PARTITIONS.
ROOFS - 15#/SQ.FT. + FINISHES AND CEILINGS.

REVISIONS

A	28.12.60	DET. OF THE 2" DIA. HOLE IN COLUMNS AND COLUMN HEADS ADDED.
B	21.3.61	REDRAWN & REVISED TO SHOW ADDIT'N'L UNITS AND LATEST AMENDM'TS.
C	28.7.61	WTS. AND NOTE '5' ADDED
D	27.9.61	BS1, BEBS1, BEBS2, BE BS3, RTB1, CCFI & CCFE ADDED. UNIT WTS. AMEND.
E	24.11.61	WEIGHTS AMENDED.

LAINGSPAN

STANDARD DATA

SCALES: N.T.S.

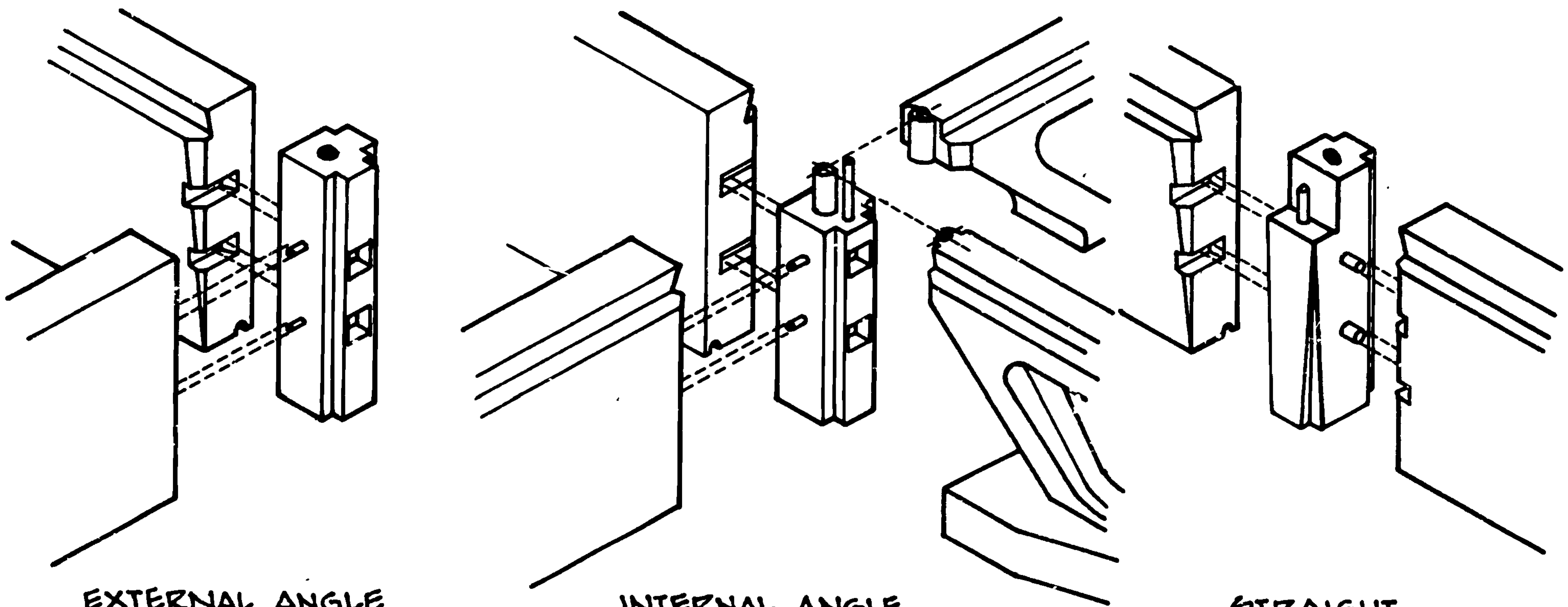
DATE: 27.7.60

DVD MTS

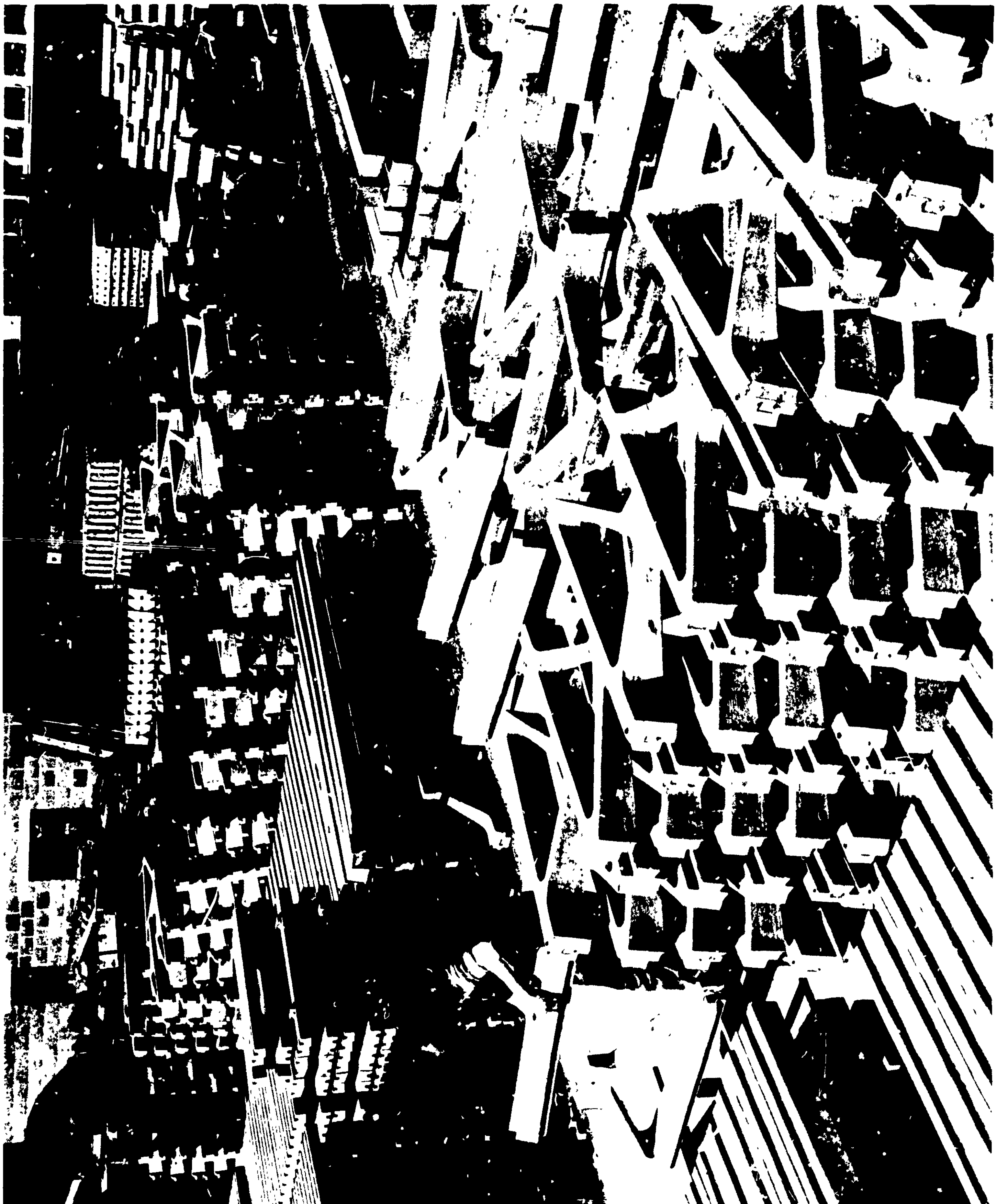
L/TECH/120/9

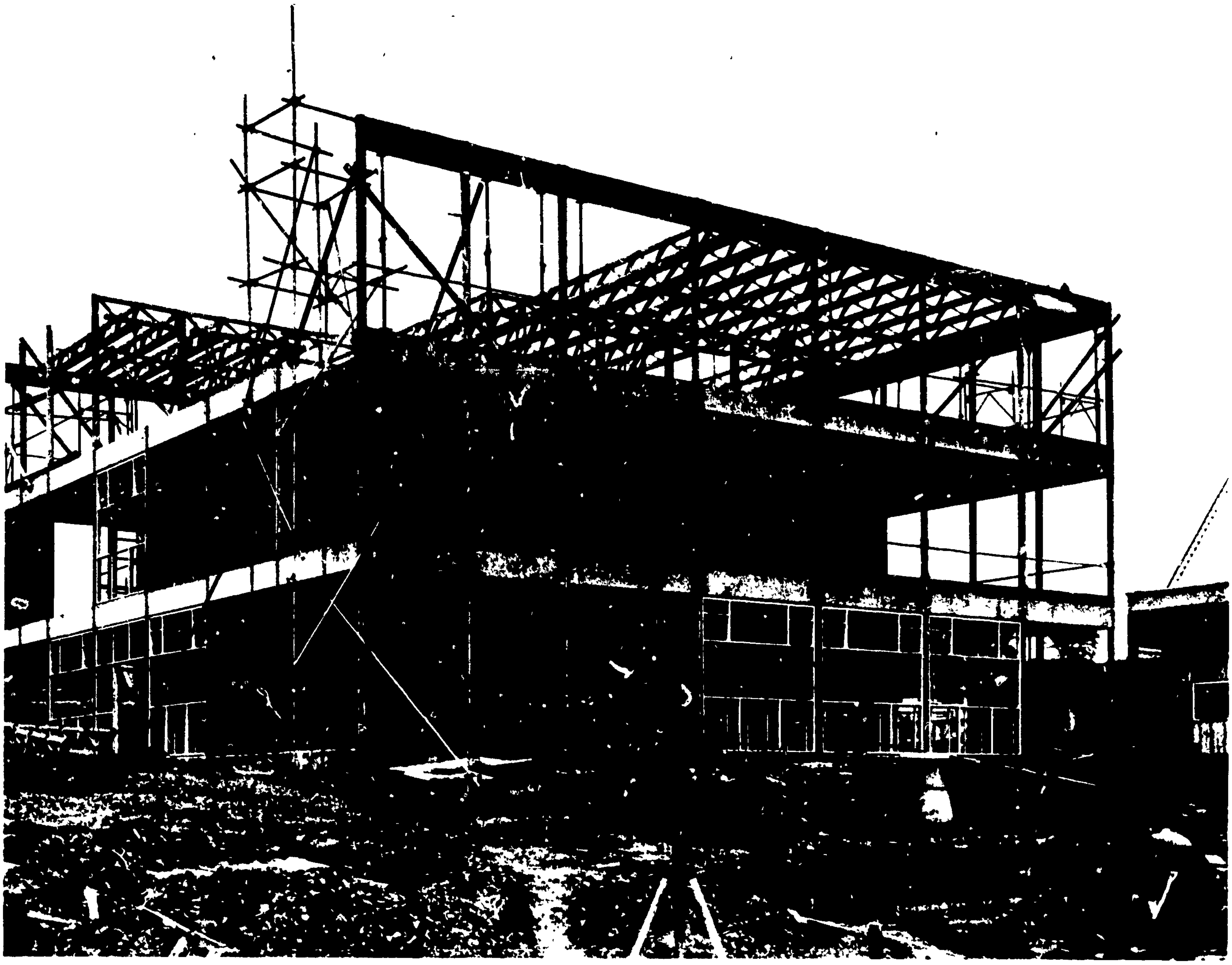
A.J. & J.D. HARRIS
CHARTERED CIVIL ENGINEERS
127 VICTORIA ST., WESTMINSTER

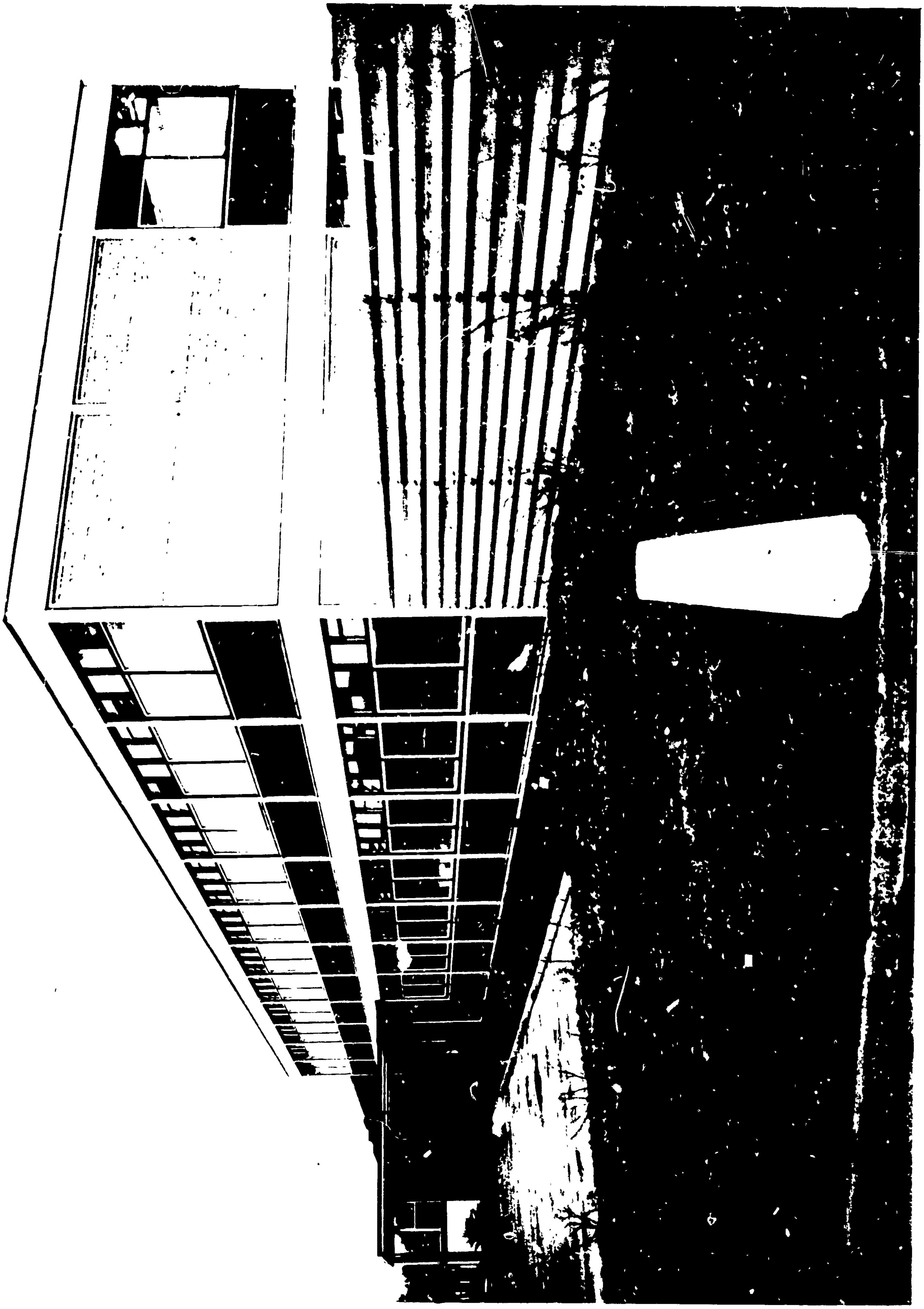
THE LAINGSPAN SYSTEM



BOUNDARY COLUMN HEADS FIGURE 21







INTERGRID

This system was developed before work began on LAINGSPAN, but the author unfortunately did not have an opportunity to visit any of the recent work designed on this system, so the material contained herein may not include some of the more recent developments.

This concrete system was developed by a group of engineers and manufacturers in conjunction with the Development Group of the Architects and Building Branch of the Ministry of Education. The prototype school was constructed at Worthing in 1954.

In this case, the 3'4" plan module was accepted due to its effective use in other systems as well as its applicability to the type of structure and the nature of the material to be used in the Worthing school.

The structure (see Figure 23) embodies a light frame of precast and pre-stressed concrete units. The system of main and secondary beams forms a grillage on the 3'4" grid lines supported by slender pre-cast columns at 6'8" or 10'0" centers around the perimeter of the structural bay. The boundary beams of reinforced concrete span between the posts and complete the perimeter on which the grillage beams rest; they are made in two lengths only: 6'8" and 10'0". The vertical module is 10" and the columns are made in various heights of this module; they are of a standard section, of overall size 6-1/2" x 4-1/2", and they are grooved to allow the cladding blocks to span between columns and to be fixed with dowels. In this way the cladding gives additional rigidity to the structure. The blocks are 6'8" or 10'0" long, 2-1/4" thick and generally 1'8" high, although some 10" high blocks are used as closers.

The main beams are made up of 3'4" elements, which are assembled together; the secondary beams are the 3'4" lengths and are placed in position between the main beams and at 3'4" centers and the cross tensioning is carried out after the structural bay has been completed. These 3'4" units can be lifted by one man and the assembled main beams, which span 33'4" for floors and 40'0" for roofs, can be lifted by a small 3, 360 pound crane. Special deep beams were made to span 50'0" for Assembly Hall roofs, etc.

Pile foundations are used on the prototype and the columns slot into a socket in the cap of the pile. Different types of column heads are used for various jointing conditions.

Three foot-four inch square pre-cast units fit on to the beam grillage to form the floor or roof panel, and when grouted-in, they form a rigid monolithic slab acting with the beams.

The outer cladding panels are of reinforced concrete with the aggregate exposed. The inner leaf of the wall is a 3" thick patent plaster panel; there is a 1" cavity between the inner and outer skin. This plaster panel is used for internal partitions as well.

THE INTERGRID SYSTEM

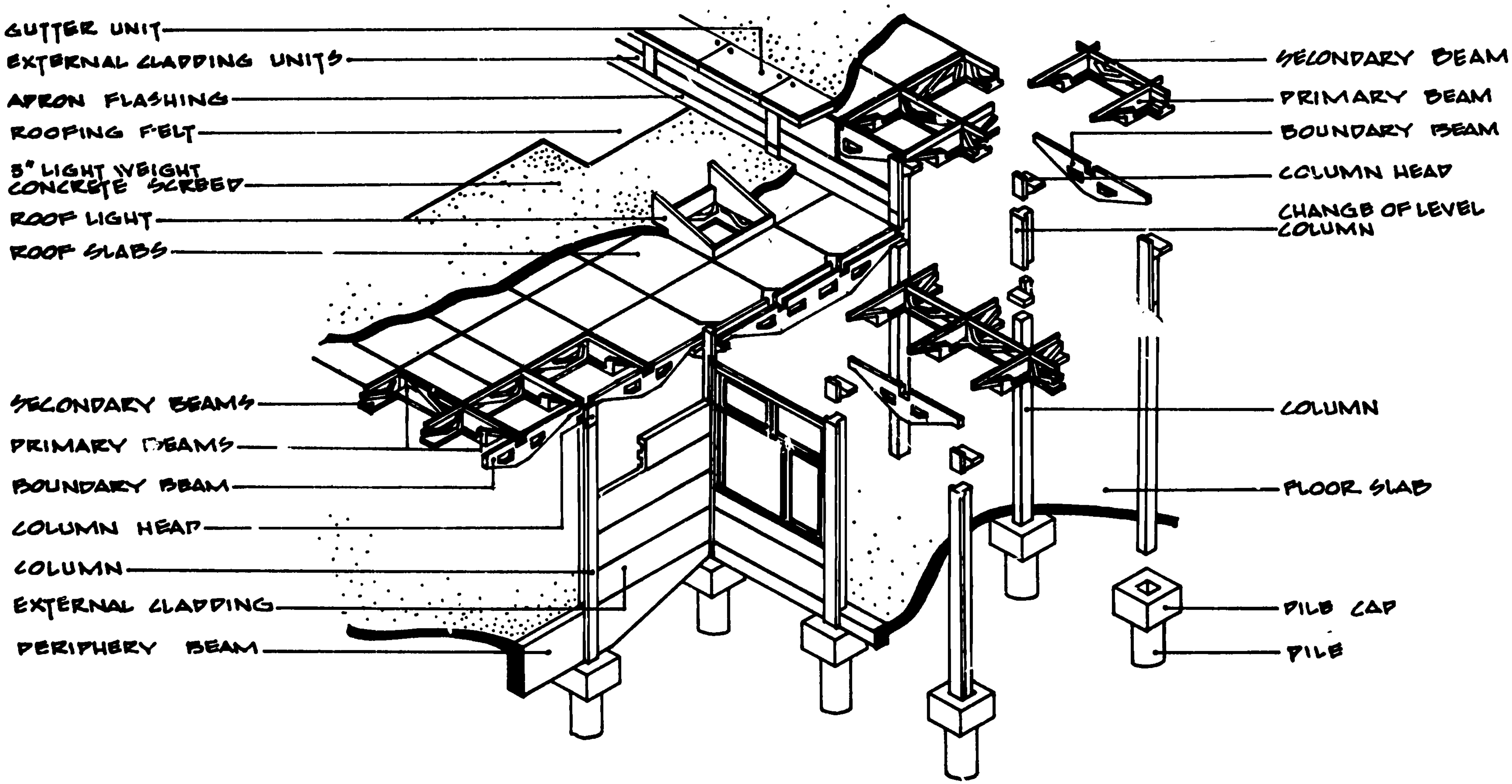


FIGURE 23

DERWENT

The system was developed from a school designed by Samuel Morrison, Architect, for Derbyshire County Council in 1952, to overcome difficult site conditions including the possibility of future subsidence due to underground mining. The decision was taken in principle to use a light weight structure on reinforced concrete rafts. The manufacturers were approached to develop a light timber structure and from this evolved a prefabricated timber system which has needed very little subsequent change.

A plan module of 6'4" was selected for the following reasons:

(1) The firm's experience led them to believe that a panel unit of 6'0" was an optimum size for fabrication in timber, because 12'0" is a common size for lengths of timber; and a unit of about 6'0" would be economical to make, and easy to handle.

(2) It was known that certain sheet materials could be obtained in a width of 3'0", and it was decided in particular to use two 3'0" wide plaster-boards to face the inside of a 6'0" wide panel.

(3) In considering the structure, a square post was selected, nominally 4" x 4", to be included in the run of panelling. A square column has the advantage of receiving beams equally on any of the four faces, and thus facilitates change of direction and height. The 4" posts with a 6'0" panel between them made up the 6'4" plan module from center-to-center of posts.

(4) Consideration was given to the special requirements of school planning and a module of 6'4" was found to be acceptable.

(5) With the type of construction visualized, existing standard doors could be used within the stud frame of the panel units, particularly easily in internal partitions.

Structurally, the system is a simple post and beam type with the post included in the run of panelling.

The posts, which are the same heights as the panels, namely 8'0" to 14'0" in 1'0" increments, are of laminated construction built up in various ways dependent on the height and strength required. Where the posts do not carry beams, they form infillers in the panelling run. For two story work a 3"x 3-1/2" strengthening fin has been joined to the inside face of the post in order to increase its strength, and yet not interfere with the standard panel units. See Figures 24 and 25.

All beams are 4" wide and the depth is in increments of 4" nominally but starting with 6" then 8". The main beams span in modules up to 28'0" and

THE DERWENT SYSTEM

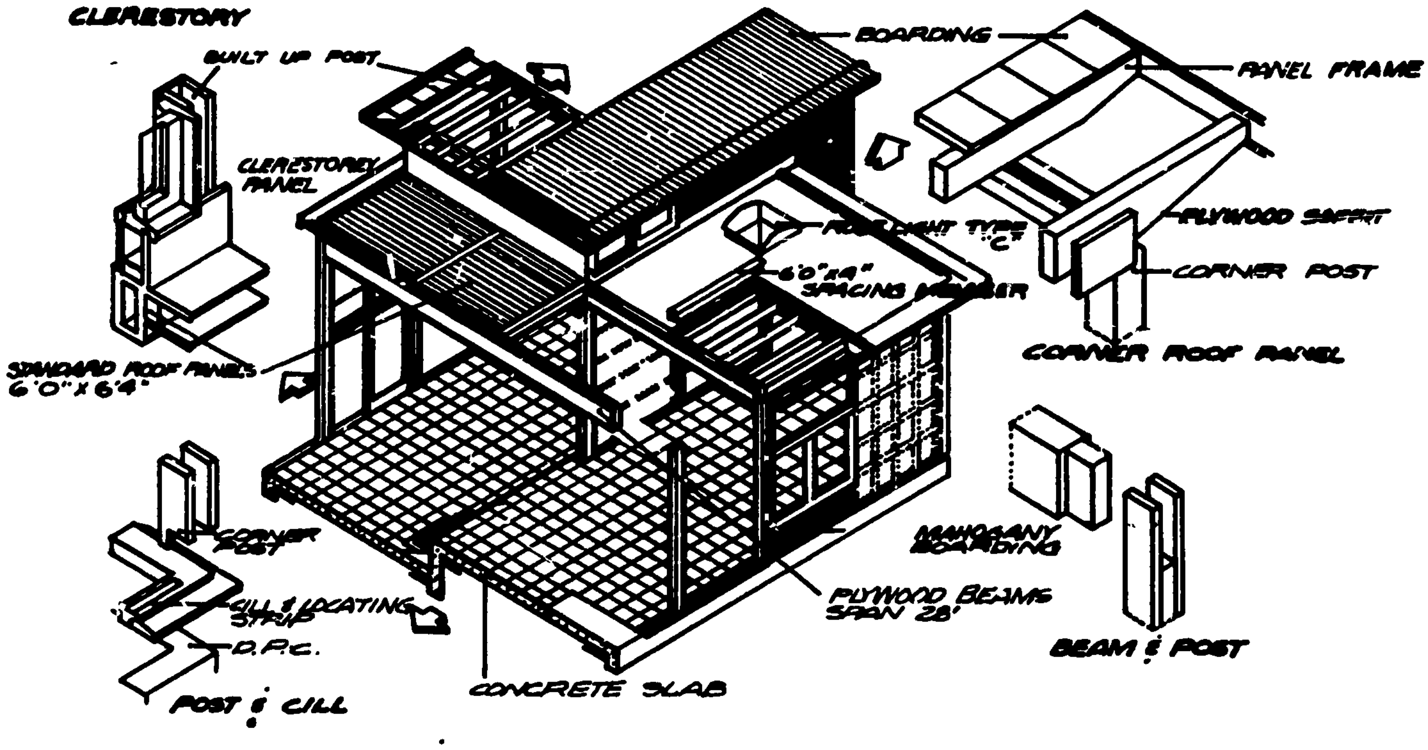


FIGURE 24

THE DERWENT SYSTEM

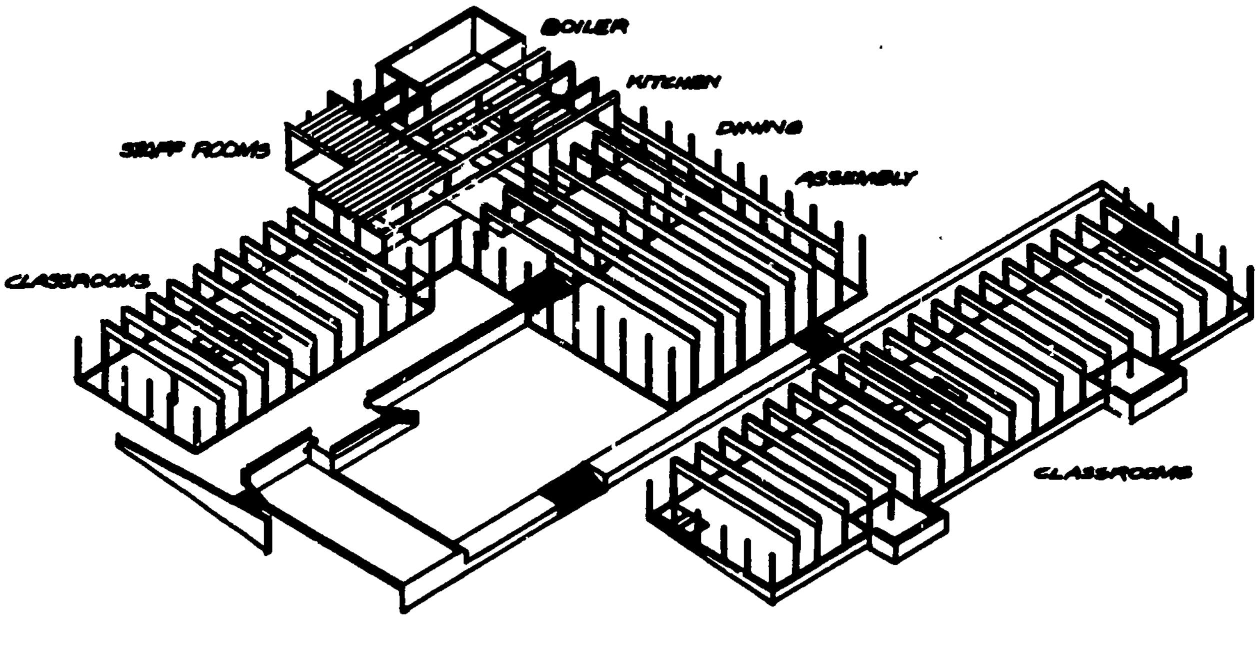


FIGURE 25

are of laminated construction.

Main beams are normally exposed below ceiling level and the ceiling between beams is made up of two 3'0" wide plasterboards. An exception is in cases of two story work where fire regulations require the ceiling below the beam.

Standard roof panels 6'0" x 6'4" span between main beams and 4" wide roof purlins at 6'4" centers.

External and internal panels are of a framed stud-partition construction. All interior faces are generally of plaster-board and external facings are of mahogany vertical boarding, though other facings can be used.

SCOLA
MINISTRY OF HOUSING
WAR OFFICE

These three organizations are presently working on the design of new systems, and it is expected that in the near future many other organizations will follow this pattern.

SCOLA is a new consortium which has been formed in the western part of the country consisting of the following counties: Shropshire, Hampshire, West Sussex, Gloucestershire, and Dorset. The initial building program for the 1962/63 fiscal year will be for £1,250,000, and it is expected that it will eventually develop to about £5 - £6,000,000. As in the case of CLASP, the consortium was developed through the top administrative officers of each county who form a group called the Consortium Council. Directly beneath this group is a board consisting of the chief architects of each of the counties who make the policy decisions for the work and under them the working party which actually designs the system. The first group meets once a year, the second every three months, and the working team meets officially once every three weeks. Each team is given specific components to design which must all fit together. Shropshire, for example, which has been the leading county in this consortium is designing the structural frame and external cladding for the system. The Ministry of Education participates in the work during the development period and helps to guide the consortium in such a way that it takes advantage of work done in other parts of the country.

A basic decision to use the 3'4" grid was made very early in the program and it was decided that the structural frame should not be pin jointed as in the case of the CLASP system. Originally another decision was made to keep the columns free of the walls, but due to the discouragement of the Ministry of Education, Architects and Building Branch, this approach has now been changed and the structural frame will receive both external and interior wall components as the Ministry feels that columns should not break into the rooms. The system itself is to be made of steel and the exterior walls will be 10" outside the grid lines. This is expected to eliminate certain thickness problems at the outside corners of buildings, but it will be necessary to see the completed design to verify this point in relation to inside corners. In the process of developing this system, an old school which has already been designed and constructed is being redesigned from scratch within the new system.

The Ministry of Education people say that new systems should always be designed in the context of designing a building. One must not only determine the sizes and nature of all the elements but their frequency of occurrence as well. If the longest beams are used infrequently, their depth will be reduced to that of the more common shorter beams, as the beam depth should be the same for most members. The choice of this depth then depends on the selection of a typical building for which the system will be used.

The MINISTRY OF HOUSING has formed a Development Team to develop a prefabricated system for the design of housing. The work is being done on a 1'8" internal grid using a modified version of the CLASP system which has been termed MINI-CLASP. This is necessary because the planning requirements for housing are much tighter than they are for schools. Unfortunately, the cost per square foot for housing is much lower than it is for school work so the work done to date has not produced an economically feasible system. It is thought that, on buildings of more than three stories, the system may be feasible economically and future work will be done in this area. Mr. Oliver Cox, who heads the Development Team, explained that where the job was small enough so that "Joe and his mate could do it", it still paid to hire them, but it appeared that if the size of the job was increased the prefabricated systems would begin to work.

The WAR OFFICE joined CLASP in 1958-59, and have 17 projects in the 1962-63 program. (See Table 4). At the same time, they have a development team which is designing a new system as they have found the grid plan approach of the HCC and CLASP too limiting for their work. This system will be based on a 2'0" deep space frame with braced panels to take wind load. Columns may be located on a 4'0" grid to support the space frame, but due to the nature of the structure, they may be widely spaced. However, the system anticipates the use of pairs of columns to accommodate changes in level. The development work on the structural system is being done with a single firm which will lead to a contract for one large installation. Afterwards, the WAR OFFICE will own the patents and the company itself will be able to market the system only with the approval of the WAR OFFICE. A wall system is being developed which will give 4" flexibility using four panel sizes: 20", 24", 28", and 4'0". The smaller sizes will be cut from a 4'0" panel. It was felt that the future of this system lay in the use of standard components on the free market.

NEW DIRECTIONS

The work being done in England is obviously very good in terms of achieving desired aims which are stated prior to the design of each system. The similarities between the systems reflect general educational requirements and regulations. The emphasis on the elimination of corridor area to obtain the maximum space utilization has undoubtedly resulted in buildings with a larger perimeter and many external corners. Similarly, in California we find covered walks and corridors in considerable use as a result of State regulations which allow the space contained within open corridors to be counted as half area. These differences make it difficult to compare these buildings in a realistic manner with the schools designed in the United States. Of greater interest to us in the United States are the directions that the various systems take in their evolutionary development. This knowledge of the methods and techniques may be applied to our own conditions.

The work in England is by no means proceeding in a uniform manner. At present it appears that a number of grids are in current use ranging from 1'8" to 6'4". The relationship of the structure to the external walls varies widely. CLASP has an in line condition; SCOLA places the walls in front of but attached to the structure; the HCC separates the walls from the structural elements which fall at the mid-point of the grid; and, in the case of the WAR OFFICE space frame approach, there is no fixed relationship between structure and walls. In the treatment of column heads, vertical modules, beam sizes, etc., similar differences are found. As each system was designed with considerable thought and care, the variety of results is significant. Each system solved certain problems, but a number of compromises were also made. It is apparent that significant developments will continue to be made to resolve a number of points. As an example, the 40" grid of CLASP is well suited to the placement of doors, but results in the waste of 8" from every 4'0" piece of sheet material. The 32" HCC grid, on the other hand, may be cut from a basic 8'0" sheet size without waste, but it is difficult to fit a single door into the system.

A new and important trend seems to be developing. The HCC is working with a single group of building components in developing its new systems, and these will fit together within the context of three separate structural systems. Mr. Heathcote of Brockhouse stated that it would be necessary to develop a system of improved components which will have general appeal for the entire building industry, and the WAR OFFICE development team is developing its system on the basis that the future will see standard components utilized on a free market. It is obvious that the future direction will be to coordinate the components of different manufacturers and even systems to increase the design choice. In discussions with people at the Ministry of Education, it became apparent that they were also thinking along these lines of increased flexibility, and that in some of their newer development projects they would try to increase design freedom considerably once again leading the way in England. These developments should allow for greater flexibility in design to handle both functional and aesthetic requirements.

APPENDIX 1

SPECIMEN COST ANALYSIS

Name of School	Blank Road School, Blanktown
Type of School	Three Form Entry Infants
Number of Places	360
Floor Area (Square Feet)	17,640
Number of Square Feet Per Place	49
Net Cost	£48,510
Net Cost Per Place	£134, 15s.
Net Cost Per Square Foot (as below)	55/-
Gross Cost	£52,773
Gross Cost Per Place	£143 16s. 2d
Gross Cost Per Square Foot (as below)	59s. 10d.
Tender Date	November, 1950

Elements		Cost in Shillings Per Sq. Ft. of Floor Area
Preliminaries and Insurance		2/9
Contingencies		1/6
Work Below Ground Floor Level		4/-
External Walls and Facings		9/6
Internal Partitions		1/-
Frame		Nil
Upper Floor Construction & Staircases		Nil
Roof		5/8
Floor Finishings		4/-
Wall Finishings		1/3
Ceiling Finishings		1/3
Metal Windows & Doors (External)		4/-
Doors (Internal)		0/5
W.C. Doors and Partitions		0/5
Cloakroom Fittings		0/8
Built-in Fittings		0/4
Fittings		1/3
Ironmongery		0/6
Plumbing (External)		0/2
-do- (Internal)		0/11
-do- (Sanitary Fittings)		0/11
Gas Installation		0/3
Electric Installation		2/3
Heating Installation		4/6
Kitchen Ventilation		Nil
Drainage		2/-
Glazing		0/5
Decorations		2/-
Playgrounds and Paved Areas		3/-
	Net Cost	55/-
External Works		4/10
	Gross Cost	59/10

APPENDIX 2

LIST OF PREFABRICATED SYSTEMS

System	Manufacturer	Description
Thermagard	Gardener, Sons & Co.,Ltd Midland Works, Bristol 2	Steel Frame with "Murrogard" curtain walling, or other forms of cladding.
Hills	Hills (West Bromwich) Ltd., Albion Road, West Bromwich, Staffs.	Light Steel Frame with pre-cast concrete slabs or glass curtain walling. Modules 8'3", 3'4", 2'8".
Derwent	Vic Hallam Ltd. Langley Mill, near Nottingham	Timber.
B. A. C.	Bristol Aeroplane Co.	Aluminum (This system is no longer in production).
Intergrid	Gilbert Ash Ltd. 2 Stanhope Gate London, W.1.	Prestressed concrete frame with precast concrete slab claddings.
Cawood	Cawood Wharton & Co. Ltd., 1 Cavendish Road, Leeds	
Brockhouse (also known as C.L.A.S.P.)	Brockhouse Steel Structures,Ltd.	Steel Frame - specially adapted for building on sites where subsidence is likely. Takes a wide variety of cladding.
Medway	Medway Building & Supplies Ltd. Phoenix Wharf, Rochester, Kent	Timber
Holoform	Morris Singer & Co., Ltd. Ferry Lane Works, Forest Road, E. 17.	Steel Frame with steel or aluminum sheet cladding
G.80	Gee, Walker & Slater, Ltd. Uttoxeter Old Road, Derby.	Precast concrete frame with precast concrete blocks or brick cladding. Module 6'8".
Intercon	Intergrated Constructions Ltd. 12 Archer Street, W. 1.	Steel Frame with brick cladding

Appendix 2 (continued)

Spooner	Spooners (Hull) Ltd. Glebe Road, Stoneferry Kingston-upon-Hull	Timber frame with brick, timber or concrete block cladding.
Orlit	Orlit Ltd., 18 Buckingham Gate, S.W.1.	Precast concrete frame with precast concrete cladding.
Anderson A75.	A. H. Anderson Ltd. Ashton Vale, Bedminster, Bristol 3.	Timber
Sims C.D.A.	W. J. Sims, Sons & Cooke Ltd., Hydn Road, Sherwood, Notts.	Timber
Laingspan	John Laing and Son Ltd. Bunns Lane, N.W. 7.	Precast, prestressed concrete frame with timber or concrete panels.

PHOTO TITLES & CREDITS

P. 22	St. Albans College of Further Education. Courtesy G. C. Fardell, County Architect, Hertfordshire.
P. 23	St. Albans College of Further Education. Main entrance with Administration block. Courtesy British Insulated Callender's Cables Ltd., and G. C. Fardell, County Architect, Hertfordshire.
P. 24	St. Albans College of Further Education. An interesting example of the use of different sized panels. Courtesy Alcan Industries Ltd., and G. C. Fardell, County Architect, Hertfordshire.
P. 25-26	St. Albans College of Further Education. Courtesy Alcan Industries Ltd., and G. C. Fardell, County Architect, Hertfordshire.
P. 32	Bancroft Lane Infants School. (upper) Example of spring loaded lateral bracing system. (lower) Example of the fixed lateral bracing system. Courtesy W. D. Lacey, County Architect, Nottingham.
P. 43-44	Winner Grand Prize, Milan Triennale, 1960. Courtesy W. D. Lacey, County Architect, Nottingham.
P. 44	(lower) Bancroft Lane Infants School. Courtesy Brockhouse Steel Structures Ltd., and W. D. Lacey, County Architect, Nottingham.
P. 45	Example of the CLASP system used on a two story school. Courtesy W. D. Lacey, County Architect, Nottingham.
P. 46-49	Bramcote Hills Primary School. Courtesy W.D. Lacey, County Architect, Nottingham.
P. 62	Stockpile, precast concrete components. Courtesy John Laing and Son Ltd.
P. 63	Stressing primary beams. Courtesy John Laing and Son Ltd.
P. 64	Erection of concrete system. Courtesy John Laing and Son Ltd.
P. 65	Polio Rehabilitation Unit, Oxford. Courtesy John Laing and Son Ltd.
P. 66	Office Building. Example of prefabricated system designed for schools being used for other purposes. Courtesy John Laing and Son Ltd.
P. 67	Prefabricated staircase. Courtesy John Laing & Son Ltd.