T H E U N I V E R S I T Y O F A S T O N I N B I R M I N G H A M

DEPARTMENT OF BUILDING

AN ECONOMIC, ENVIRONMENTAL AND FUNCTIONAL STUDY OF BUILDINGS ERECTED FOR EDUCATIONAL PURPOSES

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of Mechanical Engineers, Institution of Electrical Engineers, Institution of Heating and Ventilating Engineers, Institution of Structural Engineers, Royal Institute of British Architects and the Royal Institute of Chartered Surveyors.

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INTRODUCTION

INTRODUCTION

The construction industry is often criticised for the lack of technological progress and for the very conservative attitude adopted both by the technologist and the craftsman.

Unfavourable comparisons are sometimes made with other industries without studying carefully the reasons why the construction industry has developed into its present form.

Comparisons on an international basis are complicated by the many direct and indirect influences which affect both design and construction. Direct influences include items such as the cost and availability of land, materials, fuel and labour, together with the restraint placed on design and construction by the external environment. Indirect influences such as the relationship of wage rates between the various industries in a given country, Government policy and national characteristics can also have a marked effect on design decisions and construction techniques.

The British construction industry has a labour force of approximately 1,300,000 operatives, 30% of whom are employed on maintaining buildings up to 400 years old. Maintenance of 100-year old buildings is such commonplace that work is carried out on them without comment.

Buildings erected for one specific purpose quite often have a chequered history during which time they fill many roles. Educational buildings (the subject of this study) provide a very good example where the present requirements may be quite different to those in 30 - 40 years' time. Bearing in mind the educational changes which we are experiencing at the present time, he would be a very courageous or ignorant man who would attempt to be dogmatic about educational requirements in the next three to four decades. Intelligent predictions are possible, but history tends to demonstrate the folly of those who have attempted to forecast the future. What we can be certain of, is that the educational requirements in the year 2,000 will be different to what they are today and the life of our buildings is such that they will have to accommodate this educational development. Economic and environmental studies show that short-life buildings or movable partitions do not provide the answer to these changing needs. The requirement seems to be for a building in which the load bearing structure allows the function, size and shape of individual rooms to be changed so that the introduction of new developments both in teaching aids and practice can be fully exploited, thereby enabling educationists and students alike to operate at maximum efficiency in a pleasant environment.

Flexibility will in most cases mean that the initial costs will be higher than for a building in which only present day educational requirements have been considered, the need is to convince the client, which in this particular case is the community and their national and local government representatives, that a long term view produces a better investment.

It follows, therefore, that before a proper understanding can be obtained as to the most economic means of providing educational buildings, it is necessary to appreciate the factors which affect the design decisions for building generally and to include as a major factor, the development of educational thought and practices in order to arrive at the best solution for educational buildings in particular.

As long as we live in a progressive society there will always be educational problems to be solved, the important factor is that the buildings which are provided should not be responsible for limiting educational development.

CHAPTER I

FACTORS AFFECTING BUILDING DEVELOPMENT

No other industry has been subjected to the number and variety of factors which have affected the Construction Industry and therefore any study of constructional form or contractural organisation must take account of the diversity of factors which have influenced the design and construction of buildings.

This chapter is therefore devoted to a discussion of the factors which have influenced the design and construction of buildings in this country.

The main factors which have affected building development in the past and in most cases continue to do so are:-

1 The External Environment
2 Geological Features
3 Geographical Location
4 National and Social Characteristics
5 Political and Religious Thoughts and Practises
6 Education
7 Historical Influences
8 Availability and Costs of Land, Labour and Materials
9 Development in the Properties and Handling of Materials and Components.

1 THE EXTERNAL ENVIRONMENT

The British climate has encouraged comparatively strong roofs of moderate pitch. Window dimensions in the past, have been determined by light requirements and the need to maintain an even temperature during the summer and winter months. However, recent developments in double glazing and artificial lighting have removed many of these earlier restrictions.

Maintenance of a pleasant internal environment by the provision of heating, ventilation and measures to prevent excessive heat loss have influenced building design in the past and continue to do so.

2 GEOLOGICAL INFLUENCES

Geological influences can be seen in the erection of buildings using local materials, for example, the predominance of stone, granite and slate in buildings near to their respective quarries and the use of flint rubble for wall panels in chalk areas. The type of construction described above contrasts with the predominance of brickwork in the London area where, the extensive clay fields and absence of stone quarries have restricted the use of stone (generally Bath and Portland stone) for decorative work and important buildings.

Before the fire of London in 1666, during the reign of Charles II, most of the buildings in London were constructed of timber and thatch, but after the fire, a royal proclamation restricted the use of combustible materials in new buildings. Prior to the 12th Century half timbered work had been the characteristic style of buildings, however, the increase in population after that time was one of the main factors which brought about destruction of the large forests in Cheshire, Lancashire and Hertfordshire and was thereby responsible for bringing to an end the era of this type of construction.

3 GEOGRAPHICAL LOCATION

The effects of geographical location are best seen by examining architectural styles adopted by towns on the coast or on the major roads and rivers, which because of their access to the sea have had the benefit of either knowledge and skills brought during peaceful emigration by Continental craftsmen or, the overseas experience of the traveller, whilst the more remote districts have remained unaffected by these changes.

In more recent times developments in transportation and communication have resulted in the universal exploitation of research and development work carried out by the individual countries and research associations.

4 NATIONAL AND SOCIAL CHARACTERISTICS

The various architectural styles which have been introduced throughout history portray the national and social characteristics of the people responsible for their development. The Norman style of architecture, with its symbolic circular arch, was mainly concerned with the erection of castles and other buildings which had walls and columns of large cross sectional areas.

Examples of Norman architecture can be seen in the Tower of London, Rochester Castle, Westminster Abbey, York Minster, Salisbury and Lincoln Cathedrals.

Other examples can be seen by examining the way in which different countries have interpreted various architectural styles. The practical, matter-of-fact interpretation of the British builders in the past contrasts with the more artistic interpretation adopted by the French.

Earlier examples can be seen by examining the origins of the various architectural styles:-

The Doric order, derived from a locality in Northern Greece called Doris where the people were hardy and resolute, characteristics demonstrated in their architecture which was generally simple, symmetrical and carefully proportioned. In contrast the Corinthian order derived from a locality in Greece called Corinth where the inhabitants were gay and full of life, with the result that their architecture is more delicate and very ornate.

5 POLITICAL AND RELIGIOUS THOUGHTS AND PRACTICES

The dissolution of the monastries by Henry the VIII (1509 to 1546) which in turn produced a source of money for the erection of schools and colleges and the introduction of the Tudor Rose after the War of the Roses in 1485 are two examples of political and religious influences.

Other examples can be seen in the Renaissance period when the many elaborate mansions which were being erected for the nobility and wealthy had the benefit of the skill of craftsmen who had come to this country from France after the massacre of Saint Bartholomew in 1572.

6 EDUCATION

The influence of education on the construction industry can be divided into two parts:-

i) The education of the operatives to improve their skill and efficiency (vocational education).

ii) The general education of the community, which leads to the demand for higher living standards.

(i) VOCATIONAL EDUCATION

Craft Guilds; As soon as town life became established the various craftsmen formed Guilds to protect the interests of their members, improve their skills by introducing apprenticeship and to uphold the reputation of their products. The earliest Craft Guilds were formed in the 11th Century but they had no economic significance and restricted their activities to meeting the social requirements of their members. The development of the Construction industry was affected to some extent by this type of organisation, but as they did not deal in commodities sold "over-the-counter" the building craft guilds never enjoyed the prestige and authority of those connected with the products that were immediately retailed in the markets of the town in which they were manufactured.

It is interesting to note that because most of the stonework was carried out on a large scale, often away from towns, and because of the difficulties encountered in attempting to include hewers, layers, marblers, image makers and paviors in one association, the masons found it difficult to organise a guild.

In the thirteenth to fifteenth centuries the Crown and the

Church were the chief employers of mason and they were engaged on a direct labour basis by master masons who had been appointed by the Church or Crown, often for life. The master masons preferred labour to be unorganised in order to keep wages low.

From about the thirteenth century a large brotherhood of masons developed, based upon "Lodges" or temporary dwelling places in which they lived when employed on the large Government or Church projects.

A travelling mason would make for the lodge on arrival at the project and make himself known to the Master of the lodge by a special salutation and handshake which indicated the grade of mason he was. This would make him "free" of the lodge and lead to his employment.

Such a system gave the masons the ability to unite in order to get improved wages and conditions.

The development of Craft Guilds, professional institutions, the Council of Engineering Institutions and the Construction Industry Training Board will be discussed in Chapters II and III.

(ii) GENERAL EDUCATION

The gradual raising of educational standards throughout the world has resulted in the demand for higher standards in domestic, industrial, recreational and educational buildings.

This demand has been a major factor in the continual raising of the accepted standards of heating, ventilation, lighting, internal design and landscape architecture. The historical development of education is discussed in Chapter II.

7 HISTORICAL INFLUENCES

In the past, invasion and peaceful emigration have resulted in the introduction of new building styles into many countries including Great Britain. The influence of Rome and the Normans can be seen in many of our towns and cities. The introduction of the Flemish bond of brickwork during the rebuilding of London after the fire in 1666 was mainly as a result of the many building craftsmen coming to this country from Flanders about that time.

The growth of London after the Norman Conquest was followed to a lesser extent by the expansion of other cities such as Norwich, Canterbury, Bristol, Southampton, Cloucester and York.

Such developments led to the appearance of populations of "free" craftsmen who were not subject to the feudal obligations which had kept them tied to the land of rural manors. They were not only able to work in their own districts but could also undertake work in distant parts of the country.

The 31 masons working at Windsor Castle in 1365 had travelled from 11 different counties covering an area which extended from Yorkshire to Somerset.

This mobility of labour was a real influence in spreading variations and developments in building styles throughout the country.

8 AVAILABILITY AND COST OF LAND, LABOUR AND MATERIALS

and

9 THE DEVELOPMENT IN THE PROPERTIES AND HANDLING OF MATERIALS AND COMPONENTS

The items influencing cost in these two sections will be discussed more fully in Chapters VII, VIII and IX. It is sufficient to say here, that the acute shortage of building materials in the immediate post-war period was largely responsible for the introduction of various non-traditional building materials and methods of construction.

The shortage of steel resulted in the widespread use of reinforced concrete as a structural material. In many cases cross-sectional areas of beams and columns were made greater than ideal in order to further economise in steel.

The labour shortage has continually encouraged the development of non-traditional and industrialised buildings but their greater cost, as demonstrated subsequently, over traditional building and technological difficulties have restricted their progress.

It is interesting to note that a report issued by the National Federation of Building Trades Employers in May 1970 estimated that system builders were likely to be operating at only 18% capacity in June of that year and that this report came at a time when bricks were plentiful and when there was some regional unemployment in the construction industry.

High rise domestic buildings have enjoyed a popularity in many densely populated areas over the last two to three decades but the social problems that they caused by isolating young families is now being recognised and urging local authorities to look towards low rise buildings as a more favourable solution to their housing problems.

CHAPTER II

HISTORICAL DEVELOPMENT OF GENERAL AND VOCATIONAL EDUCATION

GENERAL EDUCATION FROM THE 11TH TO THE 16TH CENTURIES

The History of Organised Education in Great Britain started with the introduction, by the Church, of grammar and song schools which were normally established at the same time as a new Cathedral was being built. In 1179, Pope Alexander the Third ordered all cathedrals and monasteries to maintain a school. The term "school" referred to the pupils rather than the building and all schoolmasters were in orders as well as being licensed - a system which did not change until the Schools Act of 1369.

Grammar schools which provided the secondary education in the middle ages and song schools usually existed side by side and where this occurred the grammar master was always senior to the song master. A later development was the establishment of song, grammar and reading schools on the same campus. Twelfth century grammar schools became recognised as feeders to the universities and their numbers rapidly increased from the beginning of the thirteenth century. The main subjects taught in the grammar schools at that time were Latin, which was an essential subject for the clergy and learned people of that time, French, elementary logic and rhetoric. However, English replaced French at all grammar schools when the Law Courts discarded the French language in 1362.

The Church held the monopoly of schools from the eleventh to the fourteenth centuries and took action to stop unlicensed schools from operating. Collegiate churches were introduced about the middle of the thirteenth century. The difference between them and the universities of that time was that the collegiate church with its grammar and song schools attached was mainly concerned with religious services, education occupying second place, whereas the universities with their churches attached reversed the order of precedence.

The Black Death 1347-1349 which reduced the population of Britain by one-third also reduced the number of scholars able to teach in grammar schools and was largely responsible for the introduction of the teacher training colleges at Cambridge in 1439.

The Black Death was also responsible for the introduction of the "Statute of Labourers" in 1351 which was introduced to prevent craftsmen exploiting the labour shortage in order to obtain higher wages.

The dissolution of the monasteries by Henry VIII, 1509-1546 which produced a source of money for the erection of grammar schools and universities provided a fresh impetus in the provision of education for the people of this country (albeit for the selected minority).

CRAFT GUILDS, LIVERY COMPANIES AND THE EMERGENCE OF THE CONTRACTOR

As described in Chapter I, the various crafts had united in the form of Guilds which first appeared in the eleventh century.

Medieval master masons and carpenters in charge of buildings could draw rough but workmanlike plans for buildings showing such features as doorways, window openings, stairs and fireplaces.

The difficulties faced by craftsmen in the construction industry when attempting to organise Guilds was also discussed in Chapter I, however, Guilds were formed with three classes of membership; masters, journeyman and apprentices.

Apprenticeship was introduced so that technical training could be provided which would enable craftsmen to qualify in a particular craft. The period of apprenticeship was seven years and wardens of the Guild examined apprentices annually in order to assess the apprentices' progress in the craft.

Each apprenticeship was based upon a contract (indenture) and although the terms varied between crafts and also between different parts of the country, the indentures involved both the master and the apprentice in mutual obligations with the interests of the craft being of paramount importance.

Up until the middle of the sixteenth century the Guilds had exerted a beneficial influence on the living standards of craftsmen. An indication of their sphere of influence can be obtained by examining Guild legislation such as the following:-

1 An enactment of the London Carpenters Guild in 1333 stated that "brothers" with work available must give it to unemployed "brothers" for the usual wage.

2 In 1482 the Guild of Carpenters at York made arrangements for a member to be appointed annually to put unemployed craftsmen in touch with prospective employers.

3 In 1487 the Carpenters Guild introduced legislation which prevented craftsmen from taking legal action against fellow guildsmen without leave of the master and wardens.

4 An agreement between a number of craft Guilds in 1569

stated that each craftsman should confine himself to one craft.

The fifteenth and sixteenth centuries saw the growth of livery companies which were controlled by the employing members of society, whilst the employees were usually confined to the yeoman Guilds. The ceremonial clothing worn at the functions and the fees payable "to be of the livery" made it impossible for craftsmen to be real or active members of their companies. By the beginning of the sixteenth century the more prosperous members of the livery companies were becoming contractors and this was particularly noticeable amongst the masons, where a number of contractors graduated from the "freemason", who was defined as a mason "who can draw his plot, work and set out accordingly, having charge over others".

The standard of workmanship varied as great or even greater in the past than it does at the present time, there was considerable alarm at the way in which buildings were being erected in London after the Great Fire of 1666, to quote one report "all the vaults for want of strength fell in and houses came down most scandalously". This compares very strangely with houses built in Bristol at the beginning of the sixteenth century which had foundations 47 feet deep and with the timber piles provided to support the foundations of the Tower of London in 1324.

ADULT EDUCATION

The movement to educate the adult members of the working class started during the early part of the eighteenth century. The development of a programme to educate the masses was opposed by sections of the population, including members of the Royal Society (a similar attitude prevails today against applied scientists) who believed that education would make the working man dissatisfied and could lead to a revolution. Fears were also expressed concerning the adverse effect that certain literature could have on religious belief, working class morality and the possible rejection of subordination.

It was not until after the Great Exhibition of 1851 had demonstrated the need for the adequate provision of general and vocational education that the prejudices discussed above were seen to be acting against the interests of the country as a whole.

During the first half of the nineteenth century Great Britain had established an industrial and commercial supremacy over all other countries and although some attempt was made to maintain this lead by the development of schools of design in some of our major industrial cities, a comparison of exhibits from the many countries represented at the exhibition indicated that Great Britain was falling behind some of her Continental competitors. At the Paris Exhibition of 1867, British products were, in many cases, classified below those of other countries. The idea of the mechanics institutes originated in Scotland in 1760 following the successful lectures which Professor John Anderson gave to a group of workmen employed on the manufacture of chemistry apparatus for Glasgow University. It is interesting to note that before Professor Anderson gave his lectures he was told by the University authorities that the workmen would not attend the lectures, if they did they would not listen and if they listened they would not understand. Professor Anderson disregarded these warnings and by the fourth meeting the attendance had risen to over five hundred. Professor Anderson's work at Glasgow was largely responsible for the foundation in 1823 of Birkbeck College, which was named after one of the founders who had come to London after having held a professorial position at the Anderson Institute. The mechanics institute fell into decline during the latter half of the nineteenth century, when the attendance of working class members declined and was only partly replaced by middle class attendance. The reasons for the decline in working class attendance can be attributed to political activity and improvements in elementary and scientific education which culminated in the adoption of compulsory education in 1870.

University extension courses were also introduced during the latter half of the nineteenth century and became known as the Workers Education Association at the beginning of the twentieth century.

The City and Guilds Institute was set up in 1880 and was responsible for the establishment of the Finsbury Technical College in 1883 as a model trade school which in turn influenced the development of similar institutions such as the University of Aston in Birmingham which dates back to 1891 when public technical education started at the Birmingham and Midland Institute.

At first courses at the Birmingham and Midland Institute were of a craft nature and in 1895 became the nucleus of the Municipal Technical School. The standard and range of the work developed and the school became the Central Technical College in 1927, the College of Technology in 1951, the College of Advanced Technology in 1956 and finally achieved university status when the charter was granted in 1966.

EDUCATIONAL DEVELOPMENTS FOLLOWING THE 1914-1918 WAR

The Education Act of 1918 planned continuation education for all who left school at the age of 14 years and local authorities had also the legal right to raise the school leaving age to 15 years, but because of the financial problems which the Country faced at that time, the raising of the school leaving age to 15 was not adopted until after the Second World War (1939-1945) and continuation education which had only been adopted in a small number of areas was discontinued in every area except Rugby following resistance from employers. Rugby has continued to enforce continuation education right up to the present time.

The Second World War again emphasised the shortage of technologists and concern was expressed in the "Report on Higher Technical Education"published by HMSO in 1945 about the small degree of contact which existed between the technical colleges and the universities. A committee under the Chairmanship of Lord Eustace Percy made a number of recommendations among which was the need to establish Regional Councils and the development of a number of Colleges of Technology.

REGIONAL ADVISORY COUNCILS

The Percy Committee in their Report on Higher Technological Education recommends that Regional Advisory Councils should be set up to co-ordinate the technological education which was being provided at technical colleges and universities and that local industry should be represented on the Council.

An example of the failure to develop a working relationship between the universities and the technical colleges was given at a conference for educationists in 1968 when the Secretary of a Regional Advisory Council stated that, although universities were represented on the Council, it was accepted that their attendance was ineffective. Universities representatives were unable to discuss developments within their universities and their lack of knowledge of other sectors of education meant that they were unable to make contributions to the general discussions. The same speaker complained that the work of the Advisory Council was often undermined by factors beyond their control. He informed the delegates at the conference that the Regional Advisory Councils were not consulted when building programmes were being prepared and to illustrate the inefficiency which resulted from this lack of consultation he gave the following example:-

"After long discussions at a number of meetings of the Regional Advisory Council it was decided to concentrate advanced hotel catering courses at two centres in his Region. Unknown to the Regional Advisory Council a college had obtained permission to erect a building to provide accommodation for these courses and as a result were placed in a very embarrassing position, because the college concerned was not one of the centres which had been chosen to run the courses. The Council had therefore to alter their previous agreement or alternatively have a building standing practically empty".

The need for the rationalisation of the courses is discussed in Chapters VI and X.

COLLEGES OF TECHNOLOGY

The report of the Percy Committee on Higher Technological Education already mentioned, also recommended that a limited number of colleges should be allowed to develop technological courses of a standard equivalent to those offered by the Universities, and that these Colleges should cater for both part time and full time students.

It was proposed that the Colleges of Technology should offer post graduate courses and also carry out research into subjects of interest to local industry, they should be given a greater degree of responsibility, including self-government and the salaries of teaching staff should be comparable to staff in Universities.

Lord Eustace Percy added a note to the report in which he stated his disagreement to allowing Colleges of Technology awarding a degree. He was concerned about the consequence of such a move and stated that the power to award degrees was the distinguishing mark of a University.

A brief discussion of the present location of Polytechnics and the work of the Council for National Academic Awards (CNAA) is included in Chapter X.

CHAPTER III

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PROFESSIONAL INSTITUTIONS ASSOCIATED WITH THE CONSTRUCTION INDUSTRY

THE COUNCIL OF ENGINEERING INSTITUTIONS

Responsibility for establishing and maintaining minimum educational standards and registering professional engineers is in the hands of the Council of Engineering Institutions (C.E.I.) who were granted a Royal Charter on the 24th September, 1965 following negotiations and discussions which had taken place from October 1962 at meetings of the Engineering Institutions Joint Council.

At the time the Royal Charter was granted there were 13 constituent Institutions:-

The Royal Aeronautical Society
The Institution of Chemical Engineers
The Institution of Civil Engineers
The Institution of Electrical Engineers
The Institution of Electronic and Radio Engineers
The Institution of Gas Engineers
The Institution of Marine Engineers
The Institution of Mechanical Engineers
The Institution of Mining Engineers
The Institution of Mining and Metallurgy
The Institution of Municipal Engineers
The Institution of Production Engineers
The Institution of Structural Engineers

Since the Royal Charter was granted the Royal Institution of Naval Architects has become a constituent member of the Council and an application by the Institution of Heating and Ventilating Engineers for membership is at present being considered.

REGISTRATION AS A CHARTERED ENGINEER

A student who passes the Council's examination or obtains an alternative academic qualification at degree level which is acceptable to the Council and who is made a corporate member of one of the constituent Institutions will be registered by the Council as a Chartered Engineer and will be allowed to use the abbreviation C. Eng.

Final date for registration as Chartered Engineers for those members who do not meet the Council's academic requirements is the 31st December, 1973.

MINIMUM AGE FOR REGISTRATION

C.E.I. regulations restrict registration, to candidates who have satisfied the academic requirements and are not less than 25 years of age.

The minimum age for admission to corporate membership of any of the constituent Institutions is also 25 years with only one exception; the Institution of Electrical Engineers requires candidates to be 26 years of age.

PROFESSIONAL INSTITUTIONS ASSOCIATED WITH THE CONSTRUCTION INDUSTRY

THE INSTITUTION OF CIVIL ENGINEERS

The Institution was founded in 1818 by a group of men whose main interests were in the construction of machinery, but the Institution now covers all branches of engineering.

Thomas Telford became the first President in 1820 and the Royal Charter was granted in 1828.

Civil Engineering is defined as "the art of directing the great sources of power in nature for the use and convenience of man".

Total membership is approximately 34,000.

HISTORY OF EXAMINATIONS

Examinations for corporate membership were first introduced in 1897 and section "C" was added in 1919. A complete revision of the Associate Membership examination was made in 1945.

In 1952 the Associate Membership examination (Section A and B) was renamed (Parts I and II) and Section C became the professional interview.

The graduate class of membership, which had been abolished in 1864 was also re-introduced in 1952.

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The following figures which were supplied by the Institution show the academic background of candidates attaining corporate membership up to 1969:-

	Percentage of all Candidates attaining Corporate Membership
Candidates who have studied part-time and taken the Institution's examinations	7
Candidates who have been exempted from Parts I and II by virtue of qualifications obtained from part-time study	32
Candidates exempted from Parts I and II by virtue of a university degree or other qualifications taken after full-time study	61
TOTAL	100

There is a failure rate for the candidates who enter Part II of the Institution's examination of approximately 84%.

THE INSTITUTION OF CIVIL ENGINEERS

THE FULL-TIME ROUTE LEADING TO CORPORATE MEMBERSHIP

Age	16	17-18	19-20-21	22-23-24	25	26-27-28
	Minimum of 5 GCE "O" levels	2 or 3 GCE "A" levels (normally in pure and applied maths and physics	3 Year Degree in Engineering	3 Years training under agreement with a civil engineer including one year in a civil engineer's office and one year in or upon engineering works		From 1974 all candidates must have passed the CEI examination "The Engineer in Society
	or					
	Minimum of 4 GCO "O" levels or Grade 1 CSE including maths science and an English subject	A good ONC including maths or an OND in Building or Engineering	Attended a 3 year Degree course even if he has not obtained a degree. Must have passed Parts I and II of the CEI examinations	4 years experience on engineering design and/or construction under a civil engineer or 3 years research and 1 year in or upon engineering works or 1 year post graduate study in an engineering college plus three years as an assistant under a civil engineer		Professional Interview The candidate must satisfy the Council that he has acquired adequate practical knowledge of the design and construction of civil engineering works.
	Students with passes in at least three subjects in the "G" course, including maths and one other at credit level and at least a pass in science are admitted to ONC and OND courses		Attended a full-time course for not less than 2 years in an eng. college and passed Parts I and II of CEI exams	Three years training under agreement plus one in the design or construction of eng. works. At least 1 year of the foregoing 4 must have been spent in a civil engineer's office and 1 year must have been spent in or upon eng. works	Minimum age for Corporate membership	FICE (Fellows) Not less than 33 years of age and be in a position of responsibility in the design or execution of important engineering work. Members with a minimum of 5 years experience in positions of responsibility in important engineering work are eligible

THE INSTITUTION OF CIVIL ENGINEERS

THE PART-TIME ROUTE LEADING TO CORPORATE MEMBERSHIP

Age	16 17	18 19	20 21	22 23 24	25 26	27 28
	At least three passes in the "G" course including maths and one other subject at credit level and at least a pass in science	2 GCE "A" levels; an ONC or an OND in engineering with credits.	Part-time course preparing for 6 subjects examination of CEI Part I	Part-time carse preparing for 6 subject examination of CEI Part I.	At least 3 years under agreement under a civil engineer and in addition 3 years experience in the design or construction of eng. work.	**Professional Interview** The candidate must satisfy the Council that he has acquired adequate practical knowledge of the design and construction of civil engineering works
	A minimum of 4 GCE "O" levels or Grade 1 CSE including maths science English	Candidates with very good results at HNC level can be granted exemption from Part I of the CEI examination.		At least 1 year must have been spent in a civil engin. ofice and one year on site. At least 2 of the foregoing 6 years must be after passing Parts I and II of the CEI exams. or 7 years as an assistant under a civil engineer		Minimum age for Corporate Membership

This Table shows the absolute minimum amount of time required to gain Corporate Membership. The majority of candidates could not expect to reach Corporate Membership status in under 2 years longer than shown in this Table.

The pass rate for part "C" is nearly 100%. After 1973 it is expected that about 90% of the candidates for corporate membership will be graduates who have completed a full-time or sandwich degree course.

THE INSTITUTION OF MECHANICAL ENGINEERS

The insistance of the Institution of Civil Engineers that George Stephenson should prove his capacity as an engineer by submitting a probationary essay before they could consider his application for membership and Stephenson's subsequent refusal to do so, were largely responsible for the formation of the Institution of Mechanical Engineers at Birmingham in 1847.

The Institution's headquarters were moved from Birmingham to London in 1877 and have been at their present address in Birdcage Walk since 1899.

The founder President was George Stephenson. The aims of the Institution are to enable "Engineers to meet and correspond and by mutual exchange of ideas respecting improvements in the various branches of Mechanical Science likely to be useful to the world".

The Royal Charter was granted in 1930, an earlier application made in 1878 having been refused.

FIG. 3.3

THE INSTITUTION OF MECHANICAL ENGINEERS

THE ROUTE LEADING TO CORPORATE MEMBERSHIP

Age 16	17 18	19 20 21	22 23 24 25	26
Minimum of 5 GCE "O" levels	2 or 3 GCE "A" levels (normally in pure and applied maths and physics)	3 year full-time degree in engineering	Training and Experience (Duration not specified but a period of 2 years is usually accepted as the minimum requirement.) Candidates must submit a report of between 1000 and 3000 words covering any professional accomplishments and responsibilities, in addition, candidates may be asked to attend an interview	Minimum age for corporate membership Fellows Minimum agee 33 years.
Minimum of 4 GCE "O" levels or grade 1 CSE to include maths; science and English	An ONC or OND of high stan-	4 or 5 years sandwich course leading to a degree		
		Part-time course preparing for 6 subject examination of CEI Part I	Part-time course preparing for 6 subject examination of CEI Part II	
Students with passes in at least 3 subjects in the G course with credits in maths and science are admitted to ONC and OND courses		Minimum amount of time required to pass Parts I and II of the CEI examinations by part-time study.		

The graduate class of membership was introduced in 1850, the Associate Membership in 1893 and the Student Membership in 1922. The designations of M.I.Mech.E.; G.I.Mech.E.; A.I.Mech.E.; and Hon. M.I.Mech.E. were introduced in 1890. Total membership is approximately 64,000.

HISTORY OF EXAMINATIONS

The Graduate and Associate Membership examinations were introduced in 1913 and were revised in 1924, 1935 and 1944.

THE INSTITUTION OF ELECTRICAL ENGINEERS

The Institution was founded in London in 1871 as the Society of Telegraph Engineers and had Charles William Siemans, C.E., F.R.S. as the founder President.

The title was changed in 1880 to the Society of Telegraph Engineers and Electricians and was changed again in 1888 to the Institution of Electrical Engineers.

The headquarters of the Institution have been at Savoy Place since 1910. Meetings of the Institution prior to this date were held at the Institution of Civil Engineers, Great George Street.

FIG 3.4

THE INSTITUION OF ELECTRICAL ENGINEERS

ROUTE LEADING TO CORPORATE MEMBERSHIP

Age	16	17 18	19 20 21	22 23 24 25	26
	5 GCE "O" levels including Maths, Physics, Eng. Lang. & Chemistry	2 or 3 GCE "A" levels including Maths & Physics	University or CNAA degree course in electrical/electronic engineering or physics	Aggregate of further education, training and responsible experience to be not less than 7 years. Must have a minimum of 2 years experience in a responsible position as an electrical engineer in addition to any other approved experience. In cases of doubt candidates are asked to attend an interview. The membership committee interview approximately 30% of the candidates and about 70% of those interviewed are successful.	Minimum age for corporate membership Fellows Minimum age 33 years
	4 GCE "O" levels including Maths, Physics or other app'd science subject & English	A good ONC or OND	CNAA degree. Course usually of 4 or 5 years duration		
			Part-time course preparing for 6 subject examination of CEI Part I	Part-time course preparing for 6 subject examination of CEI Part II	
			This is the minimum amount of time which would be required to pass Parts I and II of the CEI examinations by part-time study.		

The aims of the Institution are to promote the general advancement of electrical science and engineering and their applications. The Royal Charter was granted in 1921. The classes of membership were increased in 1899 to include Associate Members and at the same time the designating letters of A.I.E.E.; A.M.I.E.E. and M.I.E.E. were adopted. The classes of membership were further increased with the introduction of Graduates in 1912 and Companions in 1929. Total membership is approximately 53,000.

HISTORY OF EXAMINATIONS

Examinations for associate membership were introduced in 1912 and the title was changed to the graduateship examinations in 1929. After 1931 honours degrees were accepted as exempting qualifications from the Institution's examinations.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS

The Institution was founded in 1897. In addition to the normal educational and research activities of a professional institution the main objectives are "to promote the science and practice of heating, ventilating, air conditioning, drying, domestic hot water supplies and all branches of engineering kindred thereto".

Under the articles of association which were revised in 1969 the membership shall consist of Honorary Fellows, Fellows, Members, Companions, Associates, Graduates, Licentiates, Students and Affiliates.

The Institution is not a member of the Council of Engineering Institutions although an application for membership has been made. Total membership is approximately 5,000.

HISTORY OF EXAMINATIONS

The Institution has been conducting membership examinations since 1920.

The National College for Heating, Ventilating, Refrigeration and Fan Engineering was established in 1948 and receives financial support from the Department of Education and Science and the Heating and Ventilating Industry.

Because of the small number of students it was impossible to establish satisfactory courses at various centres throughout the Country and the National College was considered to be the only alternative.

APPROXIMATE NUMBER OF STUDENTS EMERGING FROM TRAINING COURSES LEADING TO, OR EXEMPTIONS FROM, THE MEMBERSHIP EXAMINATION (1964 RECORDS)

National College Associateship Course	20
National College Sandwich Course	10
National College Diploma Course	210
National College Evening Course	60
Provincial Courses and Private Study Leading to the I.H.V.E. examinations	75

THE INSTITUTION OF STRUCTURAL ENGINEERS

The Institution was founded in 1908 as "The Concrete Institute" to bring together for discussion and common action persons interested in the study and development of reinforced concrete.

The founder President was the Rt. Hon. The Earl of Plymouth.

The name was changed to "The Institution of Structural Engineers" in 1922 and the interests of the Institution were widened to include engineers who were designing and building in steel.

The Royal Charter was granted to the Institution in 1934.

The total membership is approximately 13,000.

HISTORY OF EXAMINATIONS

The first examinations were held in May, 1920. Since 1926 there has been no exemption from the drawing and design paper of the Corporate Membership examination.

The following figures which were supplied by the Institution of Structural Engineers show the academic background and the success rate of candidates taking the corporate membership examination.

	Percentage of all Candidates	Percentage of Candidates passing the examination
Candidates who have studied, part-time, taking the Institution's examinations to Part II level	17	18
Candidates who have been exempted from Part II by virtue of qualifications obtained after part-time study	55	60
Candidates exempted from Part II by virtue of a university degree or other qualification taken after full-time study	28	22
TOTAL	100	100

It is interesting to note that candidates who have had the benefit of a full-time education have a lower success rate than candidates who have studied part-time. This demonstrates the practical nature of the examination and the failure of university graduates to apply their academic education to practical engineering problems.

THE INSTITUTION OF STRUCTURAL ENGINEERS

THE FULL-TIME ROUTE LEADING TO CORPORATE MEMBERSHIP

Age 16	17 18	19 20 21	22 23 24 25	26 27 28 29
Minimum of 5 GCE "O" levels	2 or 3 GCE "A" levels (normally in Pure and Applied Maths and Physics).	3 year Eng. Degree	**Design Staff** A minimum of 2 years practical experience before entering the Design Practice examination and a minimum of 3 years before election as corporate member.	Minimum age for Corporate Membership (C.Eng. MI Struct.E) (F.I. Struct.E) Fellows - not less than 35 years of age.
OR				
Minimum of 4 GCE "O" levels or Grade 1 CSE including maths, science and an English subject	A good ONC including maths or an OND in Building or Engineering		**Teachers** 1½ years design or construction experience and 3 years teaching in an approved Structural Engineering course. **Research Workers** 1½ years design or construction experience and 3 years research. **Research and Teaching** Not less than 6 years experience in research and teaching.	Elected from members having at least 5 years experience in a position of responsibility for the design and construction of important structural Eng. work. OR Being not less than 45 years of age, elected from members having at least 15 years experience in a position of responsibility for the design and construction of important Struct. Eng. work.
Students with passes in at least 3 subject in the "G" course, including maths and one other at credit level and at least a pass in science are admitted to ONC and OND courses.		4 Year Sandwich Course	Length of practical training the same as for the three year degree course but training obtained during sandwich course included.	

THE INSTITUTION OF STRUCTURAL ENGINEERS

THE FULL-TIME ROUTE LEADING TO CORPORATE MEMBERSHIP

Age	16 17 18	19 20 21	22 23	24 25 26	27 28 29
		Degree Course without structures.	Practical training will probably be longer than for Eng. Degree students and candidates will be required to attend an interview or present a thesis in addition to passing the Design Practice examination.		(No exemption)
				Minimum age for taking Design Practice Examination	

THE INSTITUTION OF STRUCTURAL ENGINEERS

THE PART-TIME ROUTE LEADING TO CORPORATE MEMBERSHIP

Age	16 17	18 19	21 22	22 23 24	25 26	27 28
	At least three passes in the "G" course, including maths, and one other subject at credit level and at least a pass in science.	Two GCE "A" levels; an ONC or OND in engineering with two credits.	Part-time course preparing for six subject examination of CEI Part I	Part-time course preparing for six subject examination of CEI Part II.	Preparing for corporate membership examination.	
	A minimum of 4 GCE "O" levels or grade 1 CSE including maths, science and English	Candidates with very good results at HNC level can be granted exemption from Part I of the CEI examination.			Minimum age for corporate membership.	
				Minimum age for taking corporate membership examination. (No exemptions.)		

This table shows the absolute minimum amount of time required to gain corporate membership. The majority of candidates could not expect to reach corporate membership status in under two years longer than shown in this table.

After 1973 it is expected that about 90% of the successful candidates for corporate membership will be graduates who have completed a full-time or sandwich degree course.

THE ROYAL INSTITUTION OF CHARTERED SURVEYORS

The Institution was founded in June 1868 and was incorporated by Royal Charter in 1881.

THE EXAMINATION

The professional examinations of the Institution are divided into the following Sections:-

General Section (Valuation; Housing Management; Town and Country Planning; Building Surveying)

Agriculture and Land Agency Section

Quantity Surveying Section

Mining Surveying Section

Land Surveying Section (including hydrographic surveying)

With the exception of the Quantity Surveying Section the examinations consist of the following:-

Intermediate Examination

The Final Examination

OR

Direct Membership Examination

In the Quantity Surveying Section the examinations are:-

The Intermediate Examination

The Final Examination Part I

The Final Examination Part II

OR

The Direct Membership Examination

EXEMPTIONS

Certain University Degrees and College Diplomas give either partial or complete exemption from the Institution's Examinations. Minimum age for associate membership is 21.

PERIOD OF PRACTICAL TRAINING

Two years approved practical experience required after graduation (4 years in the case of degrees obtained externally) before the candidate can be elected to membership.

Four years approved training required for candidates who take the external examinations of the Institution - 5 years for the Quantity Surveying Section.

RICS EXAMINATION STATISTICS

	1966		1967	
	Sat	Passed	Sat	Passed
Final Quantity Surveying				
Part I	364	148	736	292
Part IA	534	170	339	141
Part I and IA re-examination in single subjects	68	39	100	52
Final Part II	547	150	744	266
Total	1613	507	1919	751
Final Agricultural and Land Agency				
Parts I and II	28	5	28	7
Part II (Practical)	63	43	66	35
Part II (Written)	75	31	98	39
General	440	214	713	326
Mining Surveying	22	16	26	10
Land Surveying (Full Examination)	30	12	37	14
Land Surveying (written papers only)	55	19	51	19
Land Surveying (Thesis and/or Task)	19	13	13	10
Valuation	144	18	-	-
Housing Management	1	-	-	-
Town and Country Planning	11	2	-	-
Building Surveying	76	44	-	-
Final (Re-examination in Typical and/or Single Subjects				
Agriculture and Land Agency	17	10	11	6
General Section	-	-	8	8
Valuation	93	31	117	34
Town and Country Planning	44	4	4	2
Building Surveying	14	8	6	5
Quantity Surveying Section	85	25	47	30
Mining Surveying	5	3	3	-
Total	1182	498	1228	545
Direct Membership				
Agriculture and Land Agency	4	2	5	2
General	25	8	60	17
Quantity Surveying	19	3	37	8
Mining Surveying	2	-	1	1
Land Surveying	16	8	24	15
Building Surveying	31	11	-	-
Valuation	7	1	-	-
Housing Management	1	1	-	-
Town and Country Planning	2	2	-	-
Total	107	36	127	43

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS

The Royal Institute of British Architects (R.I.B.A.) was founded in 1834 and the present membership of 22,000, accounts for the majority of registered architects in the United Kingdom.

The Architects Registration Acts of 1931 to 1938 made it an offence for any person to practice or carry on business under any name, style or title containing the word "Architect" unless he has been registered with the Architects Registration Council of the United Kingdom.

There are three routes open for candidates to membership of the R.I.B.A.:-

1 By attending a full-time or sandwich course at a school of architecture recognised by the R.I.B.A. There are at present 32 recognised schools in the United Kingdom and one in Eire, the duration of the courses at the above schools vary from 5 years for full-time courses to 6 years for sandwich courses.

2 By attendance at one of the "listed" or "Facility" schools.

The listed schools are those which are granted the freedom to submit school work in lieu of testimonies of study laid down by the R.I.B.A.

Students from both the listed and facility schools must sit the external examinations of the R.I.B.A.

3 The door via the part-time route is still open but the number of architects who acquire professional status via this route is now very small.

COURSES AT RECOGNISED SCHOOLS OF ARCHITECTURE

There are variations between the courses offered at these schools but the general tendency is to divide full-time courses into two parts. The first part, normally of three years' duration, provides a broad educational background to architecture, whilst the second part of two years duration is usually more specialist. Most University Schools of Architecture award a first degree at the end of 3 years and a Diploma or a Master's Degree, which gives exemption from the R.I.B.A. final examination, at the end of the fifth year.

PRACTICAL TRAINING

Before a student can qualify as an architect he must obtain a minimum of two years practical experience, one of which must be in an architectural office, but the other year can be spent with a contractor or on some other relevant work. One of the two years is normally taken between the 3rd and 4th academic years, but the other year must be taken after the student has passed the final examination.

QUALIFICATIONS

Student architects who have fulfilled the above requirements and in addition passed the R.I.B.A. examination in Professional Practice and Procedure can apply for election as an Associate of the R.I.B.A. (his professional qualification) and be registered with the Architects Registration Council of the United Kingdom (A.R.C.U.K.).

Fellowship of the R.I.B.A. is awarded to an architect who, after a minimum of 7 years' experience as an Associate has reached a certain standard of achievement in the field of architecture.

Licentiates of the R.I.B.A. are architects who have had no formal architectural education, but have been engaged in the profession. The R.I.B.A. has not accepted fresh entrants to this class of membership for a number of years.

OTHER INSTITUTIONS

	Founded
I.O.B.	
I.Q.S.	1938
Institution of Sanitary Engineers	1895
Incorporated British Institute of Certified Carpenters	1890
Incorporated Institute of British Decorators	1899

CHAPTER IV

CHAPTER IV

THE VIEWS OF THE GRADUATE EMPLOYER

As the employer usually has the last word in the overall assessment of a student's potential, it follows that the employer's opinion will influence to some extent future trends in higher education. This educational development will place certain demands on the actual building and will also effect the ability of the construction team to provide the buildings required. Therefore, a survey was carried out in the London area during 1969 in order to obtain the employer's opinion of the type of education being provided for future members of the building team and also to determine what type of relationship existed between employers and educationists.

The results of the survey, which follows, are given in six sections:

> Architecture; Civil and Structural Engineering; Surveying; Mechanical, Electrical and Services Engineering; Building Management; and finally a precis of the Noel Hall Report on joint education.

ARCHITECTURE

Fourteen employers were contacted twelve of whom had graduate training schemes, although some of the schemes were very close to the "deep end" approach. Architectural firms which did not employ recently qualified students gave the following answers to my questions:-

"The firm is not departmentalised which restricts the operation of a training scheme".

"The salaries asked by graduate architects are too high".

"Graduate architects cannot draw and have poor practical knowledge".

"We prefer our employees to study part-time and obtain technician qualifications".

SUMMARY OF COMMENTS FROM EMPLOYERS OF GRADUATE ARCHITECTS

A number of firms complained about the standard of draughtsmanship, but this was countered by others who considered that architects who were most concerned about the quality of draughtsmanship were the products of pre-war training, who had spent many hours copying details of classical architecture. Never-the-less the firms with the most established post-graduate training schemes paid particular attention to draughtsmanship generally and the ability to produce production drawings in particular.

RELATIONSHIP BETWEEN ARCHITECTURAL SCHOOLS AND EMPLOYERS

The majority of firms have developed a preference for students from certain schools and what is more important there is very good agreement between firms about the quality of students from particular schools. This preference is based upon the past record of the school and the firm's experience with previous employees and plays a very important part in the particular firm's recruitment policy. In this context it may be surprising that most firms considered that the closure of the part-time route was a very unfortunate move.

Some of the larger organisations had developed a very close relationship with particular schools and staff from the schools visited the students during their industrial training period, but other firms complained that schools were becoming increasingly isolationist.

Architects were of the opinion that students were being prepared to start practices on their own account in provincial areas rather than filling responsible positions in a large organisation.

THE TRAINING POLICY OF THE EMPLOYER

There was an interesting difference of opinion between firms, which reflected the type of post-graduate training which was being provided.

Some firms complained that graduate architects were too impatient in their quest to do creative work and to undertake a high level of responsibility. These were the firms who also experienced up to 80% turnover of graduate staff in the first year of employment. In many of these firms a graduate architect can be expected to be employed for two years before being given any degree of responsibility. The member of staff responsible for training of one of these firms informed me that the training programme in his firm was effected by the partners being very cost-conscious and therefore small jobs could not always be entrusted to the young graduate.

The experience of the firms discussed in the previous paragraphs contrast markedly with organisations such as the

Greater London Council and the Building Design Partnership who have developed detailed training programmes which seem to include the best features of all the training schemes studied, where the interest of the Graduate and the Profession seem to be paramount. Detailed discussion of these training programmes is beyond the scope of this thesis but a close examination of the objectives provide food for thought for both industrialists and educationists alike.

THE INNER LONDON EDUCATION AUTHORITY OF THE G.L.C.

The I.L.E.A. programme is responsible for providing training at any one time for approximately 270 members of staff either on part-time courses or some other form of sponsored training. This is in addition to the training provided for up to 45 students and graduate architects described hereafter.

The architectural services of the I.L.E.A. are provided by 45 groups, each group having a normal complement of 12 architects. All group leaders are nominated student supervisors and are instructed to examine the students' log books each week. There is usually one student attached to each group, although students are given experience in various groups in order to broaden their experience. Students participate fully in all the group's activities to which they are attached and are encouraged to meet and discuss problems with other members of the construction team. An attempt is made to provide a feed-back to the various schools, by encouraging the students receiving practical training at intermediate level to discuss amongst themselves, the type of course and syllabus content of the various schools of architecture.

In addition to internal courses organised by the Greater London Council all student architects are allowed one month's paid leave during the first year of employment in order to attend specialist courses and qualified staff are released on a part-time day basis to attend advanced courses. There is also a scheme whereby up to four professional members of staff are granted one year's paid leave in order to attend post-graduate courses, on the one condition that they remain with the Greater London Council for two years after completing the course.

A large percentage of the students who are employed by the Greater London Council at intermediate level apply to return at the end of their academic training and this, together with the appointment of a senior architect as liaison officer with every school of architecture, has resulted in the position in which there are always more applicants than vacancies and advertising has become unnecessary.

THE BUILDING DESIGN PARTNERSHIP

The training programme operated by the Building Design Partnership has as its nucleus a scheme in which small commissions are taken specifically to allow graduate architects to obtain practical experience. The young architect on receiving his project is introduced to the cleint and the quantity surveyor and is allowed to operate in the same capacity as a more senior architect would do, the only difference being the size of the respective jobs. The client is informed that his particular item of work is being handled by a newly qualified architect, but as a number of clients have returned with similar commissions the justification of the scheme is verified.

Each student architect is linked to an associate within the firm rather than to a partner in order to avoid any uneasiness which might be experienced by the student if he had to approach a more senior member of the firm. In addition one associate is appointed to supervise the training for all professions.

SPECIFIC CRITICISMS OF ACADEMIC TRAINING

A number of firms complained that the attitude of some of the student architects was unacceptable and blamed the schools for not providing the undergraduate with a greater sense of professional pride. It was stated on a number of occasions, that students seemed to have been given the impression that it would be a privilege for a firm to employ them, but contrary to many students belief, their knowledge of professional practice was poor, they had not been taught to examine architectural problems correctly, their knowledge of materials was poor and the exercises carried out at the schools seemed to have ignored the cost element.

THE STUDENT'S OPINION

Four recently qualified architects were interviewed in order to obtain their impressions of the undergraduate education and training they had received, and to make an assessment of how their academic training had prepared them for a professional career.

All four architects (from different schools) complained that they had not been given sufficient careers guidance during their academic training and one architect had decided to work as a "contract" architect in order to explore the possibilities open to him. They all agreed that structural engineering was a major weakness and said it was due to the classical approach adopted by the lecturers. Other points were raised concerning the inadequate preparation in Building Technology, a wish for a greater amount of formal lectures and more guidance from the lecturers, but the four architects concerned were not unanimous on these points.

Their reaction towards their employment varied from complete satisfaction, with the promise of a very interesting career ahead to complete frustration and the comment "If I stay with this firm I will be 30 or 40 years of age before I get any degree of responsibility".

THE PART-TIME ROUTE

The part-time route to professional membership of the R.I.B.A. is virtually closed, but there is still considerable support for this method of study amongst architects generally. A number of firms were very enthusiastic in their support for the part-time route to technician status, although some firms stated that it was very difficult to get technicians to leave the provinces and travel into London.

MULTI-PROFESSIONAL TEAMS

Architects generally were in favour of multi-professional teams and advocated multi-professional training in undergraduate courses so as to remove the problems associated with the absence of a common language.

THE OPINION OF OTHER PREFESSIONS

The main criticism came from structural and civil engineers who felt that architects had very little structural appreciation which often caused unnecessary structural problems. Both student architects and engineers saw, as a solution to this problem, a teaching approach based upon the use of medels, photo-elastic work and other visual aids in place of what was described as a "classical approach". There was general agreement among the professions that the R.I.B.A. log book system of recording students' progress and experience should be adopted by the other professions.

CIVIL AND STRUCTURAL ENGINEERS

GRADUATE TRAINING SCHEMES

The post graduate training schemes operated by the participants of the survey varied from detailed schedules or work experience, including active participation by the firm in the preparation of the graduate for co-operate membership of the Institution of Civil or Structural Engineers down to the "thrown-in at the deep end" approach.

The type of training offered is dependant, to a large extent, upon whether the graduate is employed by a consultant or a contractor and therefore the schemes operated by George Wimpey & Co. Ltd. and Ove Arup & Partners have been chosen to illustrate two such training programmes.

GEORGE WIMPEY & CO. LTD.

This firm operates training schemes for the graduate and

"A" level school leaver. All graduates are indentured to Doctor W MacGreggor and follow a well defined but flexible programme which includes:-

(a) an introductory site engineering course of three weeks' duration;

(b) one year on site obtaining experience in setting out, supervision of construction, measurement and costing;

(c) one year in the London design office obtaining design experience and preparing working drawings, which can be presented at the professional interview of the Institution of Civil Engineers;

(d) a short residential design course at the Cement & Concrete Association;

(e) a short period at the Central Laboratory working in the soil mechanics, hydraulic models and concrete technology sections.

The training scheme for "A" level school leavers is designed around a 5 year industry based sandwich degree course at the City University and industrial experience is provided on construction sites, in design offices, at the Central Laboratory and in the administrative and service departments.

OVE ARUP GRADUATE TRAINING SCHEME

Graduates join the firm from September onwards at two weekly intervals via a graduate training school. The course lasts for about 2 months and there are up to 22 graduates attending the school at any one time.

During the course each graduate completes a small project which includes analysis, drawing, quantities and a bar bending schedule.

After the training period has been completed graduates become junior members of a project team.

THE PART-TIME ROUTE

Only four of the eleven structural and civil engineering employers contacted stated a preference for part-time education although there is a very high percentage which fully support sandwich degree courses. One firm which supports part-time education has instituted a scheme whereby employees are allowed to attend a sandwich degree course after having successfully completed a course leading to the ordinary National Certificate in Construction (Structures).

UNDERGRADUATE EDUCATION

Drawing which is generally accepted as the language of the engineer, is considered by nearly all employers, to be the main weakness in undergraduate education. Opinion is divided between employers who advocate a basic grounding in structural design and detailing and those who consider graduates should be taught basic principles only and that it is both unnecessary and undesirable for universities to teach design practice or drawing conventions.

Engineering employers agreed that the graduates knowledge of building construction, building science and building materials was generally very weak, but opinion was again equally divided between those who considered a good knowledge of these subjects to be necessary and those who considered it to be unnecessary.

A number of employers stressed the importance of multi-discipline teaching in order to achieve a better understanding between the professions, and subjects such as economics, town planning, elements of management and sociology were suggested as useful topics for multi-discipline study groups.

THE OPINION OF THE ARCHITECT

Architects were generally of the opinion that engineers were too narrow in their approach to building problems and that an introduction to aesthetics in an undergraduate course would lead to a better understanding between the architect and engineer.

SURVEYORS

GRADUATE TRAINING SCHEMES

The percentage of graduate surveyors employed by the Construction Industry is still very small although there are indications of a marked increase in the proportion of graduate to non-graduates among new recruits.

Employers are still a little suspicious of the education and training provided at the new universities and polytechnics but those who have interviewed or employed graduate surveyors are generally very impressed. Eleven firms were contacted, three of which had graduate training schemes. The training schemes developed by British Rail and George Wimpey & Co. Ltd. provide the trainee with a detailed programme of industrial experience whilst the third scheme developed by a private practice was tailored to individual requirements.

BRITISH RAIL - ESTATE MANAGEMENT TRAINING SCHEME

Entrants are encouraged to take the Royal Institution of Chartered Surveyors examination and are required to take the optional subject "Estate Management", although there are opportunities for a small number of potential Building Surveyors taking Building Construction.

The scheme is designed to admit candidates at various levels of academic achievement and caters principally for:

(a) school-leavers who possess the necessary qualifications for acceptance as student-members of the R.I.C.S.:

(b) university graduates with degrees in appropriate subjects, recognised diploma holders and others who have passed acceptable professional examinations based on full-time or sandwich higher education;

(c) students studying for acceptable professional examinations by sandwich courses.

The training scheme is arranged in two stages. Stage one is for school-leavers and for those who have not yet obtained two years' practical experience combined with a pass in the R.I.C.S. first examination.

Stage two is for students who have completed their theoretical qualifications but still lack practical training and experience, or are at intermediate level in their professional qualifications, ie have obtained two years' practical experience and have also passed the R.I.C.S. first examination.

STAGE 2 TRAINING AND EDUCATION

This training period which may be up to 3 years' duration is flexible and depends upon examination progress and on the ability of the trainee to assimilate the training and experience he receives. During the training period, trainees are required to submit periodical reports to Regional Surveyors and are interviewed twice yearly by a Regional Training Committee.

Trainees work as assistants to, and under the direction of, qualified senior surveyors who are personally responsible to the Head of Department for each period of training, which is designed to cover every aspect of the Estate Department's work. Trainees may be required to spend part of their training period in offices located away from their home towns and are expected to undertake private study in order to pass any additional examinations necessary to qualify for Co-operative Membership of the R.I.C.S. but day release is normally given where approved courses are available.

GEORGE WIMPEY & CO. LTD.

Trainees attend either a 2:1:1 or a 4 year thin sandwich course at Heriot-Watt University, University of Aston in Birmingham, Liverpool College of Building or Nottingham Regional Technical College.

Practical training which includes office procedures, building construction, taking off, processing dimensions, measurements, valuations, preparation of interim certificates and final accounts, takes place either at Head Office or Regional offices, and on building sites.

THE PART-TIME ROUTE

The part-time route is still the most common route to professional membership although there is a tendency for employers to look towards the sandwich courses for future recruitment. One indication of the number of surveyors at present studying by correspondence courses and evening classes was given by a representative of a firm of surveyors, who said that although they had released only 12 employees to attend part-time day courses at all levels, 30 members of staff had taken the final R.I.C.S. examination in 1969.

MULTI-PROFESSIONAL TEAMS

The role of the quantity surveyor becomes more diverse where multi-discipline teams operate and this diversity is reflected in the training given to trainee surveyors.

FUTURE EDUCATIONAL POLICY

I was informed that it was not the intention of the R.I.C.S. to draw up a list of approved training officers and that the R.I.C.S. future scheme would probably lie somewhere between the index of offices adopted by the R.I.B.A. and the present

R.I.C.S. insistence that all training should be under the supervision of a chartered surveyor.

THE OPINION OF THE OTHER PROFESSIONS

Surveyors are generally considered to be good business men, the main criticisms being that they do not have a very practical outlook and their knowledge of building technology is often very weak.

MECHANICAL, ELECTRICAL AND SERVICES ENGINEERS

GRADUATE TRAINING SCHEMES

Only 2 firms (British Rail and George Wimpey & Co. Ltd.) out of the 9 contacted were operating recognised graduate training schemes.

The British Rail graduate training schemes are for mechanical and electrical engineers who will be employed on locomotive and associated work, whilst the "Wimpey" schemes are for "A" level school-leavers who wish to enter the electrical or mechanical engineering professions and includes attendance at the City University, London, on a 5 year sandwich degree course.

The student follows a programme of industrial training composed of periods in the workshop, site and the design office and although this experience is slanted towards construction techniques rather than production engineering, employment is mainly on composite projects in the oil, chemical, steel, coal, power generation and process industries.

One other firm who have not previously taken part in any graduate training scheme intend to sponsor a student on a sandwich degree course at the National College from September 1969.

The majority of firms contacted stated that the question of employment of graduate staff had not arisen and only one firm considered that they were unable to provide the experience to allow an employee to become professionally qualified.

Except for employees of the two firms with graduate training schemes and a small percentage of engineers who had attended H.N.D. courses, the part-time route is still <u>the</u> recognised form of study for employees in this sector of the industry.

THE PART-TIME ROUTE

There is a marked preference among employers towards engineers who have obtained qualifications after following a course of part-time study. The argument which is continually repeated is that the part-time student has a "down to earth" approach which is developed as a result of experience at all levels within the firm and in addition he must have certain personal qualities such as determination and perseverance which are <u>not necessarily</u> found in the engineer who has qualified after completing a course of full-time education.

The changing educational opportunities is always overlooked by the proponents of this line of argument.

MULTI-PROFESSIONAL TEAMS

Two out of the 9 firms had experimented with multi-professional teams, which had proved to be successful in one firm and a failure in the other. I consider that the results of the experiment were largely due to the different attitudes adopted by the firms towards technician staff and services engineers.

The firm where multi-discipline teams are successful, consider technician staff uneconomic and dangerous, because of the tendency for other professions to be unaware of individual qualifications. Service engineers and surveyors are the only professions employing staff who are studying on a part-time basis. There is also a very keen competitive spirit between staff of the same profession.

The firm which has returned to individual professional groupings after having abandoned the multi-professional team approach, claims that the reason for failure was due to the large number of technician staff which accompanied the civil and structural engineers and that this together with the technician level of the services engineer caused an atmosphere of incompatability due to the different personal interests.

In this firm, it is also openly accepted that the services engineer is the poor relation in the building team and that their intellectual capacity falls below that of the other members of the building professions with only occasional peaks.

THE OPINION OF THE ARCHITECT

Architects are of the opinion that a great amount of trouble is caused on site by services engineers, due to the lack of planning and insufficient detailing.

There is a feeling amongst architects that whilst they try to understand the problems of the services engineer, the absence, or low level of professional training, does not allow the services engineer to appreciate the problems of the other members of the building design team.

BUILDING MANAGEMENT

George Wimpey & Co. Ltd. was the only firm contacted who had a definite interest in building graduates, but this could be due to the restricted nature of the survey. George Wimpey & Co. Ltd. operate schemes for the "A" level entrant, graduates and Higher National Diploma students. Graduates are offered a two year indenture to cover practical training during which time they are given experience in all the specialist departments within the firm. The "A" level entrant attends a sandwich course leading to a degree at the University of Aston in Birmingham, Heriot-Watt, Manchester or Lanchester OR a Higher National Diploma course at one of the selected Colleges of Technology.

Experience within the firm follows a similar pattern as for the graduate, but indentures are for three years and students attend an "in-company" site engineering course where instruction is given on the use of surveying instruments, calculation of quantities, abstracting and billing.

Students in both schemes are encouraged to study for the Associate Membership of the Institute of Building.

THE PART-TIME ROUTE

This is still the most common route for students training for positions in site management, but there are indications that the more senior positions in future will be filled by the graduate. Students following the part-time route obtain either the Technician's Certificate or the Ordinary and Higher National Certificate before proceeding to membership of the Institute of Building.

JOINT COMMITTEE ON TRAINING IN THE BUILDING INDUSTRY

The Committee which was under the chairmanship of Sir Noel Hall, M.A., Ll.D., was composed of representatives from the R.I.B.A., R.I.C.S., I.Struct.E., the Board of Building Education and an H.M.I.

INTRODUCTION

The R.I.B.A., R.I.C.S., I.O.B. and the I.Struct.E., first met in 1961 and made the following recommendations:-

(i) Joint education and training at the pre-qualification level was best left to experts.

(ii) A Joint Committee having powers to co-opt and with an independant chairman should be established composed of representatives from the R.I.B.A., Board of Building Education, R.I.C.S. and I.Struct.E.

(iii) Training to be considered:-

- (a) Courses with options to produce a man of common usefulness in architecture and building.
- (b) The secondment of trainees to other disciplines.
- (c) Joint training at undergraduate level.

Because the courses which prepare students to enter the building industry include education and training, it was decided to adopt the term "training" to cover both these functions throughout the report.

The Committee decided to make only brief recommendations on (a) and (b) and to concentrate on (c).

THE COMMITTEE'S WORK

The Committee

(a) Studied the syllabuses and entrance requirements for membership of the professional institutions.

(b) Prepared minimum common syllabuses for certain subjects.

(c) Examined the present joint training activities and the availability of post-graduate and advanced courses.

THE COMMITTEE'S RECOMMENDATIONS

(a) Courses should, where possible, be in the same educational establishment and within the same faculty.

(b) Teaching and examining should express the strong common subject content relevant to the syllabuses of the four institutions.

(c) The institutions should encourage joint training experiments and the minimum common syllabuses prepared by the Committee should be implemented on a permissive basis.

(d) The common element in the syllabuses of the four institutions and the inter-relationship between the goals of each of these institutions should be emphasized.

(e) Encouragement should be given for trainees to gain experience in other disciplines on secondment.

(f) The four institutions should maintain an advisory body to assist and encourage the development of joint education at all levels and invite other interested parties to join.

THE COMMITTEE'S GENERAL VIEWS ON TRAINING FOR THE BUILDING INDUSTRY

A FRESH APPROACH TO TRAINING

The necessary influence of the professional institutions will only be fully effective when the service industry is represented by one institution.

FUTURE ENTRANTS TO THE INDUSTRY

The present trend for students to study by full-time rather than part-time courses will provide new opportunities for joint education. The requirements can be met most effectively if the various members of the building team are taught against a unified intellectual background.

INTERMEDIATE POSSIBILITIES

Training should emphasise the common elements in each of the four institutions and provide an awareness of each others duties and responsibilities which are at present, concealed by differences in terminology.

INVESTIGATION OF SYLLABUSES

In an attempt to emphasize the common element, Working Parties prepared common syllabuses for the following subjects which seemed to satisfy the requirements of all four institutions:-

Building Technology

Theory of Structures

Economics, Law and Management

History

THE USE OF THE MINIMUM COMMON SYLLABUSES

The syllabuses prepared by the Working Parties are recommended to the Institutions for inclusion in the first phase of training as a useful basis upon which schemes can be developed.

THE PURPOSE OF TRAINING

The detailed syllabuses which are necessary in order to communicate the particular institutions requirements may obscure the common element; the unity and the individual contributions from each discipline should therefore be emphasized.

JOINT TEACHING

Joint teaching involves lecturing to large multi-discipline audiences and it would therefore be necessary to include single and multi-discipline tutorials and seminars in the course programme. Collaboration of teaching staff would influence the outlook and interests of the students and where it was not possible, the students should be informed of the functions and responsibilities of members in other disciplines.

LOCATION OF COURSES

Courses should be held in the same establishment and where possible in the same faculty. Account should be taken of the interests of other disciplines when the location of new courses are being considered.

JOINT TRAINING AT LATER STAGES

After the preliminary stage, joint training will have to be of a less direct method and arranged so that the requirements of each institution is catered for, even so, the work in the initial part of the course will allow for the development in the later stages.

POST GRADUATE WORK

An enquiry revealed that there was very little co-ordination between industry and educationists and that none of the courses provided any substantial contribution to training needs. The four constitute members should encourage joint projects at post-graduate level and at the same time provide guidance which will ensure that the needs of industry are given priority. Joint projects at this level could encourage co-operation at lower levels and at the same time improve the co-operation between industry and educationists.

CONCLUSIONS

MINIMUM COMMON SYLLABUSES

Joint training experiments should be encouraged and the unity of the four institutions should be emphasized. The institutions should adopt the common syllabuses prepared by the Committee and should help educationists by developing training manuals providing guidance on examination and subject requirements. The Committee's findings should also apply to part-time education.

SECONDMENT OF TRAINEES

Pilot schemes for the secondment of architectural students to other disciplines were introduced between 1962 and 1964 by the R.I.B.A. and proved to be very successful. The Committee recommends that the other constituent bodies should develop similar training schemes to allow students to gain experience of other disciplines early in their careers.

MAN OF COMMON USEFULNESS

Common usefulness at present, normally comes after one discipline has been mastered, therefore, emphasis should be placed on improving the quality of training in each specialism.

A new degree course could be devised which would include the basic knowledge of the four disciplines and the common syllabuses prepared by the Committee. This new course could then be followed by a specialist course.

PROPOSAL FOR PERMANENT ADVISORY BODY

This body could emphasize the common element in the syllabuses, develop training courses up to post-graduate level and explore common ground between the four constituent bodies.

MINIMUM COMMON SYLLABUSES

The aim of the syllabuses is to allow for the study of fundamentals and to provide a base for the development of specialist study.

AN EXAMPLE OF JOINT TRAINING

The first and final years of an under-graduate course seems to be the most critical. Students should be made aware of the work of other specialists from the early stages of their course and should appreciate the social responsibilities of the building team. Building economics and the effective use of land, labour and materials should be developed in all four disciplines at an introductory stage.

Specialist work should follow the introductory stage but students should be kept informed of the significance of the work being carried out by the other three disciplines, considerable teaching skill will be necessary to avoid irritation caused by interrupting specialist work for items which may seem to be irrelevant. More involved joint projects should be introduced in the later stages of the course which could be illustrated by lectures and would continue up to graduation. The attitude of minds could be further developed by planned involvement with other disciplines after graduation.

SURVEY OF PRESENT JOINT TRAINING ARRANGEMENT: SUMMARY

Replies indicated that each college had devised joint training schemes in order to meet their own particular needs and attitudes. The reasons given for the existence of these schemes were, a belief in joint training, a wish to produce students of wider usefulness, a more active atmosphere and the need to produce viable groups where student numbers were small. The courses operating, varied from craft to post-graduate level and ranged from completely combined classes down to informal activities only.

SOME OBSTACLES TO JOINT TRAINING

The reluctance of some educational authorities to support experimental courses, attitudes of educationists, professional prejudices, differences in syllabuses, the distance between colleges and the lack of guidance were considered to be the main obstacles to joint training.

It was suggested that joint training could be developed by using the National Diploma and National Certificate courses and including recognition of the ordinary National Diploma as a professional entry qualification.

SURVEY OF POST-GRADUATE AND POST-H.N.C. COURSES

A high percentage of courses offered at this level involved structural engineering although courses were offered in architecture, building, law, quantity surveying, town planning and traffic engineering.

PERSONAL VIEWS

There can be no doubt that if each member of the building team had a greater appreciation of the duties and responsibilities of the other members of the team that the resultant efficiency would be reflected in the overall economy of the project.

This report outlines some of the obstacles which have to be overcome if joint training schemes are to be developed. In addition to those mentioned in this report there are two further obstacles:-

(a) The tendency for individuals to be more concerned with status and the narrow interests of their own particular discipline rather than the overall interest of training, or of the industry.

(b) Heads of Department and senior members of staff who promote the interests of their own Departments to such an extent that they develop an "inward looking" attitude which counteracts the efforts made by those trying to develop joint training.

The O.N.C. is now accepted as an entry qualification to building and engineering degree courses.

CHAPTER V

CHAPTER V

A BRIEF HISTORY OF THE DEVELOPMENT OF BUILDINGS ASSOCIATED WITH EDUCATION

The development of educational building is presented in three sections.

1 A study of the buildings erected for the Colleges and University of Cambridge.

2 The problems associated with the development of Warwick University.

3 The development of educational establishments providing tuition below university level.

1 A STUDY OF THE BUILDINGS ERECTED FOR THE COLLEGES AND UNIVERSITY OF CAMBRIDGE

The first European universities were in Italy. However by the twelfth century Paris had become the intellectual centre of Europe and it was from there that a migration of scholars to Oxford occurred in the year 1167. This was followed by a similar migration from Oxford to Cambridge in 1209 although it is not known whether the Oxford migrants went to join an existing body of scholars in Cambridge, or if the Oxford migrants were responsible for the introduction of an educational establishment at Cambridge.

Oxford and Cambridge were the only two universities in England and Wales until 1825 and it is therefore only from these establishments that a historical study of university buildings in this country is possible.

CAMBRIDGE UNIVERSITY

This section has been devoted to a study of the buildings erected for the Colleges and University of Cambridge because of the open gate policy adopted by all the Colleges of Cambridge, which allowed me to visit all the buildings discussed in this section and also because of the relative absence of any effects of industrial development. One of the important factors which appears as a result of studying the functions of particular buildings is that most of the early colleges have been subject to structural and architectural alterations; window sizes have been altered, buildings have been refaced with ashlar, entrances to colleges have been modified, the functions of rooms and even buildings have been changed.

The changes which these buildings have undergone highlight the need for new educational buildings to be constructed with flexibility in mind.

Another important factor is the way in which the buildings reflect not only the architectural style of the era in which they were constructed but also express the character of the architect, the master craftsman and the particular benefactor to a much greater extent than would be evident in present day buildings.

COLLEGE BUILDING

At first colleges were built to provide residential accommodation for lecturers only and students had to obtain lodgings in private houses. It was because of the ever increasing cost of this private accommodation that students tried to solve their own residential problems by organising "hospita" and it was not until the middle of the fourteenth century when the movement to house students in colleges was started that the "hospita" becam unnecessary. The magnitude of the problem resulting from increased charges for private accommodation is illustrated by the fact that Henry III issued a writ in which he directed two masters of the University in association with two townsmen to make fair assessments of rents charged by all hostels where scholars lived "according to the custom of the University".

The hostels of that time were boarding houses, often established by individual masters, except for two properties given to the University by Roger de Haydon before 1279, one of which occupied the site upon which Pembroke College now stands and the other stood on the site of the present chapel of Corpus Christi College.

The transfer of students from hostels to colleges was noted by Dr Cauis when comparing the situation which had existed in the early 1530's to that which he found some thirty years later. Of the eighteen hostels which had been operating in the 1530's most of them had become deserted and given back to the townsmen, except for a few which had been merged in colleges.

Peterhouse, which was founded in 1284 and which developed from a community of scholars established in Cambridge by Hugh of Balsam, Bishop of Ely was the first college to provide residential accommodation for students studying in Cambridge, which helps to demonstrate the predominant role that the religious orders played in the early life of the universities.

From that time on the increased number of undergraduates attending university made it necessary to provide sets of rooms for student accommodation, and colleges were forced to use improvised buildings in order to meet these residential requirements, examples being:

Corpus Christi in 1569
St John's in 1584 and 1589
Gonville & Cauis in 1594
Christs in 1613

By the end of the sixteenth century, colleges were starting to erect buildings specifically for undergraduate accommodation.

The student population almost doubled between 1550 and 1580, which resulted in increased building activity on the part of the colleges between the years 1562 and 1640. Figures compiled by J A venn show that the number of matriculated students at Oxford and Cambridge for the year 1600 was 305 and 265 respectively and although there was a slight increase from 1600 to 1660 the general trend was downwards, until in the year 1800, there was only 225 matriculated students at Oxford and 150 at Cambridge.

The slump in student population from 1660 to 1800 was responsible for the cessation of college building during that period and it was not until the student numbers started to increase again after 1800 that building recommenced.

Downing College which was started in 1807 was the first new college to be built at Cambridge since the sixteenth century. Based upon designs by W Wilkins, the development is in the form of separate buildings constructed around large lawns and completely disregards the quadrangle plan which had been the accepted layout for earlier colleges. The College also claims the distinction of introducing the Greek revival style of architecture into Cambridge.

The number of matriculated students at Cambridge increased from 235 in 1810 to 440 in 1830 and continued to do so until at the beginning of the present century there was a student population of just over 1000. At the outbreak of the Second World War in 1939 there was 2000 undergraduates studying at Cambridge and the number in 1970 is over 10,000. This continual growth in the student population has been accompanied by the provision of additional student accommodation by the colleges and the founding of a number of new colleges.

The first two women's colleges were built in the 1870's at the time of the introduction of lectures for women at Cambridge. Prior to the construction of the women's colleges, students rooms had been arranged so that they were entered direct from landings on the staircases, however, supervisory problems indicated that the arrangement of womens rooms along corridors would be most appropriate and a number of other college buildings erected since then have adopted this layout.

UNIVERSITY BUILDINGS

It was not until the rapid growth of the sciences in the twentieth century that there was a proliferation of collegiate buildings, the functional nature of which, resulted in the construction of a number of large brick buildings. It comes as some surprise that bearing in mind the need to provide buildings for science students, the University had never tried to prepare a comprehensive plan for its future development prior to the appointment of Peter Chamberlain in 1962. Even at the present time Chamberlain is only concerned with the central science sites and his terms of reference do not include the new academic area beyond the backs. The University has a chief architect but he is only concerned with restoration work and the construction of minor buildings.

THE DEVELOPMENT OF CAMBRIDGE UNIVERSITY

At the present time Cambridge University is made up of 29 colleges, of these 21 are for men, 5 for women and there are three mixed colleges. College foundation dates and student population are as follows:-

College	Founded	Number of		
		Under-graduates	Post graduates	Fellows
Peterhouse	1284	197	45	27
Clare (as University Hall)	1326	330	100	45
Pembroke	1347	354	86	29
Gonville	1348	included with Cauis		
Trinity Hall	1350	300	70	24
Corpus Christi	1352	193	88	42
King's	1441	281	124	74
Queen's	1448	387	74	27
St Catherine's	1473	363	92	22
Jesus	1496	327	68	38
Christ's	1505	490	73	39
St John's	1511	526	145	87
Magdalene	1542	254	36	18
Trinity	1546	639	227	103
		Gonville & Cauis		
Cauis	1557	372	98	55
Emmanuel	1584	355	61	36
Sidney & Sussex	1596	213	47	44
Downing	1800	310	40	28
Fitzwilliam College	1869	346	144	24
Girton College				
at Hitchen	1869			
at Cambridge	1872	307	57	35
Newnham	1871	289	70	32
Selwyn College	1882	287	42	28
Churchill	1959	360	180	57

In addition to the 22 Colleges listed above there are 7 graduate institutions recognised by the university and 5 colleges providing training for the Ministry.

MATERIALS AND CONSTRUCTION

The buildings of Cambridge generally provide a good example of the way in which geological influences have affected the type of construction. Cambridge does not possess the same quality of stone as Oxford, however there are large quantities of good brick, earth and lime in the vicinity of Cambridge and records provide evidence of the use of brickwork as a structural element dating back to the middle of the fourteenth century.

Examples of early brickwork can be seen at Magdalene and Queen's Colleges begun in 1428 and 1448, the gallery connecting Corpus Christi with the church of St Benet constructed in 1485 and Jesus College built in 1497.

The local stone called "clunch" has poor weathering properties and is normally rendered when used externally, although the ease by which it can be worked has resulted in its use internally, particularly for decorative work.

Large quantities of building materials have been conveyed by water from King's Lynn whilst other materials such as stone roofing slates have been transported from Stamford, good quality stone from as far afield as Yorkshire and Derbyshire lead was used on St John's College in 1624.

Legislation has also affected the type of building materials used in Cambridge. A Privy Council order of 1619 prohibited the use of thatch as a roof covering and all existing buildings at that time had to be roofed with tiles or slates. In addition all chimneys had to be of brick or stone.

These measures were taken almost fifty years before similar measures were adopted in London and then only as a result of the disastrous fire of 1666.

Plain tiles and pantiles were a local product, co-extensive with the local bricks, however,London also had very extensive areas of good brick earth within a very short distance of the City, which does not seem to have been fully utilised until after the fire.

LABOUR

With the exception of a small number of carpentry contracts, all building work of any importance carried out prior to the sixteenth century was constructed on a direct labour basis with the Master Craftsman responsible for the preparation of detail drawings.

The ordinary craftsmen who came from a very wide area of the surrounding country were often forcedto work on particular buildings with the needs of the King over-riding the requirements of his subjects.

The educational, technical and organisational development of the building crafts have been discussed in Chapters I and II.

ST OF RECENT STUDENT ACCOMMODATION AT CAMBRIDGE

College	Building	Date of Construction	Total Cost £	Accommodation Provided	Cost per Student Residential Unit £
nity	Bevan Hostel	1949	28,000	18 Bed-sitters	1,556
g's	Garden Hostel	1948-1950	75,100	Hostel for 42 Undergraduates	1,788
ist's	Chancellor's and Memorial Bldg.	1948-1949 and 1952-1953	170,500	Rooms for 90 Undergraduates	1,890
nity	Angel Court	1957-1959	170,000	Rooms for 50 Undergraduates	3,400
re	Castle Hill	1957-1958	92,000	Rooms for 40 Undergraduates, 2 caretaker's flats, 2 breakfast rooms and kitchen.	2,300
en's	Erasmus Building	1959-1960	100,000	43 Undergraduates plus 2 fellows sets	2,222
us	New Court	1963-1964 (Stage 1)	140,000	37 Bed-sitting rooms plus 5 sets, sick rooms, changing rooms and stores.	3,335
pus isti	Leckhampton House Graduate Hostel	1963-1964	78,000	30 Research students; 5 Bachelor Fellows; Warden + 5 studies; Common Rooms & Dining Room. Partly in existing building.	1,902
erhouse	William Stone Building	1963-1964	100,000	Rooms for 8 fellows; 24 undergraduates + landscaping	3,125
John's	Cripp's Building	1963-1966	100,000	Rooms for 191 Undergraduates, 8 fellows sets new JCR & Supervisors rooms	5,000

THE COLLEGES

Discussion so far has been of a general nature and it will therefore be useful to examine the development of a number of Colleges and University Buildings in greater detail.

The Buildings which have been chosen are as follows:-

SECTION 1 COLLEGES

1 St John's
2 Trinity
3 Churchill
4 Jesus
5 King's
6 Peterhouse
7 Clare
8 Newnham
9 Clare Hall

SECTION 2 UNIVERSITY BUILDINGS

1 The Old Schools Quadrangle
2 The Library
3 The History Faculty
4 The Engineering Laboratory
5 The Chemical Engineering Building

ST JOHN'S COLLEGE

St John's College was founded in 1511 by the Lady Margaret Beaufort, Countess of Richmond and Derby, mother of Henry VII and occupies the site of a former hospital. The buildings forming the First, Second and Third courts were all constructed of brickwork, although the south range of First court which was erected between 1511 and 1520 was ashlared and altered during the years 1772 to 1775 and those of the north side have since disappeared. Even more drastic restoration work has been carried out on Second and Third Courts since 1957 including reconstruction from ground level in some cases.

Originally the figure of St John occupied a place of honour at the entrance to First court but was replaced in 1662.

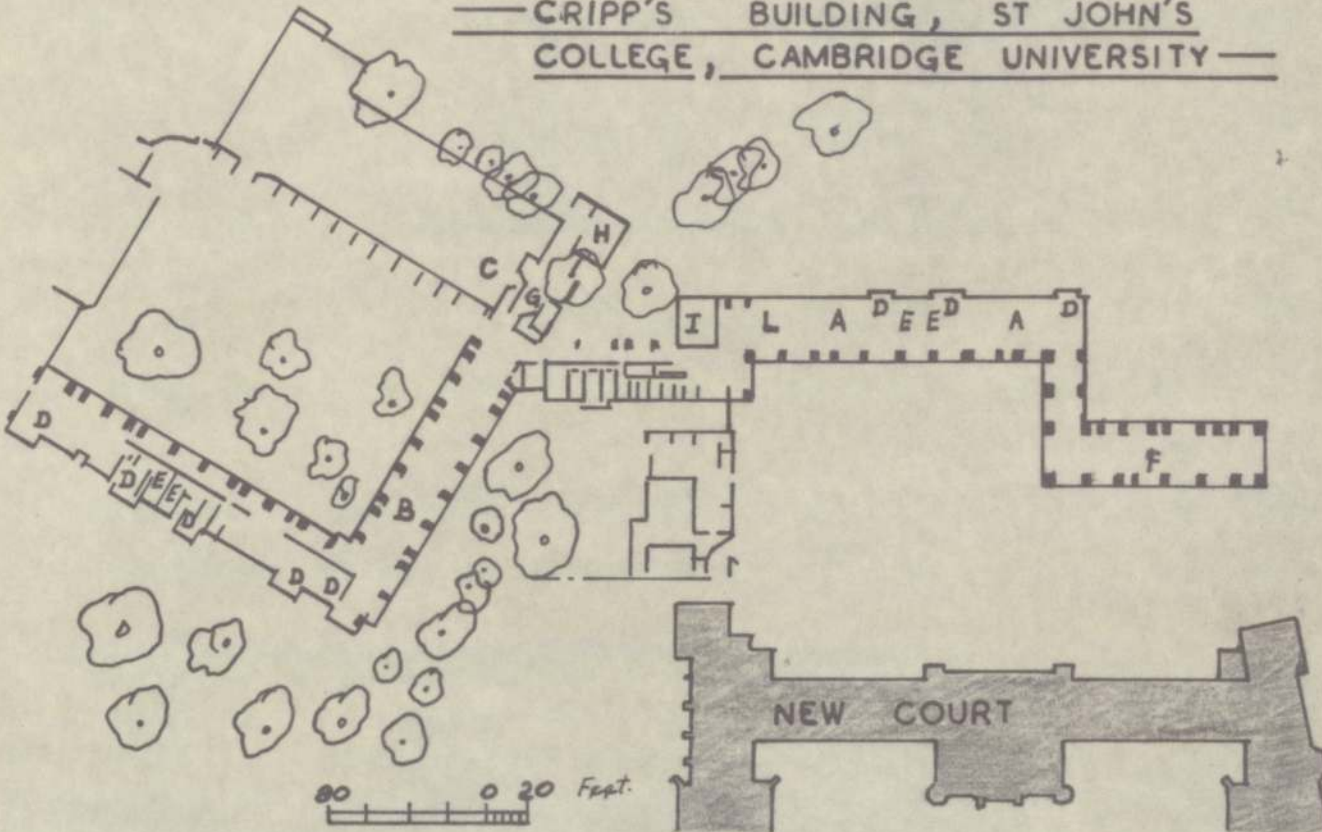
Second court was added between 1598 and 1602 using money provided by the Countess of Shrewsbury and Third court was built in 1671.

During the nineteenth century the chapel was rebuilt, piped water was introduced (1863), electric light was installed in the hall and chapel (1892), and a second high table was added (1892).

The installation of baths for undergraduates which had been proposed as late as 1912 was considered by the College authorities to be unnecessary and baths were not installed until between 1921 and 1923.

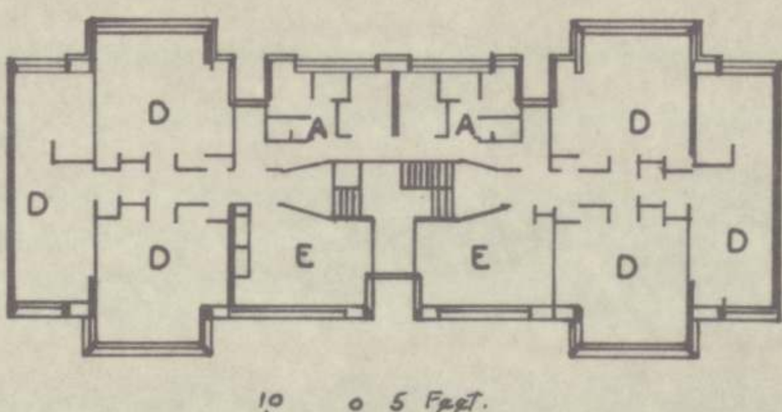
Plate No.5.1 is a view across St John's First Court, the elaborate construction and the location of the chapel and

CRIPP'S BUILDING, ST JOHN'S COLLEGE, CAMBRIDGE UNIVERSITY



A Gyps & bath
B • Cloisters
C Parking
E & D Undergraduates rooms
F Covered open space
G Refuse
H Plant
I Porters

— FIG. No. 5.1. —



Notation as for fig No 5 I

PLAN OF SET OF STANDARD ROOMS AROUND ONE STAIRCASE

— FIG. No. 5.2. —

dining hall gives an indication of the importance attached to a corporate life as a major factor in the educational development of a university graduate at that time.

Plate No.5.2 shows part of the Cripp's building constructed in 1966 and also part of Hutchinson's Gothic New Court built in 1830 and is a good example of how the architectural approach has changed during the last century in the provision of a pleasant residential environment.

Figure 5.1 shows the layout of the Cripp's building in relation to New Court and illustrates the way in which the courtyard arrangement has been preserved.

The Cripp's Building which is four stories high was built between 1963 and 1966 at a cost of £1000,000 and provides 191 sets of undergraduate rooms seventy five per cent of which are two room sets, the remainder being single bed-sitting rooms. Eight larger sets of rooms are provided in the penthouse for Fellows. In addition to the residential accommodation a junior common room, three squash courts and college workshops are provided.

The undergraduate rooms are arranged in two groups of four as shown in Figure 5.2. The ends of the north facing wings have through rooms in order to allow the sun to reach at least one window, whilst the middle rooms are provided with bay windows so as to allow for east and west sun.

Plate No. 5.1 First Court, St. John's

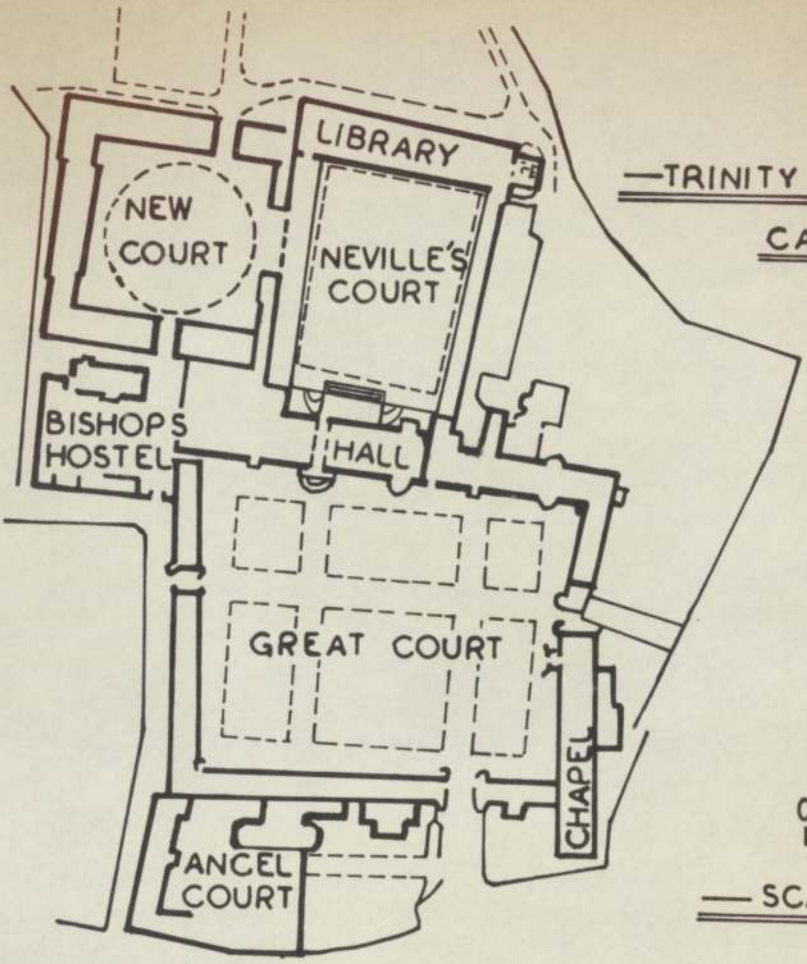
Plate No. 5.2 Cripp's Building, St. John's

The construction of the Cripps Building consists of "L" shaped reinforced concrete perimeter columns (incorporating service ducts) and flat insitu concrete floor slabs, the exposed edges of which have been grit blasted in order to expose the calcined flint aggregate. All external columns are faced with Portland stone "Whitbed", window mullions and transomes are white polished concrete, external walling (eg the back wall of the cloisters) is composed of Portland stone "Roach" with quoins of Whitbed. Partitions are non-loadbearing and are formed with concrete blocks in two leaf cavity construction. All internal surfaces are rough tectured plaster, the floors and joinery are of hardwood. Windows are bronze with lead faced panels below. Electric floor heating supplemented by fan assisted storage heaters under the window seats maintain a pleasant internal temperature.

TRINITY COLLEGE

Trinity is the largest of the Cambridge colleges and the plan in Figure 5.3 is a good example of the courtyard arrangement which creates that inward looking collegiate atmosphere so prevalent in places of learning. As can be seen the disadvantage of this type of arrangement is that restrictions are placed upon future extensions and alterations.

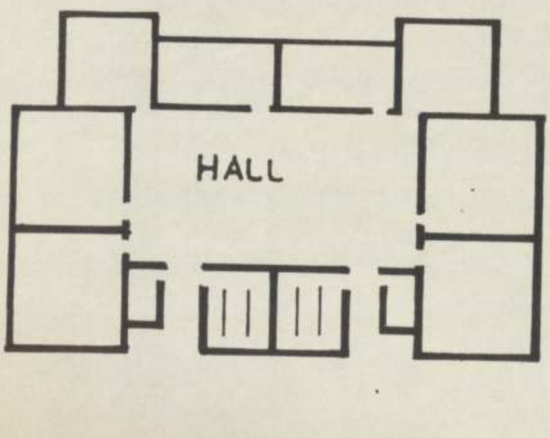
The College was founded in 1546 when the acquisition of Michaelhouse gave Henry VIII the opportunity to refound King's Hall on a much larger scale. King's Hall originated in a writ of 1317 by which Edward II granted Royal monies for the maintenance of a number of scholars to be sent to Cambridge by him. In 1336 Edward III converted the grant into a



—TRINITY COLLEGE—

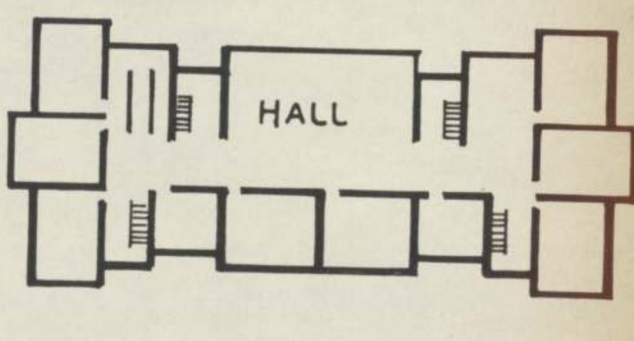
CAMBRIDGE

—FIG No. 5.3.—



CENTRAL HALL SCHOOL (ABOUT 1870)

—FIG No. 5.4.—



COUNCIL SCHOOL (ABOUT 1910)

—FIG No. 5.5.—

college proper with a warden and 32 scholars, thereby introducing for the first time in Cambridge a College which provided accommodation for students as well as fellows.

Michael House was founded in 1323 by Harvey de Stanton, Edward II's Chancellor of the Exchequer. It was for a master and 7 scholars, all belonging to the clergy and as it was reserved for clerics, it fell under the acts of dissolution of religious houses and reverted to the Crown in 1546.

Trinity College was therefore founded following the acquisition of Michaelhouse and the consequent refounding of King's Hall to provide accommodation for a Master and 60 Fellows.

The majority of the buildings which comprise Trinity at the present time were erected during the 16th and 17th centuries although sections of 14th century work still exist.

It is not surprising that with so many Royal benefactors, which includes Queen Mary in addition to those mentioned above that Trinity should be one of the four colleges which controls over 50 per cent of total unearned income of the 29 colleges. The other three being, King's, St John's and Cauis.

Plate No.5.3 is a photograph of the Great Gate, built between 1490 and 1535 which provides a very impressive entrance to the Great Court.

Plate No. 5.3 Great Gate, King's

Plate No. 5.4 The Chapel, King's

JESUS COLLEGE

Jesus College was founded in 1496 by Bishop Alcock of Ely who was at that time Controller of the Works for Henry VII. He obtained permission from the King to suppress the Benedictine nunnery which was then tenanted by only two nuns and which occupied the site upon which Jesus College now stands. The monastic buildings dating from the 12th and 13th centuries together with all revenues were appropriated by the Bishop and used to found Jesus College.

KING'S COLLEGE

King's was the second Royal foundation at Cambridge, founded in 1440 by Henry VI, the same year in which he established Eaton College.

Plate No.54 is a view of the Chapel which was built in two phases between 1446 and 1515, the magnificence of which seems to symbolise the wealth and historic traditions of the College.

Stone from two different sources was used for the construction of the Chapel. Magnesian limestone from Yorkshire was used for Phase I, whereas oolitic limestone transported from Weldon was used for the construction of Phase II.

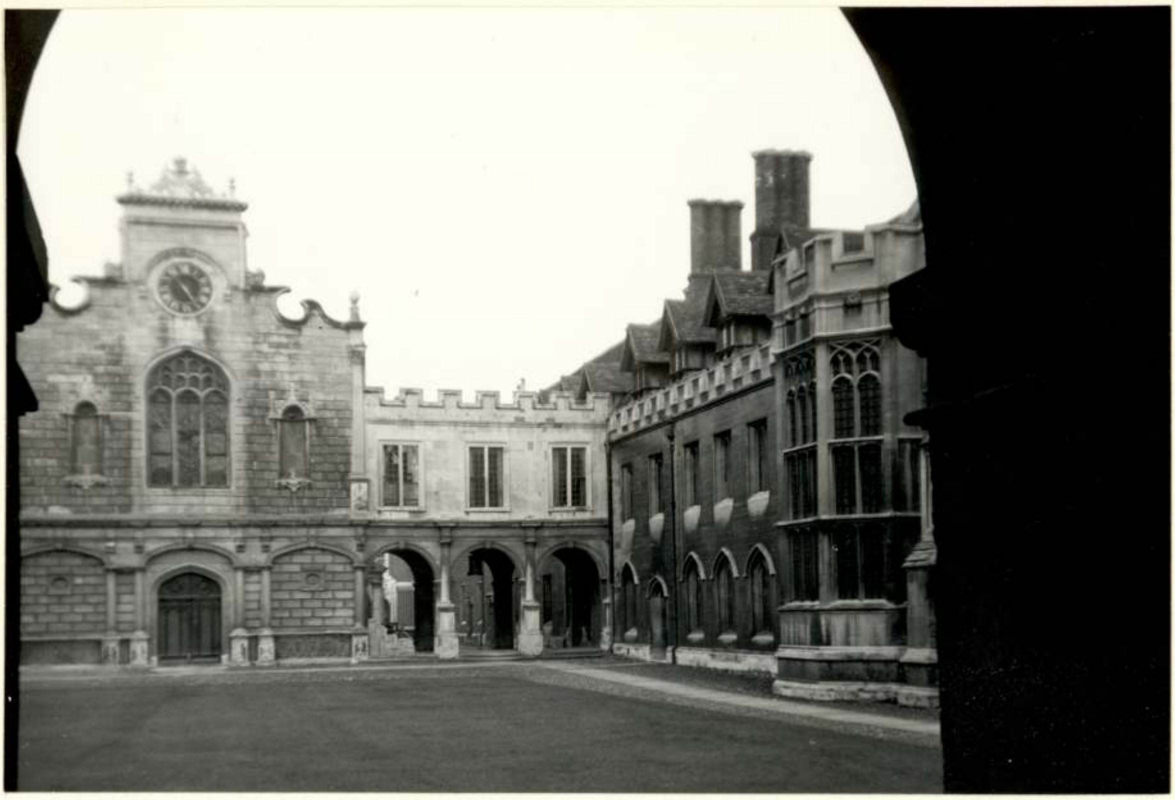


Plate No. 5.5 The Main Entrance, Peterhouse

Plate No. 5.6 The Archway Entrance, Memorial Court

PETERHOUSE

Plate No.5.5 is a view across the courtyard showing the main entrance with the Chapel and Dining Hall on the right.

Peterhouse is the oldest of the Cambridge Colleges but the College was destroyed by fire in the 15th century and the Hall, Library and Chapel seen in this photograph were built in the 17th century.

CLARE COLLEGE

Clare College, like Peterhouse, was destroyed by fire and the buildings on the left of King's Chapel in Plate No.5.4 show a section of the College which was rebuilt in the 17th century.

The archway entrance to Memorial Court which was built between 1924 and 1935 of pale grey brick is shown in Plate No.5.6. The relative simplicity of this entrance contrasts markedly with the elaborate entrance to Trinity shown in Plate No.5.3.

NEWNHAM COLLEGE RESIDENTIAL BUILDING

The view shown in Plate No.5.7 cannot fully convey the depressing appearance of this building. It cannot be commended either aesthetically or on the grounds of economics. The red tile elevations give a utilitarian appearance, and the shape of the elevations suggest a very wasteful form of construction.

Plate No. 5.7 Residential Building, Newnham

Plate No. 5.8 The University Library

CLARE HALL

The foundation of Clare Hall in February 1966 as a mixed graduate college including complete families introduced a new concept to Cambridge University. The traditional divisions between students and fellows are discouraged and the high table which occupies a position of esteem in all the colleges is abolished.

The central block of 2 to 3 storey buildings are made up of 4 "U" shaped court houses each of which encloses its own private courtyard.

There are a total of 20 dwellings of 6 different sizes all of which have internal wood finishings giving a Scandinavian appearance, (the Architect was Ralph Erskine who considers that the standard is similar to normal Swedish housing) the external walls are 11 inch cavity brickwork having an external leaf of brown bricks. Central heating and hot water is supplied from a central boiler house. The quality of construction, amenities and general environment should all contribute to making this venture a success.

UNIVERSITY BUILDINGS

THE OLD SCHOOLS QUADRANGLE

The first building to be erected specifically for teaching purposes was the Divinity School in 1350, before that time lectures had been given in rooms of houses. Progress towards the provision of additional school building in Cambridge was slow and the second building for the teaching of Common Law (after the Reformation, for Philosophy and Arts in general) was not erected until between 1430 and 1460.

The third school building which was used for the teaching of Civil Law, Philosophy and Library was built between 1457 and 1470 and completed the construction of what is now known as "The Old Schools Quadrangle".

The first 2 schools were constructed of rubble but brickwork was used for the later school which tends to illustrate the recognition that bricks were obtaining as an acceptable structural material.

The roofs of the school buildings are covered with slates and lead;but rainwater pipes were not added until 1583.

THE LIBRARY

Plate No.5.8 shows the front elevation of the University Library which was built between 1931 and 1934 of pale russet brick at a total cost of £500,000. The building is symmetrical having a total length of 420 ft (128 m). The 12 storey central tower shown in the photograph serves as a stockroom.

This building seems to belong to the same family as the Engineering and Chemical Laboratories and there can be no doubt that to the economically minded it symbolises all the features one would expect in a maintenance free, low running cost building.

HISTORY FACULTY

Plate No.5.9 is a view from the south-east of the History Faculty which was built between 1964 and 1966 at a cost of £336,785.

The predominance of glass seems to have high maintenance and cleaning costs written all over it, however, as this building was subject to a limited competition and, therefore, chosen by the staff of the History Faculty we must assume that it meets the requirements of the staff concerned.

The accommodation includes 14 seminar rooms of various sizes; common rooms for Dons, Research Students and Undergraduates; a Faculty Office and the Seeley Library which provides reading facilities for 300 people and in addition 12,600 sq ft (1170.58 sq m) of shelving. The Library accounts for approximately 50% of the total floor area. Double skin standard industrial glazing with an inner skin of obscure glass occupies about 75% of the external wall area above the red brick plinth supporting the main structure. The outer skin of glazing has openable louvres which allow a current of air, assisted by stack effect to circulate between the 2 skins of glazing in an attempt to control the internal temperature and a large specially designed skylight in addition to 3 extract fans have

Plate No. 5.9 The History Faculty

Plate No. 5.10 The Chemical Engineering Building been provided in the roof space.

Measures taken to control the internal environment have not been entirely successful and peak temperatures of over 32 degrees Celcuis have been recorded in the Library. It is also reported that the ventilation system is only able to reduce such peak temperatures by between 5 and 6 degrees Celcuis.

Remedial measures such as the provision of venetian blinds in the cavity formed by the glazing, extra ventilation and ventilating louvres, have already been undertaken in order to try and solve the thermal problems.

Hot water convector heaters are provided around the base of this huge 7 storey glass stepped pyramid and in addition heating coils have been placed in the floors of the reading room in order to provide heating when required.

The roof glazing is supported on tubular steel roof trusses providing a cavity between the 2 skins of glass of up to 12 feet high which has allowed catwalks to be installed so that access to the fluorescent lighting also within the cavity can be obtained.

Suspended floors are reinforced concrete flat slab construction. I am left with the impression that this very expensive building will involve the University Authorities in high annual costs which will not be fully compensated by the amenities and environment provided.

CHEMICAL ENGINEERING BUILDINGS

This 6 storey building plus a basement was built between 1953 and 1960 at a total cost of £2,250,000, it has a total floor area of 238,000 sq ft (22,111 sq m) and accommodates two hundred research students and staff in addition to classrooms and lecture theatres for five hundred undergraduates.

The main principles are so similar to the Engineering Laboratory that it comes as no surprise when one discovers that the same architect was responsible for both buildings. As for the Engineering Laboratory, this is a steel frame building with the floor beams spanning the full 45 ft (13.716 m) width of both wings of the building thereby providing classrooms unobstructed by intermediate columns and allowing maximum flexibility in the positioning of partitions.

The aesthetically minded may point the finger of scorn at both the Engineering and Chemical laboratory buildings which with their symmetrical brick elevations declare their functional nature, but I have no doubt that their flexibility and low maintenance costs will justify the principles upon which their design is based.

ENGINEERING LABORATORY

Constructed in four stages between 1948 and 1964 and having a total floor area of 286,000 sq ft (26570 sq m) the Engineering Laboratory houses drawing offices and laboratories for 200 research students and 1000 undergraduates. Plate No.5.11

Plate No. 5.11 The Engineering Laboratories is a view across the small courtyard looking towards the new wing which is 105 ft (32 m) long, the steel frames which span the full width of 48 ft (14.63 m) together with the allowable superimposed floor loading of 200 lb/ft^2 (8.43 kg/sq m) provide the flexibility required both for the positioning of heavy point loads and also the arrangement of any necessary division walls. The 5 in (127 mm) thick reinforced concrete floor slabs are supported by 18 in (457 mm) deep steel beams at 10 ft 6 in (3.2 m) centres which are fixed to the steel columns using high strength friction grip bolts forming a rigid connection. The steel design was based upon the plastic theory in order to achieve economy in materials. The external walls are 13½ inch (343 mm) solid brickwork.

WARWICK UNIVERSITY

Information for this section has been obtained from:-

(a) A programme broadcast by the BBC in which undergraduates criticised the administration and buildings of the university.

(b) A discussion with a third year student.

(c) A personal visit to the city of Coventry, Lanchester Polytechnic and the University.

(d) The book "Warwick University Ltd", which is the result of the combined effort of a group of students and staff.

There can be no doubt that the members serving on the Council and the Committees of the University were politically right of centre and equally beyond doubt is the fact that the most active members of the students' revolt were left of centre. These political considerations should not necessarily affect the judgement of good professional conduct providing that one remembers that truth and justice normally lies at some point between the extremities adopted by the various parties in any dispute.

The political nature of this dispute is outside the scope of this thesis, what is important is that the social environment was one of the main factors contributing to staff and student unrest.

THE FOUNDATION

Any visitor to Coventry cannot help but admire the enthusiasm and civic pride which has resulted in the rebuilding of the city and cathedral following the second world war. It was the same enthusiasm which was responsible for the feeling that a university should be founded to complete the city and that the interests of both the community and the university would be best served by forming strong links between the people of Coventry and the academic population within the university.

The strong industrial tradition of Coventry naturally led to the opinion held by most of the interested parties that the university should be a technical institution and suggestions were made that it should be modelled on the Massachusetts Institute of Technology.

Opposition to the foundation of the university came from sections of the community who wanted to expand the technical college and others such as the City Education Officer refused to give their support to a university which was an entirely technical institution.

In 1954 the Council for the Establishment of a University in Coventry was formed under the chairmanship of Mr W H Stokes who had been for many years a permanent official of the Amalgamated Engineering Union but after two years this Council reported that "the establishment of a university of Coventry was not a possibility of the immediate future".

An announcement by the Government early in 1958 that they had decided to spend £60,000,000 over the next four years on new university buildings, which would include the expansion of existing universities and the establishment of new universities, was responsible for a revival of interest in a university at Coventry. Dr Henry Rees a lecturer at the Technical College, who had been continually campaigning for a university at Coventry persuaded the city architect and a colleague to prepare a plan and model for a university building and in December 1958 the City Council decided to submit their case for a university in Coventry. At the same meeting the Council reserved the 200 acre site valued at £250,000 which the University now occupies and undertook to donate the proceeds of a penny rate.

During informal talks with the University Grants Committee the Town Clerk and Education Officer of Coventry were told that the UGC would be interested in the scheme if more public support could be obtained, which should include the participation of more than one local authority and providing also, that a considerable sum of money was promised by local industry.

Warwickshire County Council were contacted but because of the existence of a university at Birmingham they did not consider the interests of the County were being served by the foundation of another university in Coventry. Opposition reduced when the Vice-Chancellor of Birmingham University, Sir Robert Aitken offered his support to Coventry during a meeting held early in 1960 and The Bishop of Coventry finally won over the County of Warwickshire with his suggestion that it should be called the University of Warwick. The city of Coventry made this concession and Warwickshire promised to meet the City's endowment and provide an equal area of land adjoining that pledged by the City.

Following this agreement the Lord Mayor of Coventry invited 14 people who had been campaigning for a university to form the nucleous of a promotion committee and on the 17 March 1960 a letter was sent out in the name of this group to a number of prominent people in Coventry and Warwickshire inviting them to join the promotion committee.

This letter was not sent to representatives of the trade unions and it is suggested by the authors of "Warwick University Ltd" that the trade unionists, who were represented on the governing body of Lanchester Polytechnic, were more concerned with safe-guarding the position of the Polytechnic and therefore did not seem to make any attempt to become involved in the promotion committee of the University.

In 1961 the Government announced that Coventry was to be included on the list for approved new universities and an Academic Planning Board under the chairmanship of Mr E T Williams of Oxford University was set up, composed of academics from various universities in addition to three business men who had been involved in university administration.

The Academic Planning Board were responsible for controlling the academic affairs of the University until the Charter came into effect in 1965 and appointed the first Vice Chancellor, J B Butterworth, Esq., Bursar of New College, Oxford in November 1962. The Vice Chancellor expressed his wish that the University should have strong ties with local industry right from the beginning of his appointment and industry responded generously.

The first building to be erected was a small self-contained block which was to serve as interim accommodation until plans for the university could be fully developed.

Early planning was based upon a student population of between 20 to 25 thousand but by the end of 1963 it was realized that the 1966 bulge of students would probably be absorbed by the older universities and the present student population is approximately 2,000, 50% of whom are resident on the campus. Credit squeezes and cuts in grants had an adverse effect during these planning stages, and could be partly responsible for the sprawling campus which attracts so much criticism from staff and students.

The university does not seem to have encouraged close ties with the City. Proposals by Coventry for the university to participate in building a sports stadium and centre near the University which could be shared by all the educational institutions in the City as well as independent athletic groups were rejected by the University who, at that time, were planning a sports centre of their own. This policy of complete independence is further highlighted by the University's intention to spend a large sum of money on a swimming pool rather than share the good facilities provided by the one in Coventry.

The student population were obviously dissatisfied with the isolation from the local community, a feeling which has been expressed by students in other green belt universities, and it was this feeling of isolation aggravated by the general invironment, together with what the students considered a dictatorial regime, which had resisted all requests for student participation in the control of a union building, which culminated in the occupation of the registry on the 3 and 11 February 1970.

THE STUDENT REVOLT

The first sit-in was planned to protest about the way in which four student representatives had been treated by the University Building Committee, on this occasion the "take-over" of the registry by over 200 students had been fairly orderly apart from a few scuffles at the beginning of the occupation and files and other university equipment had remained untouched.

At the second sit-in which occurred on 11 February 1970 to protest against the University Council's decision regarding student control over the union building, the Student's Committee agreed with the Assistant Vice Chancellor that all offices would be left open so as to allow the students some degree of comfort and in return the students agreed that University property would not be damaged. It was during this sit-in that a student who had been looking through a file left on a desk and marked "Student-University Relations" obtained evidence of political vetting by the Vice Chancellor which resulted in the more militant action taken by the students.

The first students had enrolled at the University in the autumm of 1965 and the main social building "Rootes Hall" shown in Plate No. 5.15 was completed one year later.

The student population was to be divided into groups of 1,000 members each with its own hall of residence, administration and catering in a similar manner to the college system at Cambridge discussed earlier in this chapter. Rootes Hall was the first; a second hall was to be built after the student population had passed 1,000.

It was during this period that the students began to express their wish for a union building, over which they had some control and it seems that the Vice Chancellor also expressed his opinion, that there would never be such a building at Warwick University, supporting his statement by informing the students that the University Grants Committee were opposed to a union building.

The students obviously found this decision difficult to accept especially as the first development plans prepared by the Coventry City Architect included provision for a union building. On three successive Senate Meetings in 1967 the proposal for a union building was on the agenda, but because it was the last item on each occasion, it was never discussed and at a further two meetings the Vice Chancellor got the question referred to the student Liaison Committee.

In November 1967 the Student's Union voted unanimously in favour for money which was to be spent for the building of a second hall to be used to provide a union building and a resolution was also passed by the Assembly in support of the Student's Union.

It is important not to take too narrow a view of this conflict. Our way of life, which in turn affects the decisions we make, must in turn be affected by individual experiences. Likewise, the higher one climbs the administrative ladder the easier it is to see the broader picture of development and at the same time we should appreciate the difficulties that members of any team on lower rungs of the ladder face because of their restricted view. So it could be in this case.

It seems inequitable to question the sincerity of such professional people as the Vice Chancellor and his advisers in that they must have considered their actions to be in the best interests of the University and thereby benefitting both staff and students alike. What does seem possible is that they applied too much pressure in order to achieve their aims and were unable to accept that what they honestly believed to be in the best interests of the University might not be so.

One example of what appears to be unfair pressure being brought to bear on a member of staff is the way in which Professor Zeeman, Head of the Mathematics Department was approached in order to persuade him to discontinue his support for the student controlled union building.

Professor Zeeman, who was a leading supporter of the students' case on Council was informed that if he discontinued his sponsorship of the union building the delays which he was experiencing over conversions to service an International Mathematics Research Centre would cease, although this could be another way of saying that there was only a certain sum of money available and that every project could not be started at once. Another example of the cake we hear so much about.

Finally the University Grants Committee do not seem to have contributed very much to the course of planning by first offering £200,000 for a social building, withdrawing their offer and then renewing their offer at a later date.

FACULTY DEVELOPMENT

The ease by which the arts and social sciences can expand in relation to subjects such as engineering and physics is illustrated in the early growth of this University.

It is accepted that the arts and social sciences are much less costly to found than engineering and physical sciences. Initial planning allowed for a student population of which 20% would be engineers, however, modifications were necessary due to the inadequate number of applicants and the arts (English, History, French, Philosophy) and the social studies (Economics, Politics and Law) took up the vacancies which existed, resulting in a more rapid expansion of these subjects than had been originally intended.

In 1969 264 first degrees were awarded in the arts and social sciences compared with 127 for all the physical sciences, (Mathematics, Moleculer Sciences, Engineering and Physics).

UNIVERSITY RELATIONSHIP WITH INDUSTRY

The policy of providing an education with a vocational bias which the University of Warwick is accused of adopting and the formation of strong industrial links have been criticised by the authors "Warwick University Limited".

Is it not to the advantage of both the University and students that eminent industrialists should advise the Universities of the type of graduate for which they are looking?

The views of the Graduate Employer were discussed in Chapter IV of this thesis and some of the opinions expressed concerning the ability of some University graduates were not very complimentary. If it is the hope of reward that sweetens labour, how useful it is to be on the same wave-length as the providers of such rewards.

A letter published in "Warwick University Limited" which was taken from the University's files records the concern of one Vice Chancellor regarding the preference of some employers for the products of Technical Colleges to those from University. The greater sense of discipline and capacity for loyalty attributed to Technical College students was also confirmed during my survey of graduate employers and is an impression which acts against the interests of the University graduate.

WARWICK UNIVERSITY FINANCE

Some information concerning the income and expenditure of the University is given in "Warwick University Limited" and recorded below, however, College and University finance is discussed in much greater detail in Chapters VII and X of this thesis.

	Capital Expenditure up to the 31 March 1969 £	Income Year Ending 31 July 1969 £
Total	10.6 M	1.7 M
Non-Treasury Sources	1.3 M	.25M

THE JOHN TYZACK AND PARTNERS REPORT 24TH MAY 1968

The report prepared by the above named firm of industrial consultants, called in by the Vice Chancellor to examine the University's efficiency is reproduced in full in "Warwick University Limited". Items of reference tothis thesis have been extracted there from and are discussed below.

It is reported that approximately half of the University's annual expenditure on income account is taken up by the salaries of academic staff and that it is difficult to envisage economies in this sphere which do not involve an increase in ratio of students to academic staff, or an increase in the proportion of lower paid staff. Details of the annual expenditure, including staff salaries, for a number of Technical colleges are given in Chapter VIII of this thesis.

Attention is drawn to the hotel keeping function at Warwick University in the form of accommodating vacation conferences and possibly tourist parties which is expected to exceed a turnover of £100,000.

The uneconomic use of academic staff time attending committees is criticised on the basis that the majority of committees had only powers to discuss and advise, any battles lost can be renewed as the proposal finds its way through the various committees, ie from working party, to sponsoring committee, through to Senate, Council or both.

The consultants believe that responsibility tends to accompany powers of decision and committees bearing no onus of action encourage irresponsibility. A greater degree of delegation is recommended although implementation should always be through the Vice Chancellor.

There is a widespread conviction among students that the catering services are run at a profit by outside contractors and causes some degree of unrest. Another factor which in the opinion of the consultants causes unrest was the feeling amongst students that academic staff were remote or even indifferent to the student population.

PHOTOGRAPHS

Plate No.5.12 shows the double storey mathematics institute situated near to the administrative buildings and Vice Chancellor's office at the east end of the campus. Plate No. 5.13 shows the building housing the library, language laboratories, seminar and lecture rooms. The moleculer and engineering science laboratory building is connected to the library building at ground floor and first floor levels. Both buildings are situated at the west end of the campus approximately one mile from the mathematics institute.

Plate No. 5.14 A number of white tiles have become displaced from the external walls and this notice outside the library building testifies that the appearance of the white tile finishing is not the only item which is offensive.

Plate No. 5.15 is a photograph of Rootes Hall, situated between the mathematics institute and the library building. One of the students complaints is the depressing uniformity of the residential buildings which are given a utilitarian appearance by the white tile finish to all the external walls.

Plate No.5.16 shows the more recently built residential halls near to Rootes building. Although they are very simple and therefore of an economic construction the buff coloured brickwork used for the external walls constrast markedly with the harsh appearance of the nearby Rootes building.

WARWICK UNIVERSITY

Plate No. 5.12 The Mathematics Institute

Plate No. 5.13 Library and Laboratory Blocks

Plate No. 5.14 Elevation - showing unsatisfactory white tile finish

Plate No. 5.15 Roote's Hall

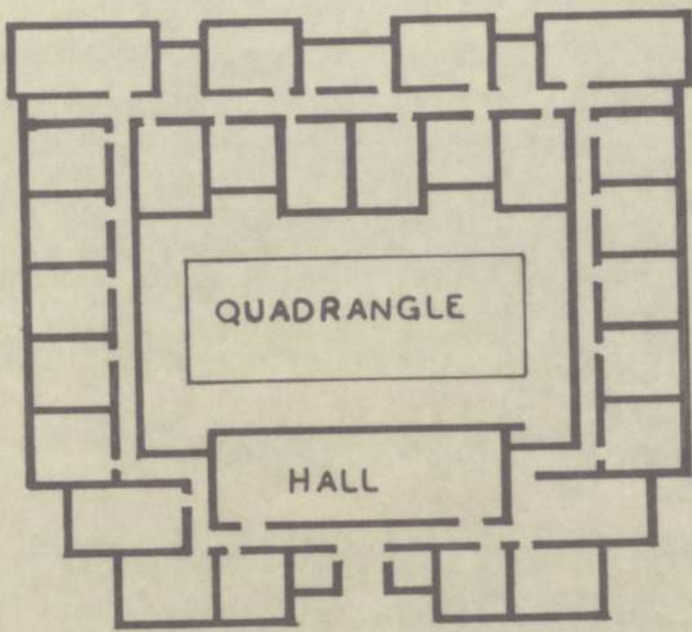
Plate No. 5.16 Recently Built Residential Buildings

THE DEVELOPMENT OF EDUCATIONAL ESTABLISHMENTS
PROVIDING TUITION BELOW UNIVERSITY LEVEL

It was not until after the seventeenth century that school architecture became independent of the influence of the Church. School buildings before that time had very low levels of both artificial and natural illumination, there were no internal sanitary arrangements, means of access was from one classroom to another and the type of layout adopted, normally resulted in cramped accommodation.

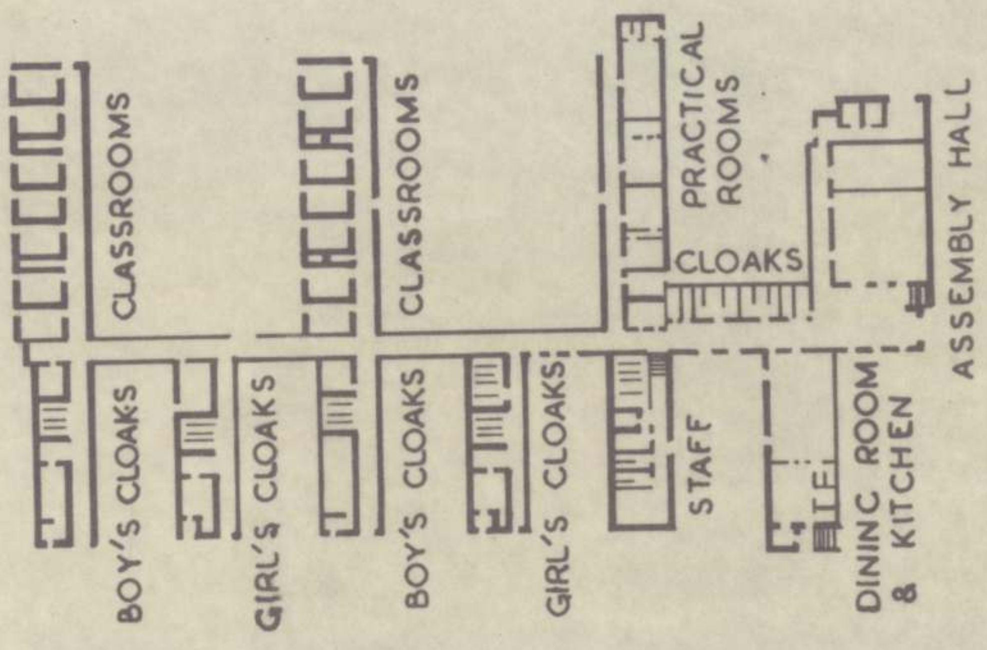
The revival of religious influence in education at the beginning of the nineteenth century, the frequent siting of schools near to churches together with the Gothic Revival were largely responsible for the re-introduction of Church Architecture into school buildings during the 1800's and continued until the advent of the Board School following the establishment of the Board of Education in 1870. Board Schools were based upon simplicity in administration, which resulted in the provision of a central hall, surrounded by classrooms, having glazed doors and partitions so as to allow immediate visual control by the head teacher, see figure 5.4. The courtyard arrangement shown in Figure 5.6 which was so predominant in collegiate buildings was also a popular feature of school buildings and remained so until the middle 1930's.

During the twentieth century attention has been focussed upon the economic design and cost control of school buildings to a much greater extent than for universities. From the beginning of the Century, Education Authorities have been



QUADRANGLE SCHOOL (ABOUT 1930)

— FIG. No. 5.6. —



THE FINCER PLAN (ABOUT 1946)

— FIG No. 5.7. —

encouraged to experiment with alternative methods of construction which has resulted in the gradual development of buildings which cater for present day educational requirements at a comparatively low cost. Whether or not this has been the correct approach is discussed in Chapter VII.

Council schools see Figure 5.5 were introduced at the beginning of the twentieth century and the major developments since that time can be classified into three main groups:-

(a) The development of open air schools during the 1920's which were only a partial success and will not be discussed further.

(b) The development of the finger plan during the 1940's in which classrooms were placed along corridors as shown in Figure 5.7.

(c) Schemes produced as a result of the work of the Development Group of the Department of Education & Science which are based upon the concept of multi-use of space.

THE FINGER PLAN

This type of layout, which became popular after the second world war consisted of classrooms and practical rooms placed in rows along one side of a corridor. Quite often there were several rows of classrooms placed parallel with each other and connected at one end by a main corridor which resulted in this type of layout being known as the "finger plan".

An attempt was made to provide satisfactory levels of ventilation and illumination by installing clerestory lighting along corridors and storage space was introduced between each classroom in order to reduce sound transmission. The main disadvantage of the finger plan were:-

(a) The extravagant use of land and floor space.

(b) The very high ratio of circulation space to classroom space.

(c) Administrative and supervisory difficulties, due to the relatively large horizontal distances which had to be travelled.

(d) Functional planning of rooms was difficult.

(e) Planning and constructional problems due to variations in site levels.

(f) The inflexibility of the layout.

THE WORK OF THE DEVELOPMENT GROUP OF THE DEPARTMENT OF EDUCATION AND SCIENCE

Although the finger plan had many disadvantages, this type of layout was used extensively up until the early 1950's and it was largely as a result of the work carried out by the Development Group of the Department of Education and Science that more economic schemes were developed.

This group identified the main factor which affected both the economic and functional solution of classroom layout to be the various teaching methods adopted for children of different ages. Infants generally stay in the same room for all lessons, whereas, pupils in secondary schools require specialist rooms which in turn necessitates a functional arrangement of classrooms and a careful study of circulation routes.

Between 1951 and 1957 designs were suggested for layouts, which allowed space to be used for more than one purpose, reduced administrative and circulating areas and thereby lowered the total floor space per pupil by up to 40 percent.

The effect of The Group's work on the cost per pupil place and cost per square foot is discussed in Chapter VII.

CHAPTER VI

CHAPTER VI

THE ECONOMIC APPRAISAL OF EDUCATIONAL BUILDINGS

When making an economic appraisal of any constructional form it is first necessary to identify the variables that need to be considered. The variables that affect the economic appraisal are:-

(1) The date of construction

(2) The geographical location

(3) The dimensions of the building

(4) The initial cost

(5) The type of construction

(6) The maintenance costs

(7) The running costs

(8) The function which the building is to serve, together with the ease and economy which those functions can be carried out.

(9) Flexibility of the building.

The ability to adapt educational buildings to meet new developments in teaching aids and practice, which enable educationists and students to operate at maximum efficiency will be an important consideration. Items (5) to (9) inclusive are discussed in Chapters VIII and IX and therefore this Chapter will be devoted to a discussion of items (1) to (4) only.

(1) THE DATE OF CONSTRUCTION

Variations in wage rates, material costs, changes in construction techniques and the competitive situation, which exist at the time of tendering, all affect the initial cost of the building.

Adjustments can be made by multiplying the initial costs by an appropriate indice in order to take account of price and wage changes. However, these indices must be used with caution, the main danger being that the unwary may ignore factors which affect construction costs that cannot be catered for in a general construction index.

In Chapter VII the effect of cost control and the application of results of economic studies by the Department of Education and Science is discussed and it is shown that the cost per square foot of school buildings bears no significant relation to trends in building costs generally.

Another example where the price changes in a particular form of construction do not reflect the changes in material costs and wage rates is provided by CLASP (Consortium of Local Authorities Special Programme). This type of construction which was developed by a number of Local Authorities working together in order to solve a common problem is based upon a light steel frame and was used for St Albans College of Further Education, details of which are given in Chapter IX. Recent valuations have shown that the cost of the steel frame has dropped from

8s. 0d. per square foot (£4.306 per square metre) of floor area in 1956 to 5s. 2d. per square foot (£2.781 per square metre) in 1970 due to increased production, accounting for 14% and modifications to design which have resulted in a further 25% saving. The above savings have been achieved during a period when the general price of steel has increased by 10%.

It will be seen therefore that variations in construction indices are caused partly through changes in construction costs, partly through changes in the nature of the buildings constructed and partly to changes in the construction process and all these factors must be considered when updating the costs of a particular building. The way in which the indices have been determined will affect their value. Indices based upon price changes and wage rates ignore to a large extent the effect of competition, whilst indices based upon tender prices may conceal the effect of competition. The difference between the official wage rates and the actual earnings of manual workers also has an important influence on cost of construction and is an important factor to be considered when comparing buildings in different Regions. Figures 6.1 and 6.2 provide a comparison between a number of cost indices prepared for the British Construction Industry. The building cost indices published by the Royal Institution of Chartered Surveyors are classified into four groups.

Class A Buildings - steel frame construction

Class B Buildings - concrete frame construction

Class C Buildings - brickwork construction

Class D Buildings - light frame construction

The cost indices are compiled by taking account of:-

(a) Changes in the hourly wage rates with productivity adjustments.

(b) Variations in price levels of materials.

(c) An adjustment to allow for "market conditions", based upon information received from Local Authority housing tenders.

The cost indices for new construction published by the then Ministry of Public Building and Works now the Department of the Environment in the "Bulletin of Construction Statistics" are based upon actual tender prices and 6.1 provides a good illustration of the factors influencing cost indices discussed earlier.

The indices of weekly earnings of all manual workers compared with construction workers is also shown in figure 6.1 and it will be seen that the earnings of manual workers in construction industry is rising faster than the overall average.

This change in relative earnings could affect construction techniques.

Figure 6.2 provides a comparison of indices, although it combines indices for productivity and costs, it serves as a useful example to illustrate the variables discussed earlier

INDICES FOR THE BRITISH CONSTRUCTION INDUSTRY

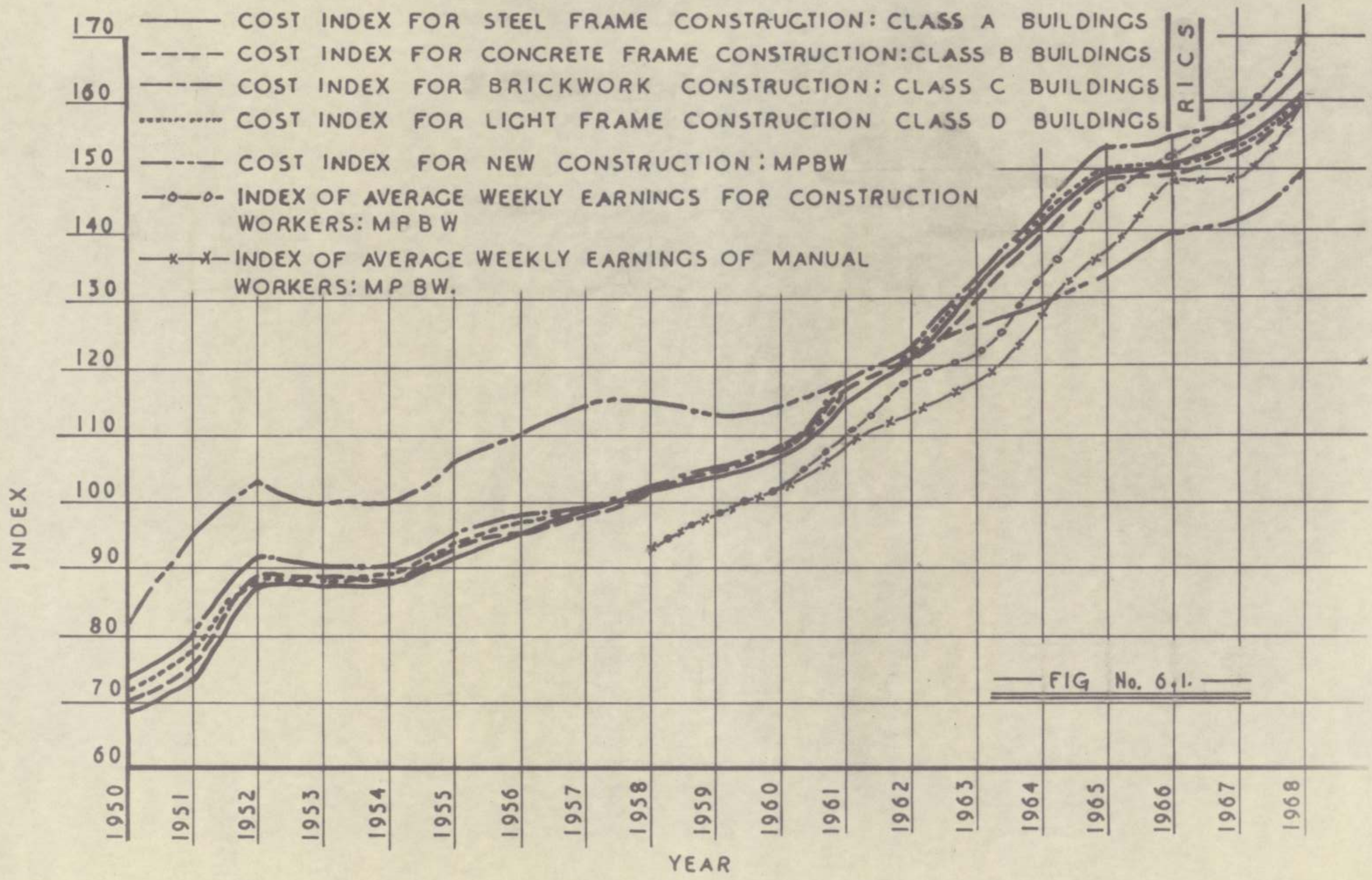
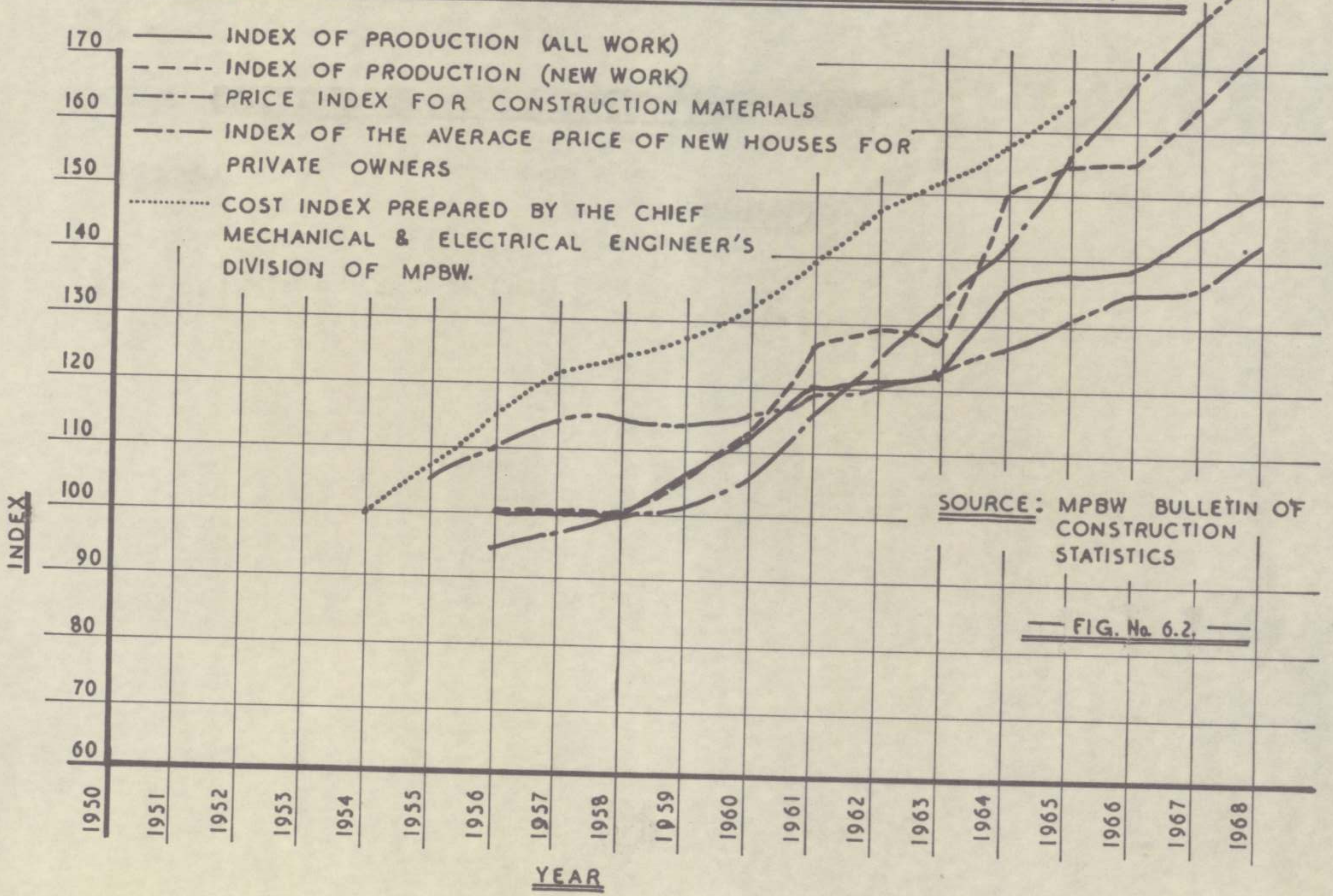


FIG No. 6.1.

— INDICES FOR THE BRITISH CONSTRUCTION INDUSTRY —



— FIG. No. 6.2. —

INDEX NUMBERS OF CONSTRUCTION MATERIALS PRICES

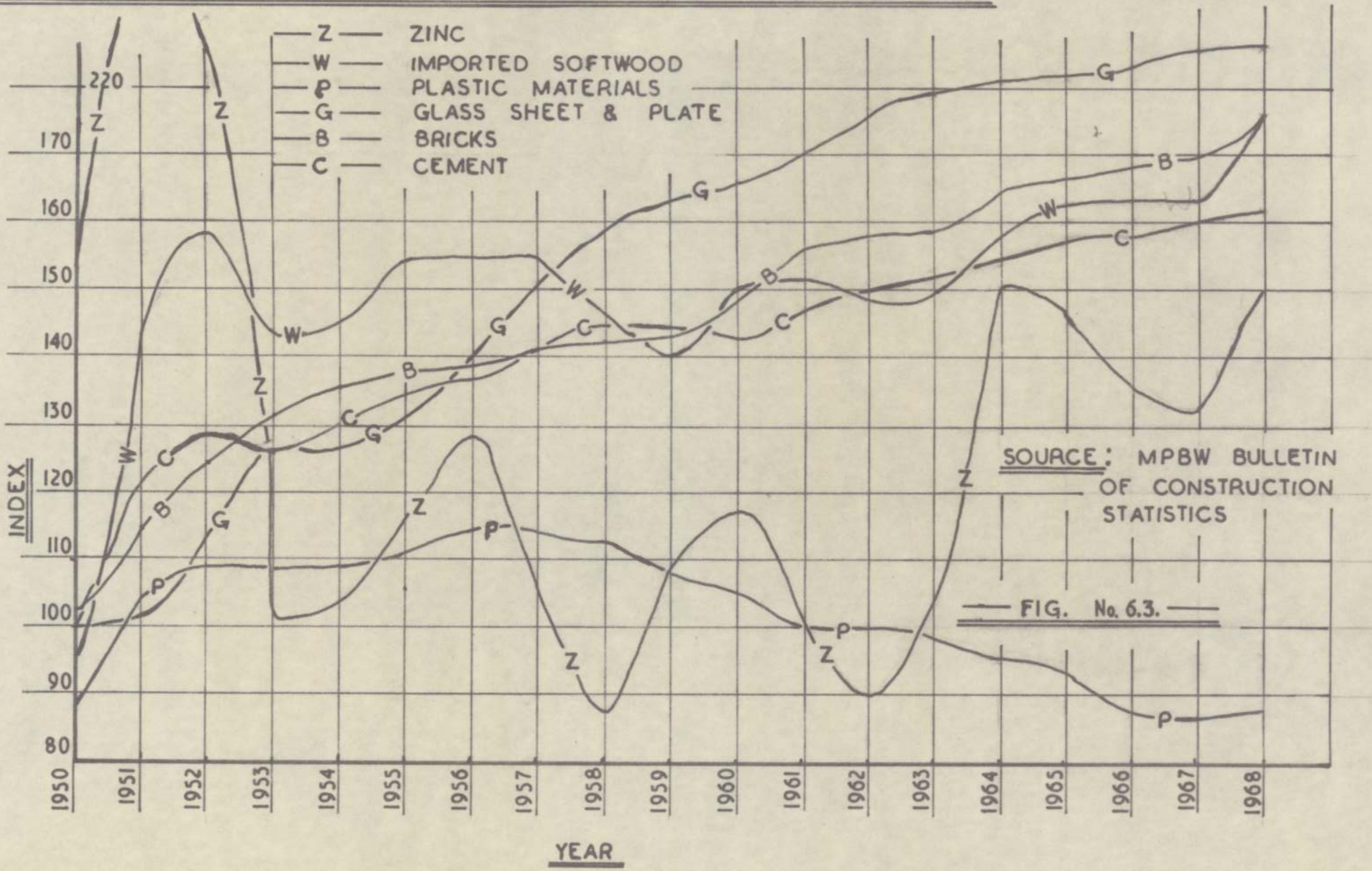


FIG. No. 6.3.

in this chapter.

Comparing the indices for "new work" and "all work" it will be seen that the "new work" index rises more steeply than the "all work" index. This is due to the inclusion of maintenance in the "all work" index, where improvements in productivity are more difficult to obtain than in "new work".

Elemental costs can also vary due to changes in material prices which do not all increase at the same rate. Market forces, including the shortage or substitution of materials and the development of new materials and techniques can affect price levels of materials produced in this country, but even greater variations can be experienced by imported materials due to changes in the exchange rate and other international factors which affect world markets.

Figure 6.3 shows the variation in cost indices for a number of materials where the factors discussed above have affected their price levels.

(2) GEOGRAPHICAL LOCATION

The geographical location can influence building economics because of the variations in availability and price levels of land, materials and labour. These variables are most marked when making comparisons on an international basis, but there can be quite large variables between different regions with a country.

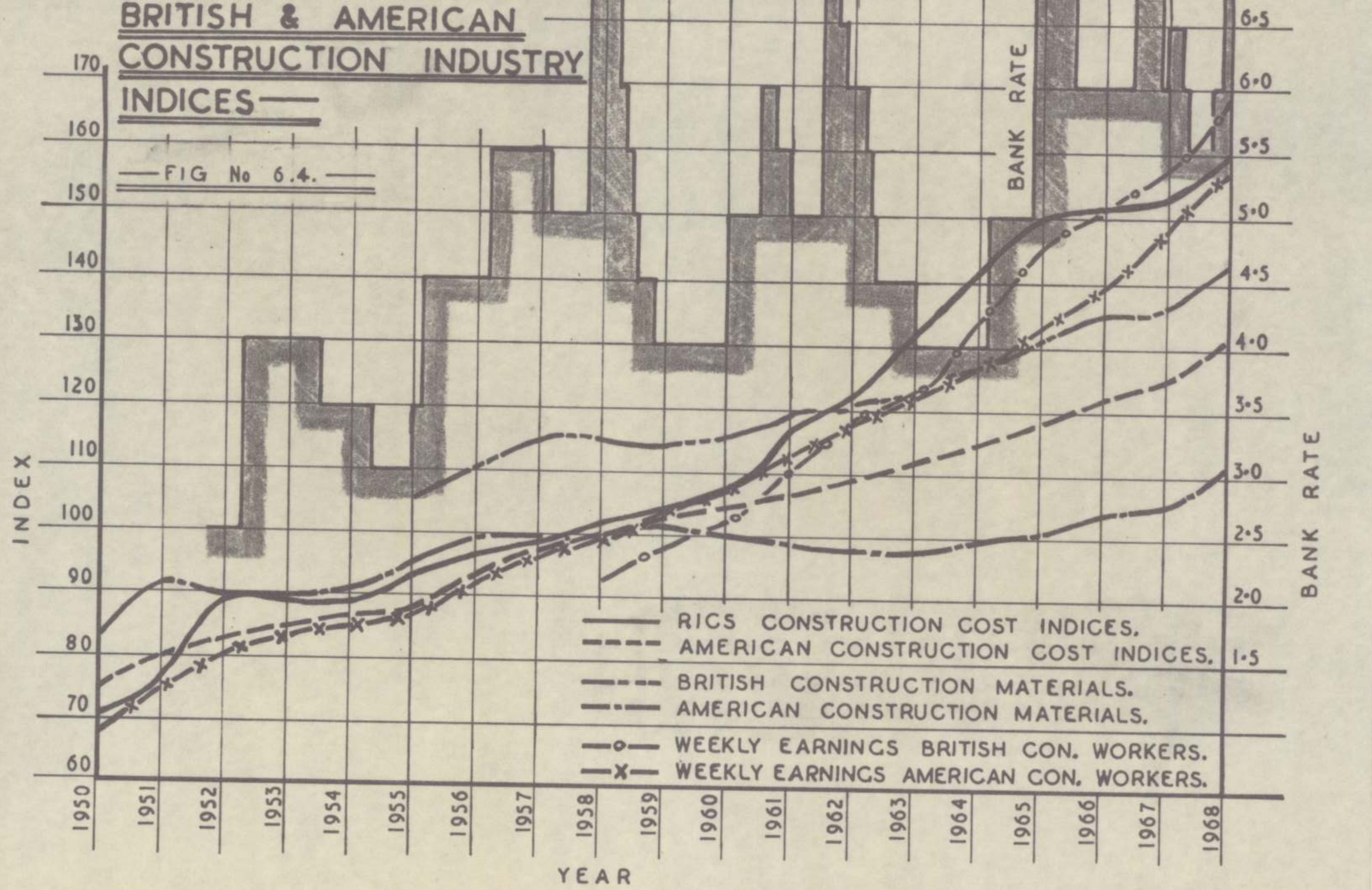
A comparison of earnings for manual workers in this country and America shows that the average hourly earnings in factories producing engineering products in the United States are about 81% of skilled earnings in the construction industry compared with 106% in this country, which obviously affect economic comparisons between traditional and industrialised systems of building within the two countries.

Figure 6.4 provides a comparison of British and American construction indices and it will be seen that the indices for the British Construction industry are rising more steeply than the corresponding indices for the American construction industry. However, caution should be exercised in interpreting these indices as increases will naturally be greater in this country where the wages and costs are at a lower level than in America.

During the study an investigation was attempted of the effects of changes in the bank rate on cost indices. No relationship was detected and the movements in the bank rate therefore have been included in 6.4 for information only.

Indices for the American Construction industry have been shown separately in figures 6.5 and 6.6.

The average earnings of any operative is automatically affected by the demand for his particular skill and in turn, the cost and availability of a particular type of operative will affect the degree of automation adopted by the employer in order to carry out a particular function.


BRITISH & AMERICAN
CONSTRUCTION INDUSTRY
INDICES
FIG No 6.4.
INDEX
170
160
150
140
130
120
110
100
90
80
70
60
BANK RATE
6·5
6·0
5·5
5·0
4·5
4·0
3·5
3·0
2·5
2·0
1·5
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
YEAR
RICS CONSTRUCTION COST INDICES.
AMERICAN CONSTRUCTION COST INDICES.
BRITISH CONSTRUCTION MATERIALS.
AMERICAN CONSTRUCTION MATERIALS.
WEEKLY EARNINGS BRITISH CON. WORKERS.
WEEKLY EARNINGS AMERICAN CON. WORKERS.

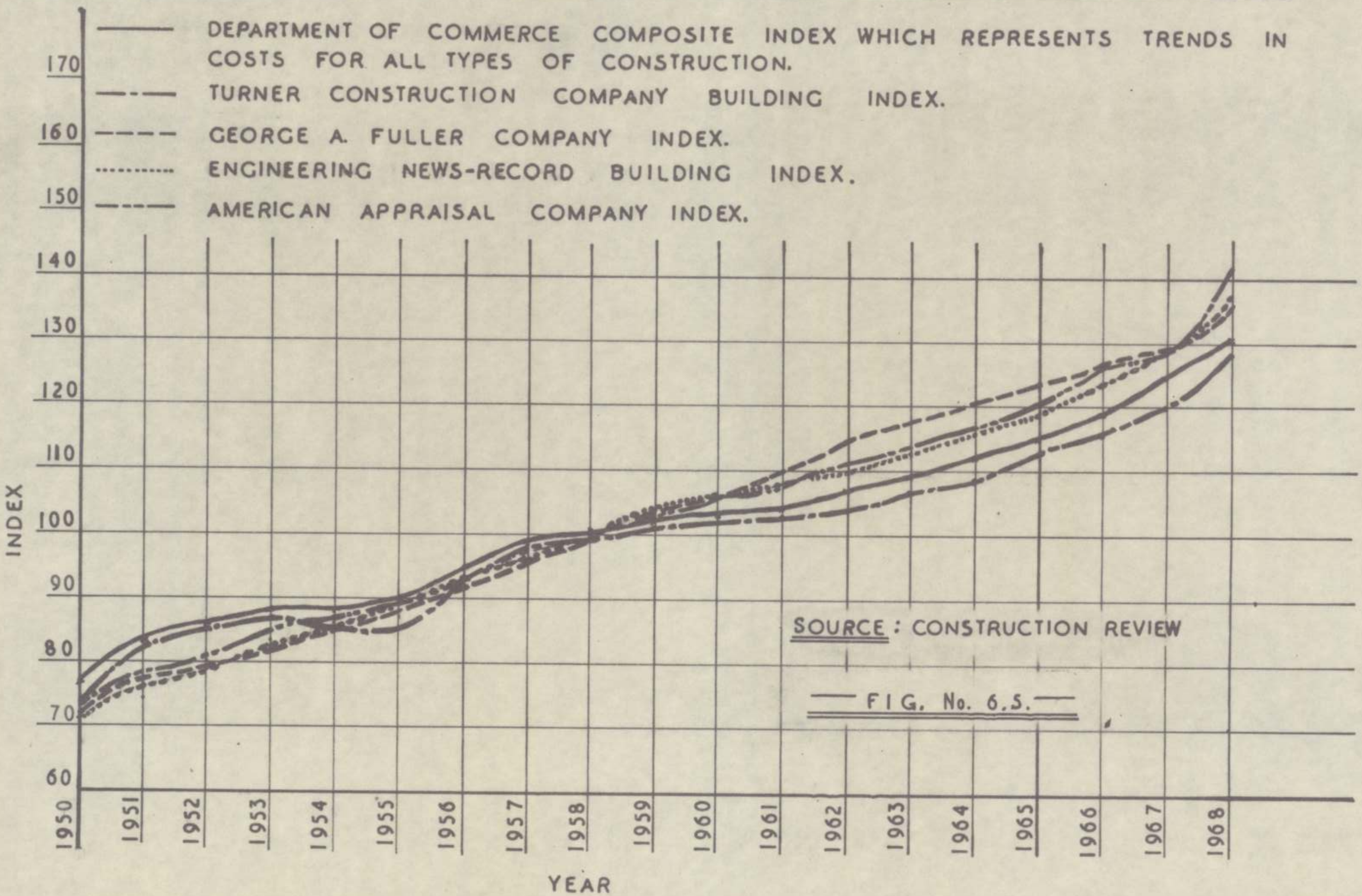
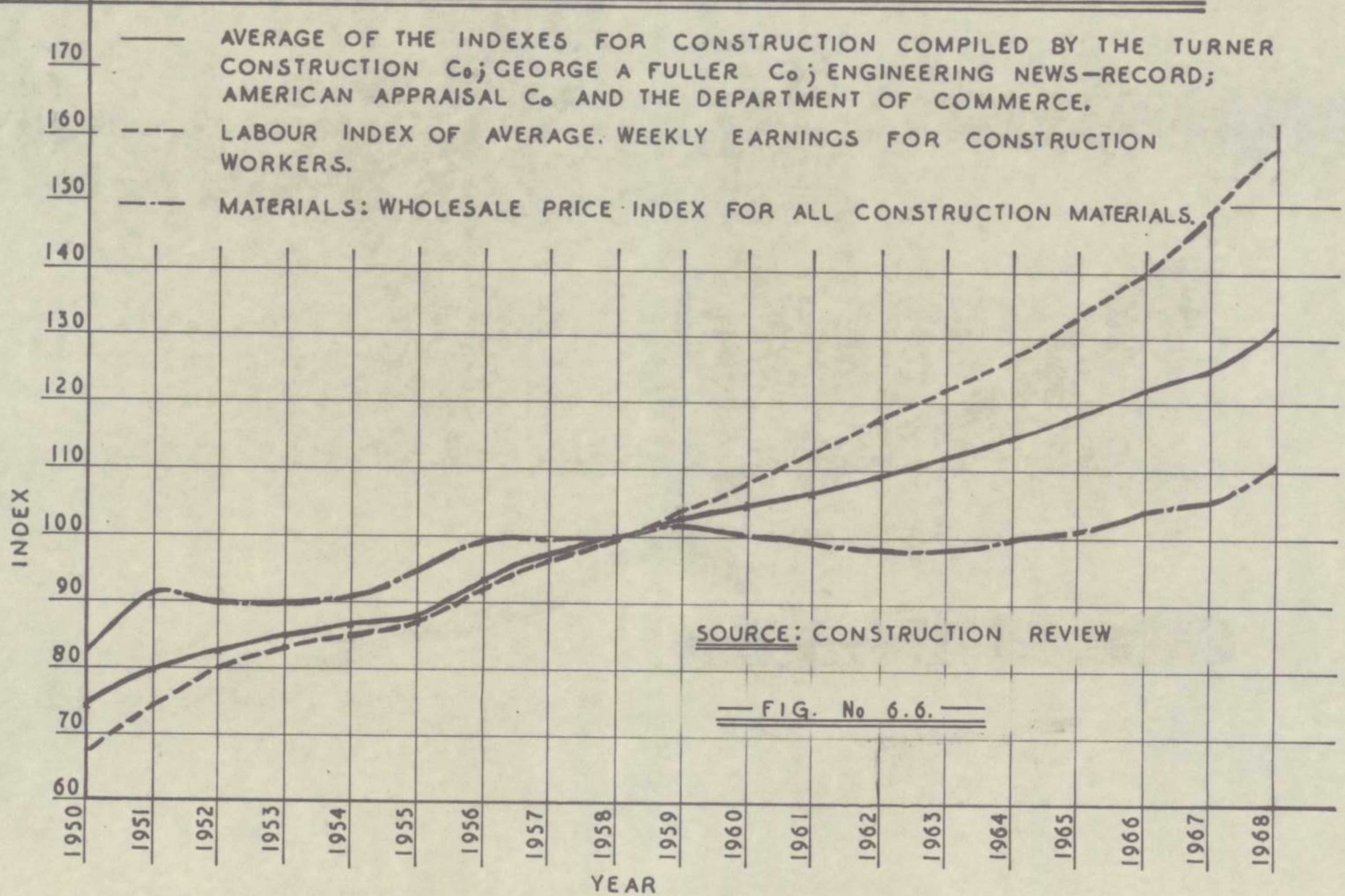

DEPARTMENT OF COMMERCE COMPOSITE INDEX WHICH REPRESENTS TRENDS IN COSTS FOR ALL TYPES OF CONSTRUCTION.
TURNER CONSTRUCTION COMPANY BUILDING INDEX.
GEORGE A. FULLER COMPANY INDEX.
ENGINEERING NEWS-RECORD BUILDING INDEX.
AMERICAN APPRAISAL COMPANY INDEX.
INDEX
170
160
150
140
130
120
110
100
90
80
70
60
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
YEAR
SOURCE : CONSTRUCTION REVIEW

FIG. No. 6.5.

INDICES FOR THE AMERICAN CONSTRUCTION INDUSTRY



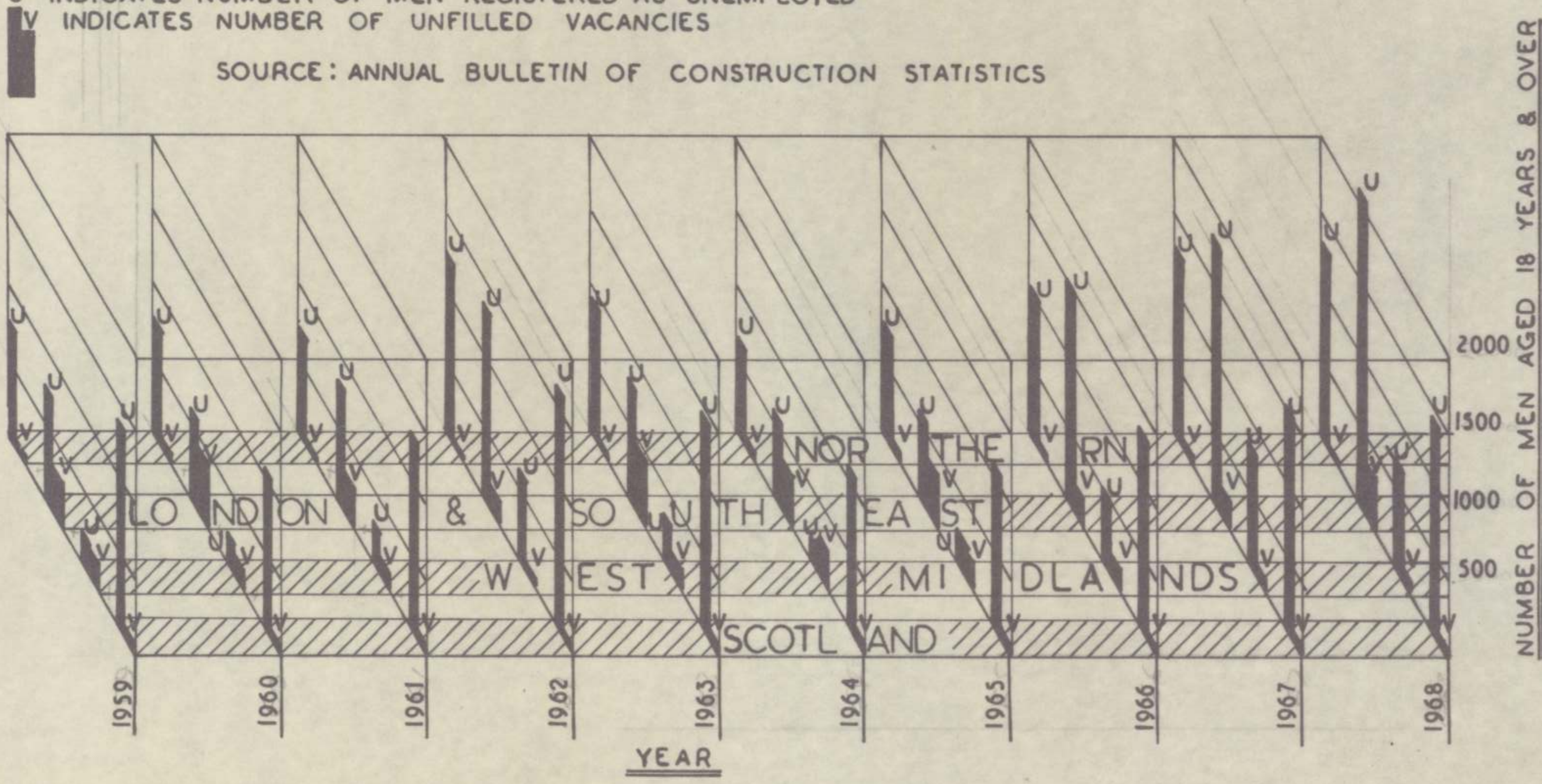
— FIG. No 6.6. —

— FIG. No. 6.7. —

A COMPARISON OF THE UNEMPLOYMENT & UNFILLED VACANCIES IN THE CONSTRUCTION INDUSTRY FOR THE NORTHERN, LONDON & SOUTH EAST, WEST MIDLANDS & SCOTTISH REGIONS OF THE BRITISH ISLES

U INDICATES NUMBER OF MEN RECISTERED AS UNEMPLOYED
V INDICATES NUMBER OF UNFILLED VACANCIES

SOURCE: ANNUAL BULLETIN OF CONSTRUCTION STATISTICS



A comparison of construction industry employment statistics for four regions in this country shown in 6.7 illustrates this point and can be further verified by examining methods of construction and conditions of employment between the South East and North East of England. The construction industry in the North East region where the ratio of unemployed operatives to vacancies is much higher than in the South East region tends to adopt fewer mechanical aids and methods of building are closer to traditional site systems.

The cost and availability of land varies considerably between regions and affects the type of construction adopted, density of population and the total cost of the building. Figure 6.8 reproduces figures obtained by the National Building Agency during a study of 400 housing schemes involving 1,600 dwellings and shows the regional variation in land prices.

FIGURE 6.8

The average land cost per acre and per person housed, the cost of land as a percentage of total costs, and the average densities.

	Average land cost per Acre	Average land cost per person	% of total	Density	Average land cost per acre	Average land cost per person	% of total	Density
	£	£	%	No.	£	£	%	No.
London	27,783	363	26	76	42,685	470	24	91
Essex	15,328	243	24	65	23,015	269	16	93
ounties	12,749	233	21	56	19,809	316	20	65
rn ies	11,368	235	20	49	21,764	276	17	82
ds	6,135	119	15	50	14,713	204	16	64
West	4,282	66	9	60	8,130	127	9	67
& rside	4,282	66	9	60	10,107	123	10	82
West	5,222	100	12	53	12,129	171	12	69
	2,296	55	7	47	10,136	133	11	76

(3) THE DIMENSIONS OF THE BUILDING

The geometrical shape of the building will affect the design of structural elements such as the economic spacing of columns, load bearing walls, beam depths etc. The ratio of wall area to plan area will also vary for different shape factors and as the total cost of each element within the structure is often converted to a cost per square metre of floor area the effect of shape factor can be concealed.

Figure 6.9 provides a comparison of the perimeter dimensions for a number of simple plan shapes all with a floor area of 2,400 square metres.

FIGURE 6.9

A comparison of the Perimeter Dimensions for a number of simple plan shapes. Floor Area 2,400 m^2.

Plan Shape		Length of Perimeter metres	Length of perimeter / Perimeter of circular plan
Circular Plan Diameter = 55.27		173.70	1.000
Hexagonal Plan Length of side = 30.38		182.27	1.049
Rectangular Plan			
Length	Breadth		
49	49	196	1.128
60	40	200	1.151
80	30	220	1.267
100	24	248	1.428
120	20	280	1.612

The shape factor will therefore affect structural economics and the total cost of external walls, which will obviously have to be taken into account during cost comparisons. However, in addition to any effect on the initial costs, variations in shape factor will also affect the heat losses through the external fabric, the provision of adequate lighting, the economic arrangement of rooms and machinery.

The effect of shape factor upon structural economics and the economic arrangement of rooms and machinery will be discussed in Chapter IX and further discussions on the effect of shape factor in this Chapter will be restricted to lighting and heating economics.

SOME GENERAL PRINCIPLES OF THE LIGHTING AND HEATING OF BUILDINGS

The constraints placed upon the occupants of a building by the type of construction is a very important consideration, however, non-the-less important is the provision of satisfactory standards of illumination and heating.

High levels of lighting and heating are no substitute for quality, and the inter-relationship between quality and quantity will now be discussed in connection with the provision of a satisfactory internal environment.

LIGHTING

The Building Research Station Day Light Factor Meter.

A daylight factor is the proportion of light which falls on any given surface, expressed as a percentage of the light which would fall on the same surface out of doors without any obstruction, and therefore takes into account reflected light and any reduction in illumination due to obstructions and light transmission which occurs when light passes through glass.

EXAMPLE

If the light falling on a desk top is 40 lux (1 lux = 1 lumen per m^2) when the illumination outdoors is 1,000 lux the daylight factor will be

$$\frac{40 \times 100}{1000} = 4\%$$

If at a later time the outside illumination drops to 500 lux the corresponding illumination on the desk would be $\frac{500 \times 4}{100}$ = 20 lu[x] however, the daylight factor would remain constant at 4%.

It is possible to measure the daylight factor at positions inside a building under a wide variety of different sky conditions, but it is common practice to take measurements when the sky is densely overcast. Even with an overcast sky the brightness is not uniform but varies from the zenith to the horizon in the ratio of 3.1.

Daylight factors in buildings are usually of the order of 0.5 to 5 percent so that the sensitivity of the meter, when used to measure sky brightness must be approximately of the same order of that necessary to measure indoor illumination. This is achieved by means of a louvred mask which is placed over the cell when the instrument is directed at the sky.

It is known that the brightness of the sky at 42 degrees is the average illumination produced by the whole sky and therefore the louvred mask will be at an angle of 42 degrees when the instrument is held horizontally.

PREDICTION OF LEVELS OF DAYLIGHT IN BUILDINGS

It is necessary when designing buildings to determine the distribution of daylight throughout the buildings. This can be done in two ways.

(1) By placing a model of the building under an artificial sky and measuring the illumination within the model, with this method a visual comparison can be obtained for alternative schemes of internal decoration and the adoption of appropriate scale factors allows the measurement of actual levels of illumination. A model where the appropriate scale factors have been incorporated also allows an assessment to be made of both the quality and quantity of the illumination.

(2) By calculation using the Building Research Station Protractors. When calculating the distribution of daylight throughout a space in a building, the reflected light must be added to the direct light passing through the windows.

The light received direct from the sky is called the "Sky Factor" and depends upon:

(a) The size, shape and position of the windows;

(b) The position of the indoor reference point;

(c) Obstructions which restrict the area of sky visible through the window; and

(d) The loss of light due to the glass (which may be dirty), glazing bars, and internal obstructions such as columns or furniture.

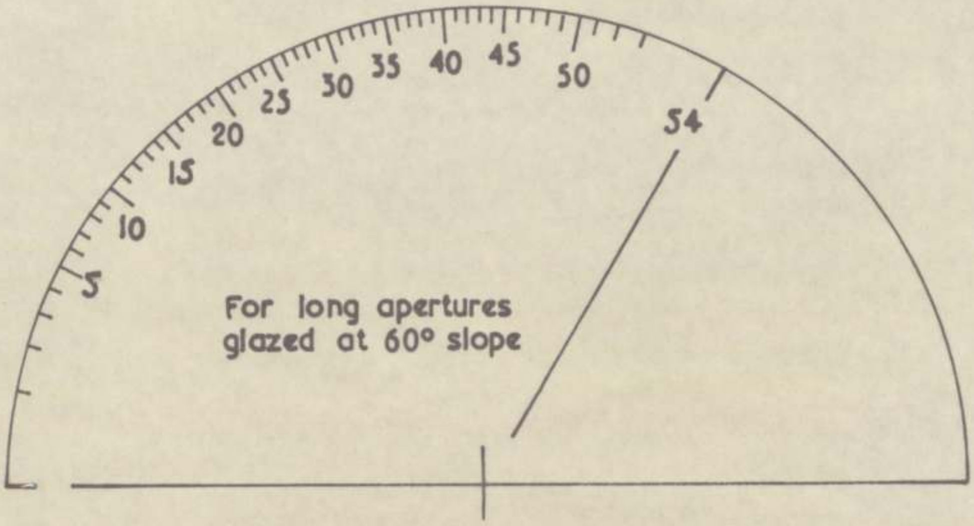
Figure 6.10 is a full size drawing of a pair of Building Research Station Protractors. There are 5 pairs of protractors in a set, each pair being designed for a particular type of fenestration. The pair of protractors shown in figure 6.10 are used for calculating the daylight factor when the room is illuminated by natural lighting passing through glazing (such as north lights) which is at an angle of 60 degrees to the horizontal.

Figure 6.11 shows the way in which the protractors are used, as will be seen, the protractors are used in pairs, one protractor being used on the plan and the other on the cross-section of the building.

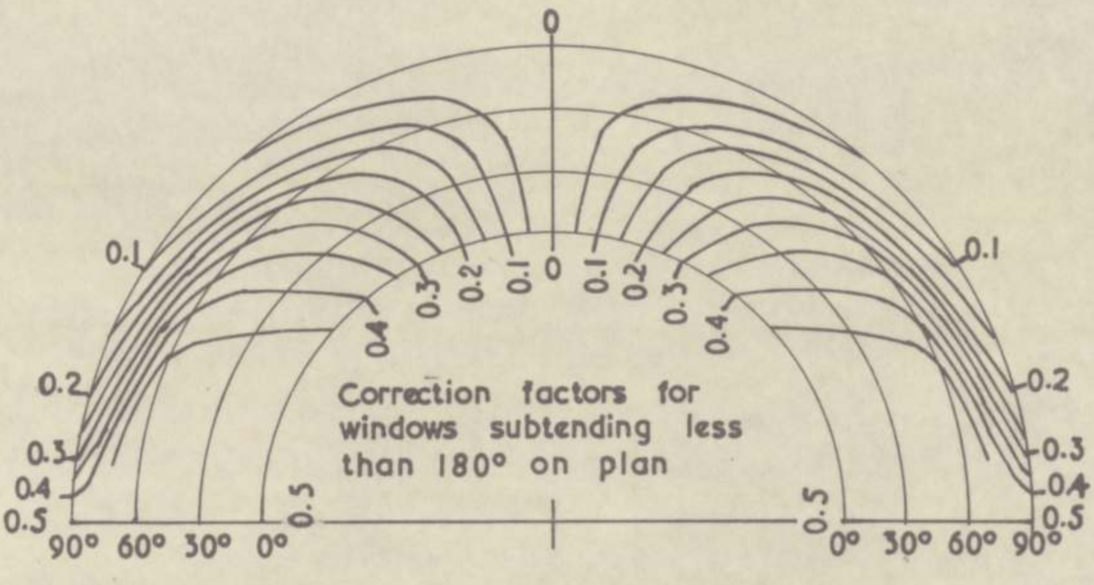
Figure 6.12 shows how the sky factors reduce as the reference point moves away from the window. It will also be obvious that very different values would have been obtained if vertical wall glazing had been used instead of roof lighting as in this example.

THE QUALITY OF LIGHT

Good lighting is not merely a lot of light, but is sufficient light coming from the right direction without producing glare. Good illumination should combine a sufficient amount

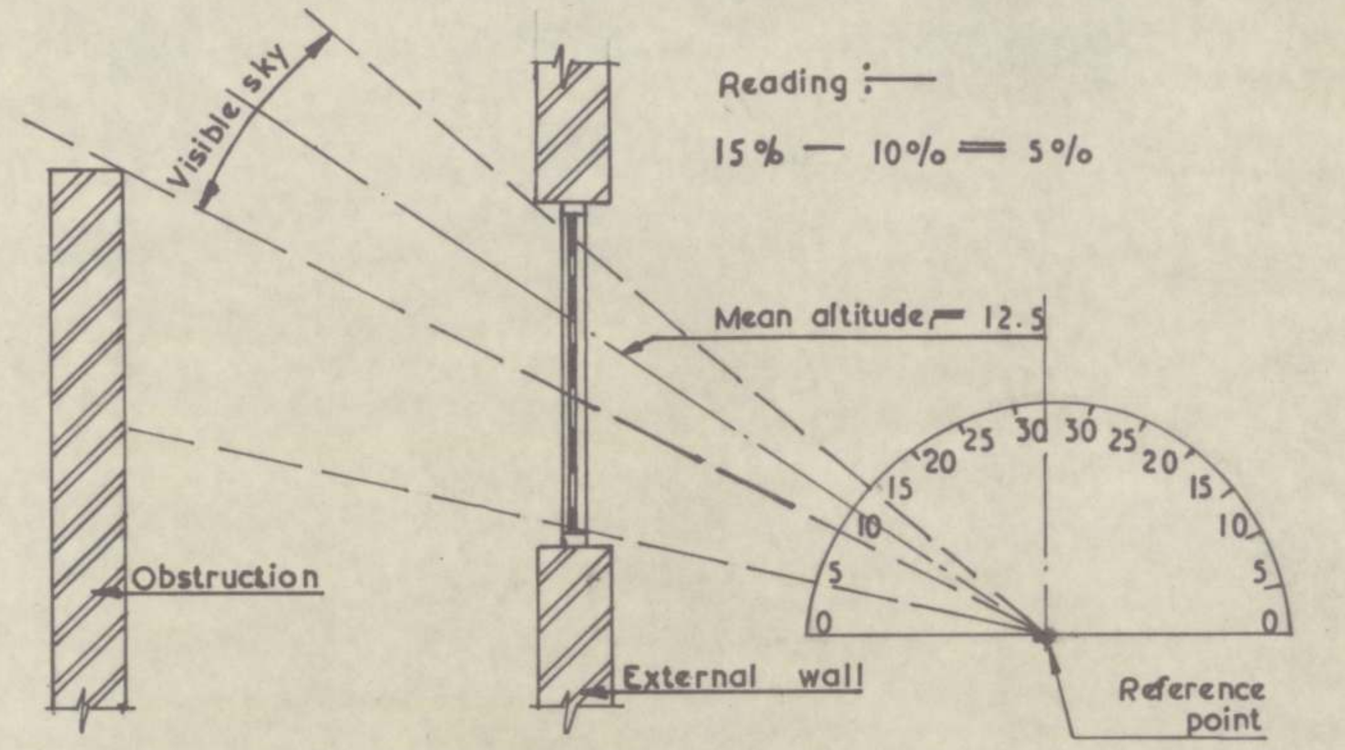


DAYLIGHT FACTOR SCALE

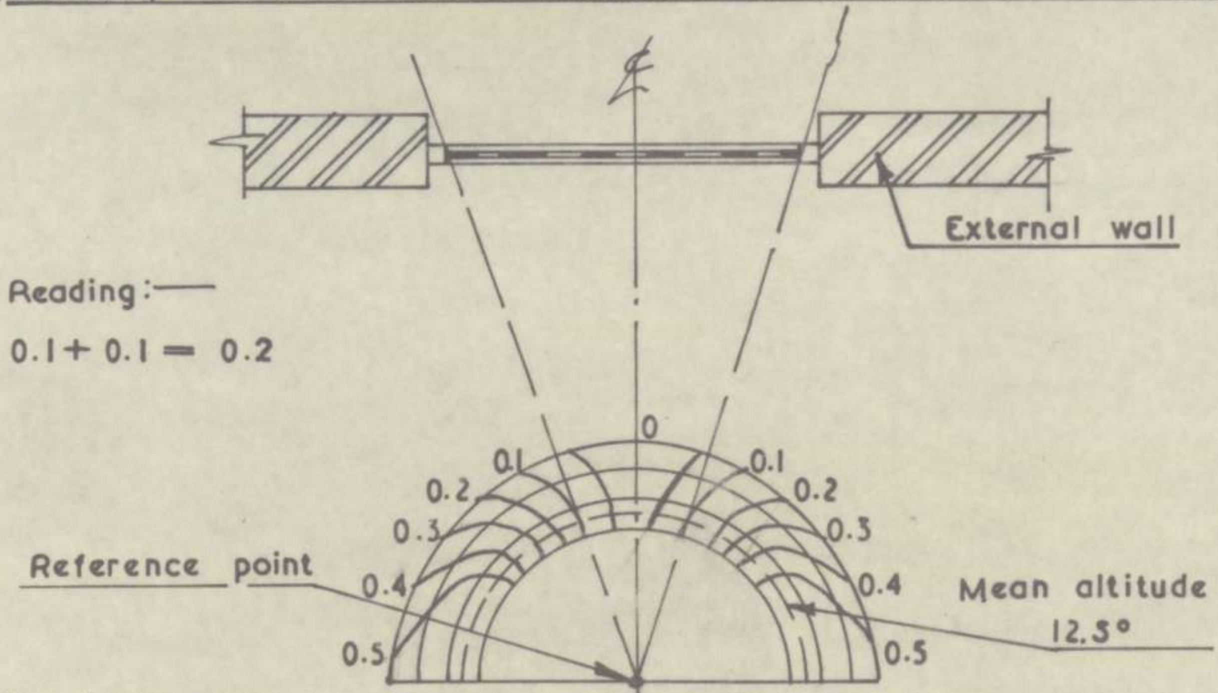


AUXILIARY DAYLIGHT FACTOR PROTRACTOR (FOR GLAZING AT 60° SLOPE)

— FIG. No. 6.10 —



(a) READING TAKEN THROUGH VERTICAL CROSS SECTION OF BUILDING



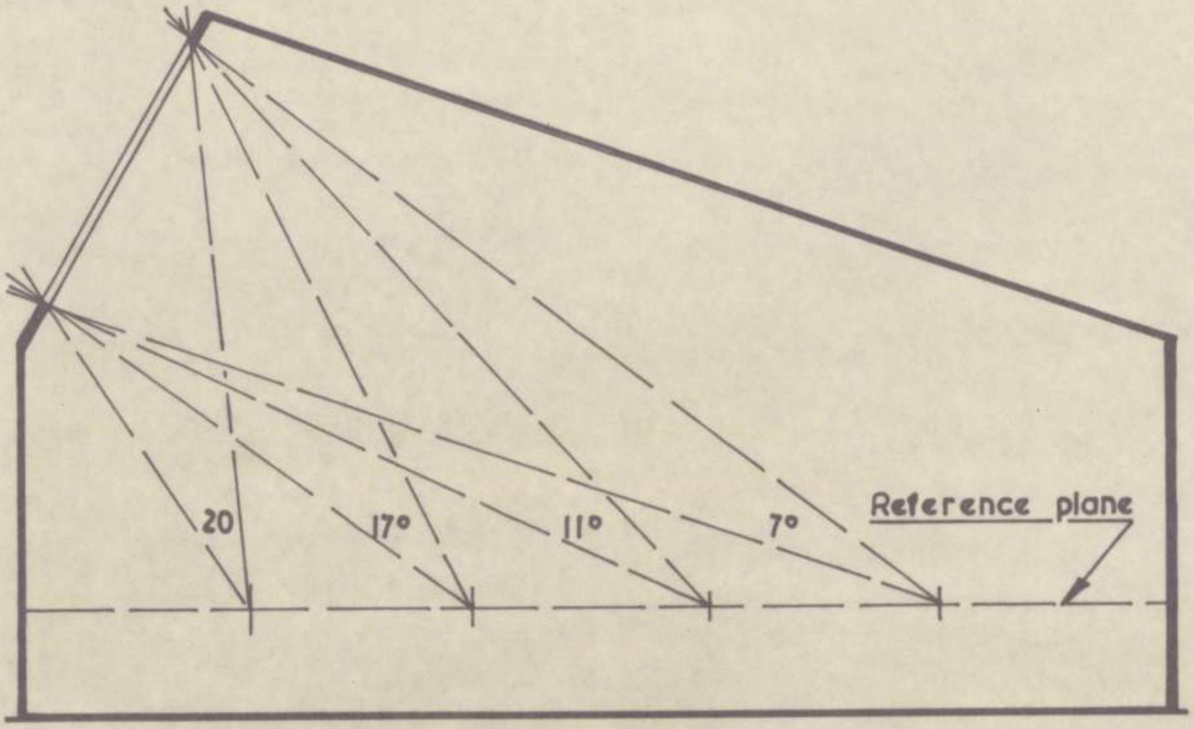
(b) READING TAKEN ON THE PLAN OF THE BUILDING

Sky Factor = Reading (a) X Reading (b)

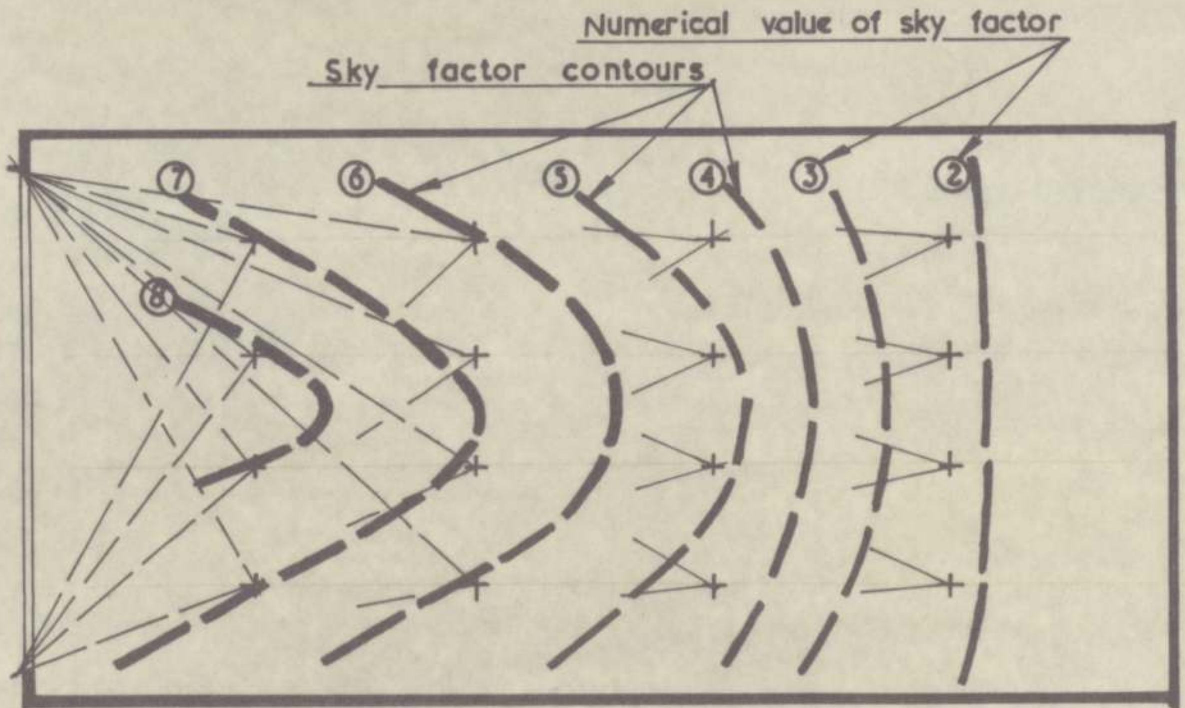
5 X 0.2 = 1.0 %

CALCULATION OF SKY FACTOR USING THE BUILDING RESEARCH STATION PROTRACTORS

— FIG No. 6.11 —



—VERTICAL CROSS SECTION THROUGH BUILDING —



—PLAN OF BUILDING —

EXAMPLE SHOWING THE REDUCTION IN THE NUMERICAL VALUE OF THE SKY FACTOR AS THE DISTANCE FROM THE WINDOW TO THE REFERENCE POINT INCREASES.

—FIG. No. 6.12. —

of general diffused light to soften harsh shadows, however, "shadowless" lighting should be avoided as shadows are one of the many aids contributing to a satisfactory internal environment which the Lighting Engineer uses to produce the required result.

The correct amount of light for any task is determined by:-

(a) The characteristics of the task - size of significant detail, contrast of detail with the background, and the distance of the object from the eyes.

(b) The sight of the worker - for example, older people need more light than young people.

(c) The speed and accuracy necessary in the performance of the work - if no errors are permissible, much more light should be provided than if a small amount of inaccuracy is acceptable.

(d) The ease and comfort of working - long and sustained tasks must be carried out without too much effort, whereas the person concerned can make a special effort for tasks of very short duration. The light needed to enable an elderly person to thread needles all day would be much greater than that required for ordinary sewing where a special effort could be made to thread an occasional needle without causing undue strain.

It is very unsatisfactory to rely on light fittings which direct all the light downwards as this will cause large contrasts of illumination, particularly if the fitting is seen against the background of a relatively dark ceiling, which gives a sense of gloom.

Flickering light sources also cause discomfort and should be avoided.

Some schemes use indirect lighting only, however, these systems usually give a shadowless form of lighting which eliminates any surface texture. At the same time, as the ceiling is the brightest surface in view and occupies such a large area it often proves to be a distraction. (Small bright surfaces are not often a distraction). An indirect system will also be less efficient than a direct system - even a white ceiling can absorb 20 to 30 per cent of the light which falls upon it.

A luminous ceiling is one in which lighting fittings are fixed above a layer of translucent material, giving an effect similar to indirect lighting, however, the ceiling is often brighter than for indirect lighting and is therefore unsuitable for areas where it is necessary to concentrate on a given object for long periods.

PERMANENT SUPPLEMENTARY ARTIFICIAL LIGHTING - (PSAL)

The reduction of the daylight factor as the reference point moved away from the window was discussed earlier in this chapter and illustrated in Figure 6.12. For very deep rooms it is sometimes necessary to supplement the daylight by artificial lighting over areas which would otherwise be relatively dark. This type of lighting installation is designed so as to provide a more uniform illumination during the hours of daylight and is called "permanent supplementary artificial lighting" and the abbreviation PSAL is often used.

THE LEVEL OF ILLUMINATION

The eye can adapt itself over a very wide range of conditions, as an example sunlit snow is more than a million million times as bright as a starlit scene, but the eye can adapt itself sufficiently to enable us to get about in both these very wide differences of illumination.

This adaptability should not be abused as poor lighting can often cause discomfort and loss of efficiency. Research work has shown that about 30 times more light is needed in order to make a task easy which could be carried out with great difficulty.

For example, drawing which requires a level of illumination of about 30 lux for easy performance can be done though with great difficulty at an illumination level of one lux.

The amount of light required for adequate visual performance is given in the Illuminating Engineering Society of Great Britain code of lighting as follows:-

Visual task	Level of illumination in lux	Corresponding daylight factors Percent
Casual reading	7	1.4
Ordinary bench & machine work	15	3.0
Carpentry	15	3.0
Sustained reading	15	3.0
Sewing	20	4.0
Typing	20	4.0
Drawing	30	6.0
Fine assembly work	50	10.0

The above values are minimum levels of illumination which must be provided by artificial, or natural lighting, or a combination of both.

ARTIFICIAL LIGHTING

The efficiency of artificial lighting depends upon:-

(a) The efficiency of the lamps used;

(b) The design of the lighting fittings;

(c) The way in which the light fittings are used (for example direct or indirect lighting) and the distance of the light source from the reference point.

(d) The colour of internal decoration - the floor and ceiling being most important.

A filament lamp gives about 12 lumens per watt (the larger lamps being more efficient than smaller lamps) whereas a fluorescent lamp gives about 3 times this amount of light for the same expenditure of power. Direct lighting mounted low over the object being examined gives the highest level of illumination for a given expenditure of energy, however, this also causes large variations in levels of illumination which can cause discomfort. Therefore, in order to avoid discomfort, direct lighting should not be placed too near to the object being viewed, a slightly greater distance between the source and the object provides a greater spread of light at a lower intensity of illumination. Good lighting is obtained when the whole field of vision is illuminated.

LOCAL LIGHTING

The eye tends to be attracted to the bright or more colourful parts of any view and therefore any object which requires special attention should be made particularly bright or colourful or both. If local lighting is provided the general lighting can be reduced, but it should never be reduced below 55 lux or 1 per cnet daylight factor in work places.

GLARE

Glare occurs when some parts of the field of vision are excessively bright in relation to the general level of brightness and can reduce the ability to see. For example a person standing in a room looking towards a sunlit window may be unable to see objects below window sill level. Light reflected from bright surfaces can have the same effect. These types of glare can be prevented by raising the level of illumination within the building or by providing light in dark corners.

Glare from very large windows is often reduced by placing louvres across the windows which enable the light transmission to be controlled.

RELATIONSHIP BETWEEN SPACING, HEIGHT AND LOCATION OF MULTI-STOREY BUILDINGS

Because the angle of the sun's rays and the intensity of light reduce with increase in latitude, multi-storey buildings of the same height have to be spaced further apart as the distance from the equator is increased.

This phenomenon can be studied by means of an helidon, which is an instrument designed for the study of sunlighting. It comprises a pivoted board, representing the earth's surface, on which is placed the model of a building or room orientated in the correct direction. The board is fitted to an angle with the vertical corresponding to the latitude of the place to be investigated and rotates about a vertical axis to give variations in the time of the day. The sun is represented by a light source which can be set at positions on a vertical scale to represent the time of the year.

HEATING

The heat loss from buildings can be accounted for by:-

(a) The amount of heat transmitted through walls, floor and roof of the building.

(b) The amount of heat lost due to air changes.

(c) Manufactured articles and other items being removed from the building.

Item (c) mainly occurs in industrial buildings and therefore only items (a) and (b) will be considered under this heading.

The amount of heat transmitted through the fabric of the building is proportional to the thermal transmittance value "U", and the difference between the internal and external temperatures.

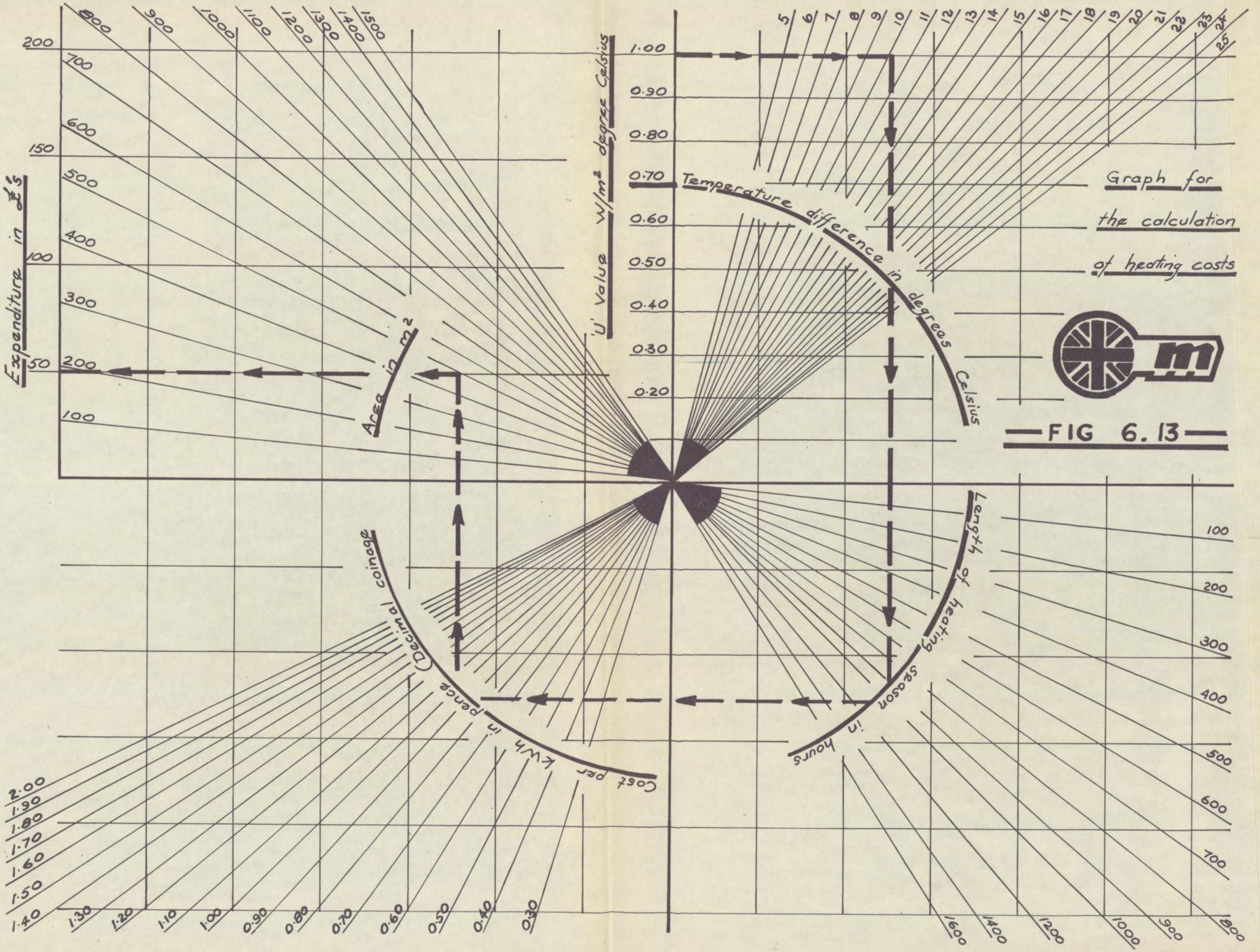
Figures 6.13 and 6.14 have been developed to provide a quick comparison of the heat loss through various forms of construction. However, an example will now be given which illustrates the way by which the heat loss can be calculated.

DATE

Thickness of Brick:	110 mm
Thickness of concrete block:	100 mm
Width of cavity:	75 mm
Thickness of plaster:	15 mm

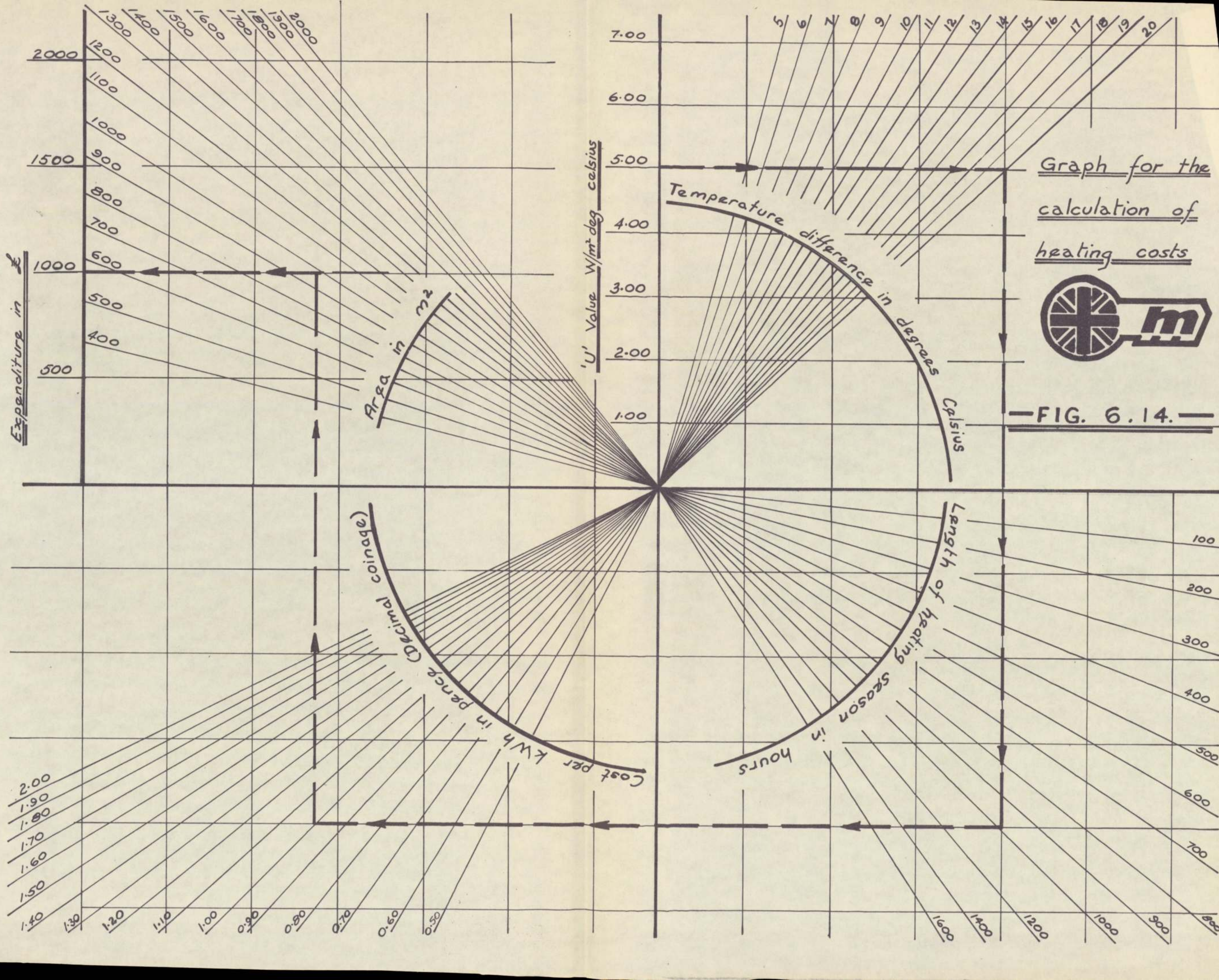
THERMAL CONDUCTIVITY OF:

Brick:	1.15 w/m^oC
Concrete block:	0.19 w/m^oC
Plaster:	0.58 w/m^oC
Internal surface resistance of wall (R_{SL}):	0.123 $m^2\ ^oC/W$
External surface resistance of wall (R_{SO}):	0.053 $m^2\ ^oC/W$



Graph for the calculation of heating costs

FIG 6.13



Graph for the calculation of heating costs

—FIG. 6.14.—

Resistance of cavity R_a: $0.176\ m^2\ ^oC/W$

Internal temperature t_I: 19^oC

External temperature (average) to: 7^oC

$$\text{Conductance (C)} = \frac{\text{Conductivity}}{\text{Thickness}} = \frac{K}{L}$$

$$\text{Thermal resistance (R)} = L/K$$

The thickness of all materials must be expressed in metres.

THERMAL TRANSMITTANCE VALUE "U"

$$U = (R_{SO} + R_b + R_a + R_c + R_p + R_{SL})^{-1}$$

Thermal resistance of outside surface R_{SO}	= 0.053
Brick $R_b = \frac{110 \times 10^{-3}}{1.15}$	= 0.096
Cavity R_a	= 0.176
Concrete $R_c = \frac{100 \times 10^{-3}}{0.19}$	= 0.526
Plaster $R_p = \frac{15 \times 10^{-3}}{0.58}$	= 0.026
Inside surface R_{SL}	= 0.123
Total Resistance of wall	= 1.000 $m^2\ ^oC/W$
$U = (1.0)^{-1}$	= 1.0 $W/m^2\ ^oC$

The current Building Regulations state that the "U" value for external walls should not exceed 1.703 $W/m^2\ ^oC$.

The total heat flow = U x temperature difference x area.

= 1.0 x (19 - 7) x area

= 12 x area (the units are watts).

SURFACE TEMPERATURES

The heat flow per unit area = q = U x temperature difference

where $U = \frac{1}{R}$ $\quad q = \frac{\text{Temperature difference}}{R}$

Therefore temperature of inner surface

$= t_i - (R_{si} \times q)$

$= 19 - (0.123 \times 12) =$

$= 19 - 1.476 = 17.5^{\circ}C$

Temperature of external surface

$= t_o + (R_{SO} \times q)$

$= 7 + (0.053 \times 12)$

$= 7 + 0.633 = 7.6^{\circ}C$

The affect of the surface temperatures upon condensation and the internal environment will be discussed later. Let us first examine a simplified calculation for the total heat loss in a building.

DATA

Building dimensions:

Length 60m

Width 30m

Height of external walls 3m

Flat roof; area $= 60 \times 30 = 1800\ m^2$

Area of windows $= 140\ m^2$

Number of air changes = 1.5 per hour

Internal and external air temperatures as for previous example

"U" values given in calculation

Element	Area m^2	x	U $W/m^2\ ^{\circ}C$	x	Temperature difference $^{\circ}C$	=	Heat Loss W
Roof	1800	x	1.14	x	12	=	21,858
Floor	1800	x	0.85	x	12	=	16,320
Windows	140	x	5.0	x	12	=	8,400
External Wall = (180 x 3) - 140 = 540 - 140 =	= 400	x	1.0	x	12	=	4,800
Total heat loss through fabric						=	51,378

HEAT LOSS DUE TO AIR CHANGES

Heat loss = Mass x Specific Heat Capacity x Temperature Change

$$\text{Mass flow rate} = \frac{\text{Heat Loss}}{\text{Specific Heat Capacity x Temperature Change}}$$

Continuing the above example.

Where Mass flow rate = volume x air change rate x density. The Watt is equal to one joule per second, therefore, as the air changes are expressed as number per hour they have to be divided by 60^2 in order to convert to air changes per second.

The constants in the "mass flow rate equation" are

(a) the density of air

(b) the specific heat capacity (SHC)

(c) 60 x 60

$$\frac{(a) \times (b)}{(c)} = \frac{1.2 \times 1.024 \times 10^3}{60 \times 60} = 0.341$$

Heat loss = Volume x air change rate x temp. diff x 0.341

= 60 x 30 x 3 x 1.5 x 12 x 0.341 J/S

33 145.2 J/S = 33145.2 W

Total heat loss = 33145 + 51378

= 84523 W

One of the factors which should be noted in the above example is the very high proportion of heat lost by air changes and that the number of air changes used was only 1.5/hour which is a relatively low air change rate. It will be seen therefore that it is well within the region of probability to lose at least as much heat due to air changes as through the fabric of the building.

It was stated at the beginning of the example that a simplified problem had been chosen in order to illustrate the way in which a heat loss calculation would be made. Variables which were not included are as follows:

(1) Temperature gradient. Due to the reduction in the density of air as the temperature increases a temperature gradient develops within a building so that the temperature difference at roof level is greater than at floor level. This temperature gradient can also be responsible for the development of a stack effect in multi-storey buildings by which stair wells or other vertical areas act in a similar way to tall chimneys.

(2) The thermal transmittance values vary with the degree of exposure and also with orientation as shown in Figures 6.15 and 6.16.

(3) Moisture content can also alter the thermal transmittance value.

(4) Any heat balance should take into account heat input from sources other than the recognised heating system. Such sources include solar gain, the heat emitted from the occupants of the building and the heat produced by machinery or manufacturing processes.

Figures 6.15 to 6.18 give typical thermal transmittance values for a number of structural elements, other values together with conductivities of building materials can be obtained from the Institution of Heating and Ventilating Engineers Guide.

E 6.15

AL TRANSMITTANCE VALUES FOR WALLS W/M^2 ^oC

	Exposure					
cation S W, SW, SE NW N, NE, E	Sheltered	Normal Sheltered	Severe Normal Sheltered Sheltered	Severe Normal Normal	Severe	Severe
brickwork with nal face plas-						
114 mm	2.61	2.78	3.12	3.23	3.46	3.69
229 mm	2.05	2.73	2.32	2.44	2.56	2.73
343 mm	1.70	1.82	1.88	1.88	1.99	2.22
silated Cavity work with inter- ace plastered						
279 mm	1.53	1.59	1.54	1.70	1.76	1.82
394 mm	1.31	1.36	1.42	1.48	1.54	1.54
Concrete						
102 mm	2.84	3.12	3.35	3.64	3.91	4.25
152 mm	2.50	2.67	2.84	3.06	3.23	3.46
203 mm	2.22	2.32	2.26	3.23	2.84	2.96
e windows	3.97	4.48	5.00	5.67	6.47	7.38
e windows	2.32	2.50	2.67	2.84	3.00	3.18
asbestos	3.63	4.08	4.54	5.05	5.67	6.36
gated estos	4.37	5.00	5.67	6.53	7.55	8.85
gated iron	4.48	5.17	5.90	6.81	7.95	9.47
m foamed concrete, ered nally, ered nally	0.71	0.80	0.91	1.05	1.23	1.41

FIGURE 6.16

THERMAL TRANSMITTANCE VALUES FOR ROOFS W/M^2 °C

	Type	EXPOSURE		
		Normal	Sheltered	Severe
(1)	Asphalt on 152 mm thick concrete	3.00	3.23	3.52
(2)	(1) plus plaster	2.73	2.96	3.18
(3)	(2) plus 1 in thick cork	1.08	1.14	1.19
(4)	Corrugated asbestos pitched roof	6.81	7.95	9.64
(5)	(4) plus 12 mm thick lining of fibre board	2.67	2.84	3.00
(6)	Tiles on battens	6.92	8.51	11.35
(7)	(6) plus felt	3.00	3.97	4.42

FIGURE 6.17

THERMAL TRANSMITTANCE VALUES FOR GROUND FLOORS

	Type	W/M^2 °C
(1)	25 mm T&G boarding over ventilated void	2.28
(2)	(1) Covered with lino	1.99
(3)	(2) plus 12 mm fibre board	1.36
(4)	102 mm concrete floor with pitch-mastic or other composition finish	1.14
(5)	102 mm concrete floor with wood blocks	0:85

FIGURE 6.18

THERMAL TRANSMITTANCE VALUES FOR INTERNAL FLOORS $W/m^2\ ^oC$

	Type	Heat flow downwards	Heat flow upwards
(1)	Wood on joists with plastered ceiling	1.25	1.65
(2)	150 mm concrete with 50 mm screed	1.99	2.44
(3)	(2) plus wood blocks	1.48	1.70
(4)	Hollow Blocks		
	150 mm thick	1.88	2.27
	200 mm thick	1.70	1.99

When heating and ventilating engineers calculate the heat requirements of a building they must ensure that the heating system can cope with the expected extremes of temperatures; however, when carrying out an economic study we are only interested in the average temperature difference.

Observations made at Kew over a period of 30 heating seasons produced an overall mean temperature of 7^oC. Therefore an internal temperature of 19^oC results in a temperature difference of 12^oC, which compares with a temperature difference of 20^oC used by the heating and ventilating engineer when designing a heating installation.

The heat input of a building cannot be turned on and off to the same extent as electric light and therefore varying periods of daily occupancy of a building do not produce significant differences in fuel consumption and can usually be ignored when making cost-in-use studies.

A normal heating season can be assumed to start at the beginning of October and to end in April of the following year. This results in a heating season of approximately 210 days duration; however this number can be reduced if it is normal practice to close down the heating installation during vacations.

QUALITY OF HEATING

As in the provision of an adequate lighting system there is a requirement for quality in addition to quantity.

Hot bodies radiate heat to relatively cold bodies and therefore if the internal surfaces of a building are at a lower temperature then the internal air a feeling of discomfort can ensue which will not be removed by increasing the internal air temperature.

It was shown in the worked example that the internal surface temperature was equal to:-

$$t^{i} - (R_{si} \times q)$$

where t_i = the internal air temperature

R_{si} = the internal surface resistance

q = the heat flow per unit area

$= U \times (t_o - t_i)$

U = Thermal transmittance value in $W/m^2 {}^oC$

t_o = the external air temperature

It will be seen therefore that an improvement in the "U" value produces a higher internal surface temperature which in turn produces a more satisfactory environment.

Figure 6.19 shows the differences between internal air temperature and internal surface temperature for various values of "U" for an external air temperature of 0°C and an internal air temperature of 19°C.

FIGURE 6.19

Thermal Transmittance Value (U) W/m² °C	Inside Surface Temperature Degree C	Temperature Difference Inside air - Inside surface Degree C
8	0.30	18.70
6	4.98	14.02
4	9.65	9.35
2	14.33	4.67
1	16.66	2.34

In addition to radiation, cold surfaces can also result in condensation. For any given moisture content of the air within a building there is a corresponding dew-point temperature at which the air becomes saturated; if it is cooled below this temperature by contact with adjacent surfaces, it deposits water upon them.

Figure 6.20 shows the temperature differences between the internal air and internal surface for different ambient conditions of humidity which must not be exceeded if condensation is to be avoided.

FIGURE 6.20

Relative Humidity %	Air Dew Point Degree C	Maximum Permissible Temperature Difference Degree C
60	8	8
70	10	5.5
80	12	3.3
90	14	1.7

SOLAR RADIATION

In a country such as Great Britain the solar radiation is only about one third of the value recorded in regions such as North Africa and this may account for the neglect of solar gain which occurs at the design stage. Nevertheless, solar gain is an important factor to consider as the occupants of the Cambridge History Faculty will testify.

Experimental work is being carried out in this country in which buildings are being heated by solar cels. However a detailed investigation of this system is considered to be outside the scope of this thesis.

LIGHTING AND HEATING ECONOMICS - GENERAL CONCLUSIONS

It has been shown that when designing lighting and heating installations quality is equally as important as quantity and that high levels of either lighting or heating does not by itself produce a satisfactory internal environment. Economic comparisons should therefore be made with quality in mind.

Very large windows will produce high levels of illumination in areas of the room close to the windows, but can also introduce glare problems and cause areas of the room remote from the windows to seem dark. Large windows will also increase heat losses and can cause discomfort by radiation especially where single glazing is adopted. Double glazing will not affect solar radiation.

An improvement in the thermal transmittance value of an element results in a more pleasant internal environment by increasing the internal surface temperature thereby eliminating problems associated with condensation and radiation.

THE SOUND INSULATION OF BUILDINGS

INTRODUCTION

The most satisfactory way of dealing with noise is to reduce it at the source, the alternative is to protect every building likely to be affected which often results in more costly construction.

Noise can eminate from within a building and can be either airborne or structure borne. Recent changes in constructional techniques in which light weight, pre-fabricated forms of construction have been adopted, have often aggrevated the sound insulation problem.

THEORY

The simple analogy used in physics, in which the waves formed by a stone dropped into a pool of water, are likened to the sound waves produced by a vibrating body provides a useful visual means of studying the propagation of sound waves. As the distance from the source increases, the magnitude of the noise reduces due to the dispersal of energy over the ever increasing area.

If we continue with our analogy it will be seen that obstructions in the path of the waves, disturb the wave pattern and so it is with the sound waves, which are disturbed by ground reflections, temperature gradients and surrounding obstructions such as buildings. The reflective properties of the walls of a room can actually produce noise levels at some areas of a room, higher than the noise level at the source.

ABSORPTION AND INSULATION

Noise levels can be reduced either by the sound absorption properties of the material or by the insulation properties of the component. Sound absorption, which largely affects noise levels within a room, is a measure of the sound energy taken up by the surface material and is therefore influenced by the surface properties of that material.

Sound insulation is the ability of a dividing wall or partition to reduce the transmission of sound to an adjoining room and is a property of the whole component.

AIRBORNE SOUND

The main factors affecting insulation against airborne sound are:-

weight, airtightness, uniformity, discontinuity and stiffness.

WEIGHT - A heavy mass will resist sound vibrations better than a light mass and of all the factors influencing sound insulation, weight is the most important.

AIRTIGHTNESS - The importance of airtightness can be illustrated by considering the insulation value of a 75 mm thick clinker concrete wall having an area of 10 sq metres and plastered on both sides. This type of construction will transmit about a 1/10,000 part of the sound energy falling on it, however, if a hole equal to 1/1,000 part of the total area is placed in the wall, ten times as much sound will pass through the hole as through the rest of the partition.

UNIFORMITY - Variations in the uniformity of the insulation value of a particular element will result in the reduction in the net value of the insulation. For example single glazing or light weight doors in a wall will cause a considerable reduction in the insulation value of the wall.

DISCONTINUITY - When sound waves strike the surface of a partition wall, the partition vibrates and thereby transmits sound energy, although somewhat reduced, to the adjoining room. If another partition is built alongside the first it might appear that sound reduction would be obtained twice over, since the first partition would re-radiate the sound energy into the air and it would then encounter the second barrier and suffer a second reduction of the same magnitude. This does not occur. Instead, the double wall tends to act as a single wall, but with some extra insulation due to the cavity. The sound reduction due to the cavity will depend upon such factors as the width of the cavity, the amount of sound absorbent it contains and the type and amount of bridging across the cavity. As an example, a 280 mm cavity brick wall with strip metal wall ties gives less insulation than a 230 mm solid brick wall, however, considerable improvements can be obtained by completely isolated box structures which have a minimum amount of structural contact.

STIFFNESS - Some degree of sound insulation can be obtained in lightweight partitions if the internal stiffness of the material forming the partition is reduced so as to dampen down the effect of sound vibrations.

IMPACT SOUND RESISTANCE

The most efficient way of controlling impact sound in buildings is to provide a resilient surface layer such as carpet, cork or rubber as a floor finish. A resilient layer can also be included in the form of glass or mineral wool under a floating floor, which because of the discontinuous nature of the construction, improves the airborne sound transmission in addition to providing insulation against impact noise.

THE DECIBEL UNIT OF MEASUREMENT

The ratio of the sound energy in a receiving room to the sound energy in the room which contains the source is expressed in decibels abbreviated "dB".

$$\text{The reduction in dB} = 10 \log_{10} \frac{\text{Sound energy in room containing source}}{\text{Sound energy in receiving room}}$$

Therefore if 50% of the sound energy in one room is transmitted to an adjoining room the reduction in dB would be

$$10 \log_{10}\frac{2}{1} = 3.01 \text{ dB.}$$

Examples of dB values corresponding to ratio changes of sound energy are as follows:-

10 dB	=	10
20 dB	=	100
30 dB	=	1,000
40 dB	=	10,000

Therefore if a partition has an insulation value of 30 dB the sound energy passing from one side of the partition to the other is reduced to 1/1000 of the original energy.

As will be seen later the frequency of the sound waves is as important as the loudness and in order to compare noise varying in magnitude as well as frequency, accoustics engineers have devised a "phon" scale. However, as the general principles of sound insulation required for this study can be appreciated without reference to the phon or sone scale no further discussion of these forms of sound measurement will be included.

THE AFFECT OF FREQUENCY

The frequency of sound waves audible to the human ear vary from 20 to 20,000 cycles per second and it has been shown that noises of equal loudness are annoying at the highest frequencies. It is here where the Builder receives a small bonus as the sound insulating performance of all partitions tends to improve with rising frequency.

NOISE LEVELS

The degree of annoyance produced by sound transmission depends upon the noise levels in the adjoining rooms and is an important factor to bear in mind when considering the provision of partition walls between classrooms.

The difficulties encountered with folding or sliding partitions, sometimes used in school buildings for varying the size of classrooms are well known to the teaching profession.

Most partitions of this type have very low sound insulating values often rendering them almost useless. The light weight of the partition which is necessary to allow it to be moved and supported on the gear in addition to the air gap which exists at the top and bottom of the partition provides very little insulating value. Even with double partitions and special precautions to reduce gaps it is difficult to achieve acceptable standards.

THE EFFECT OF INDIRECT TRANSMISSION

Improvements in the sound insulation value of partition walls will not always affect the total transmission significantly due to the presence of flanking transmission.

This occurs when the sound energy travels along the connecting wall to emerge in the adjoining room.

Flanking transmission can be reduced by providing a good bond between the interconnecting walls and for this reason the practice of inserting strips of non-rigid material, around the edges of wall panels etc., in order to provide a barrier to sound waves is no longer recommended.

It is interesting to note that in domestic building it is not practical to provide a higher standard of sound insulation for party walls than one brick thickness plastered on both sides because at this level of insulation, flanking transmission is about equal to direct transmission and there is therefore little to ge gained from improving only direct transmission.

SUMMARY

It has been shown that the two most important factors affecting sound insulation are weight and airtightness.

Flanking transmission can be reduced by providing restraint to all walls by using heavy intermediate floors such as reinforced concrete and by adequately bonding together all interconnecting walls.

Sound considerations are based upon the relative noise levels of adjoining rooms.

The noise level within a room is affected by the sound absorbent properties of the surrounding areas which is a function of the surface properties of the materials.

THE INITIAL COST

The affects of variations in wage rates, material costs, changes in construction technique, competition and construction indices were all discussed under the heading of "Date of Construction".

A detailed study of initial costs for a number of university and college buildings is given in chapter IX. This section is therefore devoted to the way in which initial costs can be incorporated with maintenance and running costs in order to complete a cost-in-use exercise.

Irrespective of whether a building is owned or rented the effective cost is really an annual one, as on the one hand, the occupant of the building is subject to an annual rent or on the other hand, interest has to be paid on money borrowed and the capital replaced.

This annual cost is called the "annual equivalent" and depends upon the interest charged, the economic life of the building as well as on the initial cost of construction. It is also sometimes necessary to convert, either a number of annual payments, or a sum of money spent during the life of a building (eg expenditure on maintenance or replacements) to a present worth. The value of present worth and the annual equivalent is determined as follows:-

THE PRESENT WORTH OF A SINGLE PAYMENT PAYABLE IN THE FUTURE

If £1 invested at 6% is worth £10.29 at the end of 40 years, then £$\frac{1}{10.29}$ is worth £1 at the end of 40 years. The £$\frac{1}{10.29}$ is known as the present worth and is normally denoted by v^n and equals $\frac{1}{(1+L)^n}$ where L is the annual rate of interest on the capital. n is the number of years.

Figure 6.19 gives the values of present worth of a single payment payable in "n" years.

THE PRESENT WORTH OF REGULAR ANNUAL PAYMENTS

Let a_n be the present worth of regular annual payments over "n" years.

V^1 to V^n be the present worth of each single payment

L as before

$$a^n = V^1 + V^2 + V^3 + \dots\dots V^n$$

$$= \frac{1}{(1+L)} + \frac{1}{(1+L)}2 + \frac{1}{(1+L)}3 + \dots\dots \frac{1}{(1+L)^n}$$

$$(1+L)a^n = 1 + \frac{1}{(1+L)} + \frac{1}{(1+L)^2} + \dots\dots \frac{1}{(1+L)^{n-1}}$$

$$(1+L)\ an - an = 1 - \frac{1}{(1+L)^n}$$

$$a^n = \frac{1 - \frac{1}{(1+L)^n}}{L}$$

The annual equivalent will therefore be $1/a^n$ and figures 6.21 and 6.22 give the values of present worth and annual equivalent for a sum of £1 over a period of "n" years at rates of interest from 2 to 8%.

THE PRESENT WORTH OF FUTURE PAYMENTS

The present worth of a number of payments throughout the life of the building can be obtained by adding together the present worths of each individual payment. Figures 6.23 and 6.24 give the present worth of regular annual payments and the present worth of periodic payments of £1 every "t" years for (n - t) years in £'s.

PREDICTION ERRORS

The factors which cause prediction errors are:

> Changes in interest rate and incorrect assumptions regarding the life of the building replacement costs and maintenance.

FIGURE 6.21

The Present Worth of a Single Payment of £1. Payable in "n" years in £'s

Number of Years	Rate of Interest			
	2	4	6	8
1	0.980	0.962	0.943	0.926
2	0.961	0.925	0.890	0.857
3	0.942	0.889	0.840	0.794
4	0.924	0.855	0.792	0.735
5	0.906	0.822	0.747	0.681
6	0.888	0.791	0.705	0.630
7	0.871	0.760	0.664	0.584
8	0.853	0.731	0.628	0.541
9	0.835	0.703	0.592	0.501
10	0.820	0.676	0.558	0.463
15	0.743	0.555	0.417	0.316
20	0.673	0.456	0.312	0.215
25	0.610	0.375	0.233	0.146
30	0.552	0.308	0.174	0.100
35	0.500	0.253	0.130	0.068
40	0.453	0.208	0.097	0.046
45	0.410	0.171	0.073	0.031
50	0.372	0.141	0.054	0.021
55	0.337	0.116	0.041	0.015
60	0.305	0.095	0.030	0.001

FIGURE 6.22

Annual Equivalent of an initial Payment of £1 (in £'s)

Number of Years	Rate of Interest (Percent)			
	2	4	6	8
1	1.020	1.040	1.060	1.080
2	0.515	0.530	0.545	0.561
3	0.347	0.360	0.374	0.388
4	0.263	0.275	0.289	0.301
5	0.212	0.225	0.237	0.251
6	0.179	0.191	0.203	0.217
7	0.155	0.167	0.179	0.192
8	0.137	0.149	0.161	0.170
9	0.123	0.134	0.147	0.160
10	0.111	0.123	0.136	0.149
15	0.078	0.090	0.103	0.117
20	0.061	0.074	0.087	0.102
25	0.051	0.064	0.078	0.092
30	0.045	0.058	0.073	0.089
35	0.040	0.054	0.069	0.086
40	0.037	0.051	0.066	0.084
45	0.034	0.048	0.065	0.083
50	0.032	0.047	0.063	0.082
55	0.030	0.045	0.063	0.081
60	0.029	0.044	0.062	0.081

FIGURE 6.23

The Present Worth of Regular Annual Payments of £1 for "N" years (in £'s)

Number of Years	Rate of Interest (Percent)			
	2	4	6	8
1	0.98	0.96	0.94	0.92
2	1.94	1.89	1.83	1.78
3	2.88	2.78	2.67	2.57
4	3.81	3.63	3.47	3.33
5	4.71	4.45	4.21	3.98
6	5.60	5.24	4.92	4.62
7	6.47	6.00	5.58	5.20
8	7.33	6.73	6.21	5.88
9	8.16	7.44	6.80	6.24
10	8.98	8.11	7.36	6.71
15	12.85	11.12	9.71	8.56
20	16.35	13.59	11.47	9.82
25	19.52	15.62	12.78	10.91
30	22.40	17.29	13.77	11.26
35	24.99	18.67	14.50	11.65
40	27.35	19.79	15.05	11.92
45	29.49	20.72	15.46	12.11
50	31.43	21.48	15.76	12.23
55	33.17	22.11	15.99	12.31
60	34.75	22.62	16.16	12.37

FIGURE 6.24

The Present Worth of Periodic Payments of £1 every t years for (n - t) years (in £'s)

Life of Building in Years	Life of Components					
	1	2	5	10	20	30
	Rate of interest = 2%					
10	8.160	3.627	0.906	-		
20	15.677	7.422	2.469	0.820	-	
30	21.848	10.534	3.752	1.493	0.673	-
40	26.897	13.089	4.804	2.046	0.673	0.552
50	31.058	15.184	5.667	2.498	1.126	0.552
60	34.445	16.903	6.375	2.870	1.126	0.552
	Rate of interest = 4%					
10	7.435	3.300	0.822			
20	13.134	6.206	2.053	0.676		
30	16.984	8.168	2.884	1.132	0.456	
40	19.585	9.494	3.446	1.440	0.456	0.308
50	21.342	10.390	3.826	1.649	0.665	0.308
60	22.529	10.995	4.082	1.789	0.665	0.308
	Rate of interest = 6%					
10	6.802	3.014	0.747			
20	11.158	5.256	1.723	0.558		
30	13.591	6.508	2.268	0.870	0.312	
40	14.949	7.207	2.572	1.044	0.312	0.174
50	15.708	7.597	2.742	1.142	0.409	0.174
60	16.131	7.815	2.837	1.196	0.409	0.174
	Rate of interest = 8%					
10	5.247	2.763	0.681	-		
20	9.605	4.508	1.460	0.463	-	
30	11.160	5.316	1.821	0.678	0.215	-
40	11.874	5.701	1.989	0.778	0.215	0.100
50	12.209	5.874	2.066	0.824	0.261	0.100
60	12.369	5.954	2.102	0.845	0.261	0.100

Reference to Figure 6.22 shows that a change in the interest rate from 6 to 8 percent has the effect of increasing the capital cost by 30% whilst variations in the life of a building over 60 years is negligible.

Attempts which I made to obtain information on maintenance and replacement costs were fruitless mainly because these costs are not recorded for individual buildings. However, Chapters VIII and IX are devoted to a study of annual expenditure costs. It is shown that salaries for academic staff account for approximately 15 times the sum of money spent on maintenance and 6 to 8 times the annual equivalent of the initial costs. It was for this reason that emphasis has been placed on the need for flexibility in building design in order to use academic staff to the utmost efficiency.

The discussion on present worth and annual equivalent costs used in this section has been based upon information obtained from the book "Building Design Evaluation" by P A Stone, M.Sc. (Econ.), Ph.D and a more detailed and extensive discussion can be obtained therefrom.

The following two examples have been taken from the above book, but for our purposes an interest rate of 8 percent has been adopted instead of the 5 percent used in the original examples.

EXAMPLE

Find the annual equivalent cost over the life of a building with an initial cost of £100,000, annual costs of £3,000 for regular cleaning, quinquennial repairs of £10,000 and replacement costs every 20 years of £20,000. The life of the building can be taken as 60 years and interest at 8 percent. The annual equivalent is:-

			£	
100,000 (0.081)		=	8,100	(Fig. 6.22)
3,000 (1.0)			3,000	
10,000 (2.102)	= 21020			(Fig. 6.24)
20,00 (0.261)	5220			(Fig. 6.24)
	26240 (0.081)		2,125	(Fig. 6.22)
Annual equivalent cost			13,225	

EXAMPLE

Find the annual equivalent value for a building with a life of 60 years, of a component which costs £1,000 to install, lasts 30 years and then needs to be replaced at a cost of £1,200 and which in the meantime costs £100 a year for an annual overhaul and an extra £500 every 5 years. Interest can be taken as 8%. The first step is to summarize the stream of payments to be met. These are:

Initial cost: £1,000

Annual payments: £100 from year 1 to year 59

Quinquennial payments: £500 from year 5 to year 55

Single payments: £1,200 - (£500 + £100) ie £600 after 30 years.

The next step is to calculate the present worth:-

		£	
1,000 (1)	=	1,000.0	
100 (12.37)		1,237.0	Fig. 6.22
500 (2.102)		1,051.0	Fig. 6.24
600 (0.100)		60.0	Fig. 6.24
		3,348.0	

The annual equivalent = 3,348 (0.081)   Fig. 6.22

= £271.188

CHAPTER VII

CHAPTER VII

COST CONTROL

GOVERNMENT CONTROL OF EDUCATIONAL BUILDING EXPENDITURE

The State first took an interest in education in 1839 when financial aid was granted to certain charitable organisations providing religious and secular education. At the same time the Government set up an education department which remained in existence until the School Boards were established in 1870. These Boards were empowered to see that all children between the ages of 5 and 10 years attended the schools which were to be provided and maintained out of rates and Government grants, thus marking the first step in the full development of an organised system of education.

Local Education Authorities were brought into being in 1902 in order to build new schools and to provide an effective administration for both Board and Church schools.

The planning and design of the Board schools were based mainly upon functional considerations and it was not until the beginning of the 20th Century when the newly established Schools Medical Service drew attention to the health and welfare of the child, that modifications were made at the planning stage of new school buildings in order to provide, cross ventilation, high levels of natural illumination, sheltered circulation areas and better sanitary arrangements.

The Board of Education (established in 1899) issued Building Regulations in 1907 which enunciated new principles of lighting, hygiene and classroom dimensions as well as recommending the provision of assembly halls, gymnasia, practical rooms and playground areas for practical training. These regulations were not statutory and after being revised in 1914 were withdrawn in 1926 and replaced by Educational Pamphlets numbers 86 and 107, published in 1931 and 1936 respectively.

The Education Act of 1944 required the Minister to prescribe by regulation the standards with which the premises of primary and secondary schools should comply and the "STANDARDS FOR SCHOOL PREMISES REGULATIONS 1945" came into formal operation on 1st April, 1945 and had statutory force. These Regulations applied to county and voluntary primary schools, secondary schools, nursery schools and classes, special schools and boarding accommodation and although they have been subject to amendments since 1945 they prescribed for the first time the maximum and minimum standards which were to be maintained in school buildings.

COST CONTROL

The Board of Education appointed a Committee in 1910 to enquire into the cost of school buildings and in 1911 an act was passed which gave new school buildings exemption from local byelaws in order to encourage experimentation with alternative methods of construction. The study of non-traditional methods of construction is still very much in evidence today and a discussion of the construction details and costs are included in another chapter.

The Department of Education and Science is responsible for all public educational building (including universities in England and Wales, but control of university buildings is exercised through the University Grants Commission.

DEPARTMENT OF EDUCATION AND SCIENCE PROCEDURE FOR CONTROLLING EXPENDITURE ON SCHOOL AND FURTHER EDUCATIONAL BUILDINGS

The total expenditure limit for educational buildings is agreed between the Department of Education and Science and the Treasury annually, the agreed sum is then apportioned by the Department, between authorities and control is further exercised on the costs and standards of the buildings provided. The expenditure on maintenance and upkeep of educational buildings is not the responsibility of the Department of Education and Science and the effect of the present system of cost control upon the running costs will be discussed in a later chapter.

Expenditure on educational buildings is divided into two sections, minor and major works.

1 MINOR WORKS: Any contract for work valued at under £20,000 on existing buildings is provided for by allocating a lump sum allowance to local authorities and approval is not required from the Department of Education and Science for this type of project provided that the total allocation is not exceeded.

2 MAJOR WORKS: Expenditure on all new buildings and contracts valued at over £20,000 is subject to control by the Department of Education and Science and the procedure outlined in figures 7.1 and 7.2 must be followed.

Cost control of major works is exercised by applying expenditure limits uniformly throughout the country, without taking account of geographical location and were first introduced by the then Ministry of Education in 1950. Before that time building proposals were approved by the Ministry when they seemed reasonable.

Before studying the way in which control is exercised, the effectiveness of the measures taken by the Department of Education and Science in controlling the initial costs of school buildings should be considered.

When cost limits were first introduced the cost per place in primary and secondary schools was £170 and £290 respectively. Figures 73 and 74 illustrate the effect of the Department's control on initial costs between the years 1949 and 1956 and are reproduced from the Ministry of Education Pamphlet No.33 "The Story of Post Was Building".

EXPENDITURE LIMITS TAKE THE FORM OF:-

(a) Cost per place

(b) Residential cost unit

(c) Cost per square foot of net floor area and are applied as follows:-

DEPARTMENT OF EDUCATION & SCIENCE PROCEDURE FOR CONTROLLING EXPENDITURE ON SCHOOL BUILDING

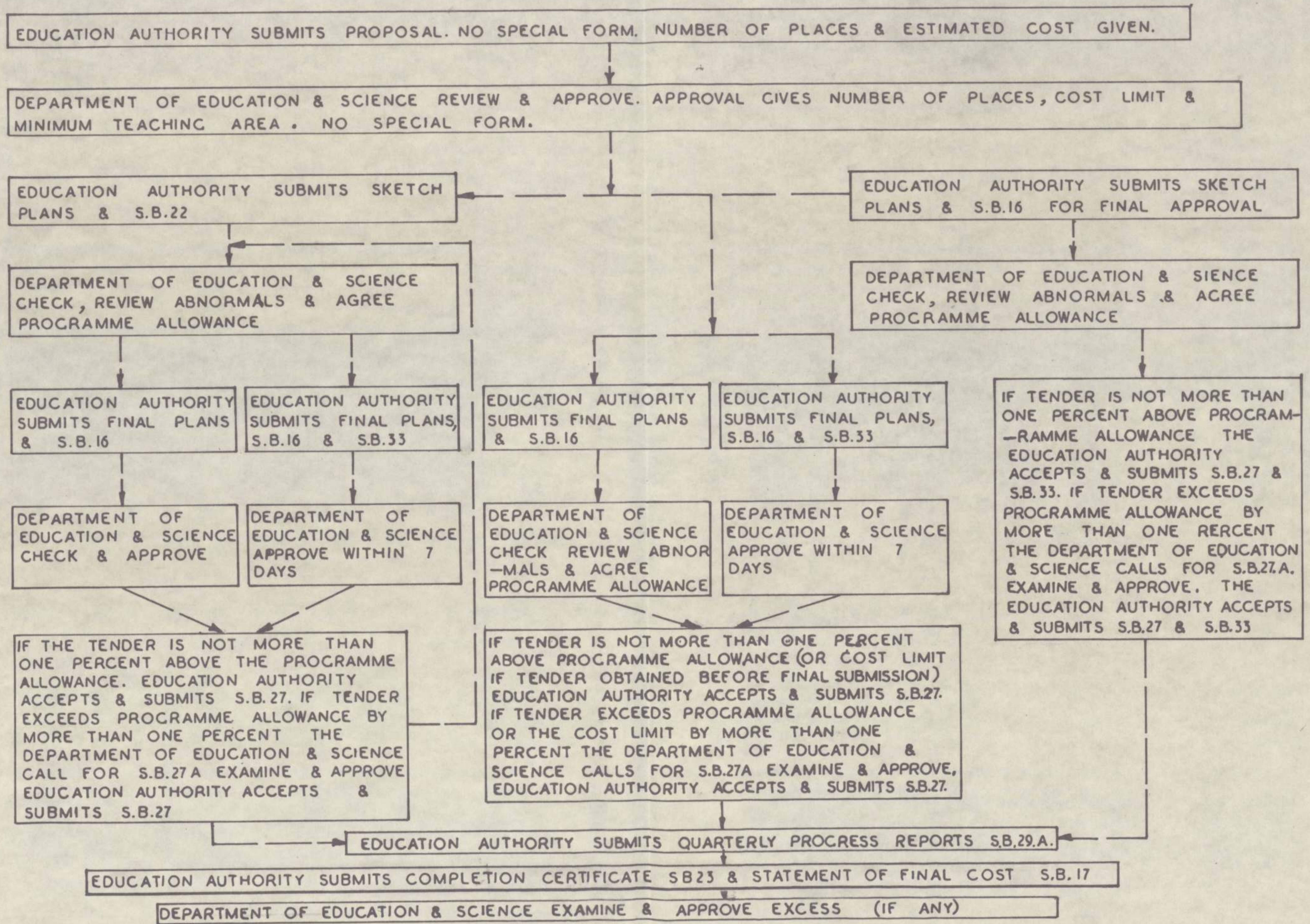


FIG No 7.1.

DEPARTMENT OF EDUCATION & SCIENCE PROCEDURE FOR CONTROLLING EXPENDITURE ON FURTHER EDUCATIONAL BUILDING.

EDUCATION AUTHORITY SUBMITS PROPOSALS ON S.B.34, STATING COURSES & NUMBERS OF STUDENTS

↓

DEPARTMENT OF EDUCATION & SCIENCE REVIEW. AGREED PROPOSAL TRANSLATED INTO NETT TEACHING AREA. EXPENDITURE LIMIT CALCULATED. EDUCATION AUTHORITY NOTIFIED OF APPROVAL GIVING COURSES NUMBERS OF STUDENTS NETT TEACHING AREAS & EXPENDITURE LIMIT. NO SPECIAL FORM.

↓

EDUCATION AUTHORITY SUBMITS S.B.22 & SCHEDULE OF ACCOMMODATION.

↓

DEPARTMENT OF EDUCATION & SCIENCE CHECK & APPROVE

EDUCATION AUTHORITY SUBMITS FINAL PLANS & S.B.16.

↓

DEPARTMENT OF EDUCATION & SCIENCE CHECK & APPROVE

(TENDERS MAY BE OBTAINED BEFORE FINAL SUBMISSION)

↓

IF TENDER IS NOT MORE THAN ONE PERCENT ABOVE EXPENDITURE LIMIT, EDUCATION AUTHORITY ACCEPTS & SUBMITS S.B.27. IF TENDER EXCEEDS EXPENDITURE LIMIT BY MORE THAN ONE PERCENT DEPARTMENT OF EDUCATION & SCIENCE CALL FOR S.B.27.A. EXAMINES & APPROVES ACCEPTANCE.

↓

EDUCATION AUTHORITY SUBMITS QUARTERLY PROGRESS REPORTS ON S.B.29.B.

↓

EDUCATION AUTHORITY SUBMITS COMPLETION CERTIFICATE S.B.23 & STATEMENT OF FINAL COST. S.B.17.

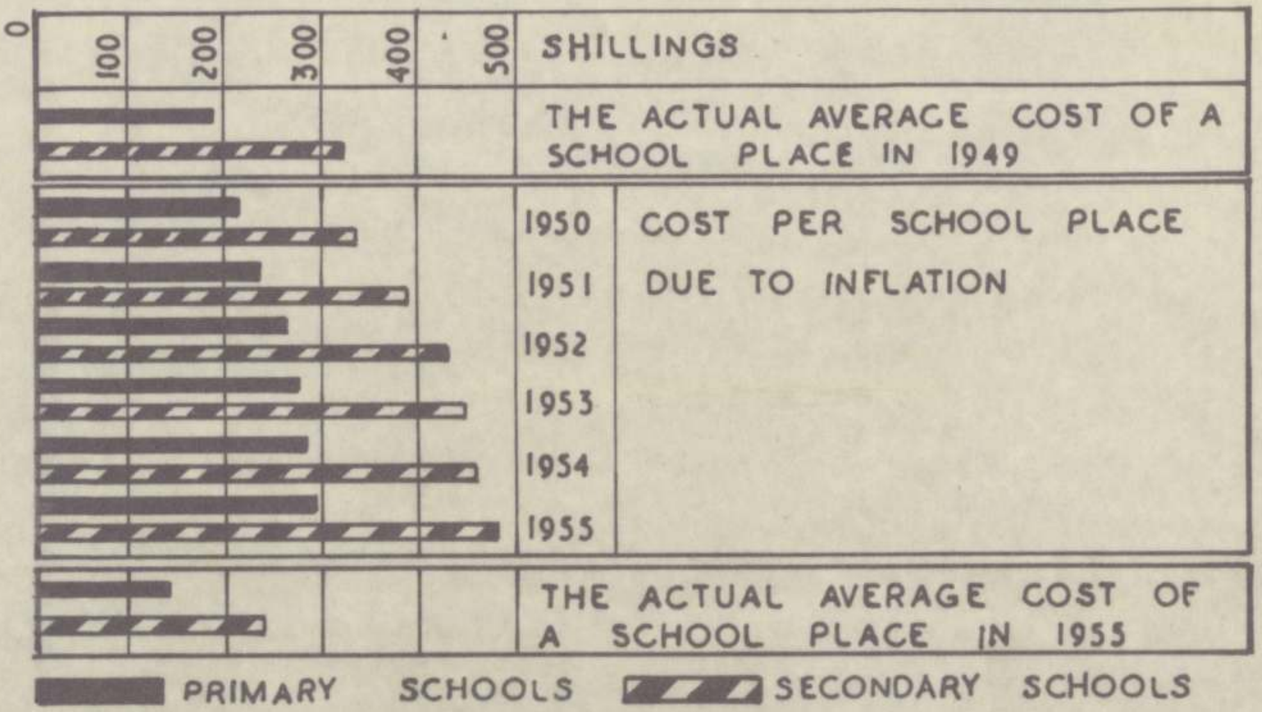
↓

DEPARTMENT OF EDUCATION EXAMINES & APPROVES EXCESS (IF ANY)

NOTE —

SKETCH PLANS MAY BE SUBMITTED BY EDUCATION AUTHORITY WITH S.B.22 IN WHICH CASE THE DEPARTMENT OF EDUCATION & SCIENCE REVIEW ABNORMALS OTHERWISE ABNORMALS ARE REVIEWED WHEN THE FINAL PLANS ARE SUBMITTED.

— FIG. No. 7.2. —



— FIG. 7.3. —

THE COST PER SQUARE FOOT FOR SCHOOL BUILDINGS BETWEEN THE YEARS 1949 AND 1956

	1949	1950	1951	1952	1953	1954	1955	1956
TRENDS IN BUILDING COSTS GENERALLY	60	64	74	79	82	85	88	92
PRIMARY SCHOOLS	58	60	58	62	65	66	68	71
SECONDARY SCHOOLS	59	62	63	63	62	65	65	70

THE FIGURES SHOWN FOR PRIMARY & SECONDARY SCHOOLS ARE ACTUAL COSTS PER SQUARE FOOT BASED ON YEARLY AVERAGES OF TENDER PRICES

— FIG. 7.4. —

(i) Cost per place for secondary and primary schools. The number of cost places can be greater or less than the number of pupils due to the application of a graduated scale which takes account of the size of the school.

(ii) Cost per square foot of net floor area for residential schools and colleges of further education.

(iii) Residential Cost units for student residences attached to colleges of further education. The present figure of £985 is the same for colleges of further education and universities.

Twelve and a half percent is added to the cost determined by the calculations outlined above to allow for external works and in addition cost allowances are made for extensions and alterations.

The cost limits are revised periodically by the Department of Education and Science in agreement with the Treasury, changes being justified by movements in tender price levels based upon the Royal Institute of Chartered Surveyors index. The Department of Education and Science do not normally get a detailed cost analysis of each project, as an examination is only carried out when the tender exceeds the cost limit by more than one percent and therefore, although there is a continual exchange of information between the various interested bodies the Department cannot provide a systematic feed-back of cost details, nor can they maintain a cost index of their own.

In addition to the cost control discussed above the areas of schools is controlled by "The Standards for School Premises Regulations 1959" known as "The Building Regulations". College of further education accommodation standards are not subject to regulations, although guidance is given in "Building Bulletin Number Five" and through Her Majesty's Inspectors.

The Department of Education and Science do not normally design or build schools and only get involved in the actual design and construction of school buildings on selected development projects, the Harris College of Further Education, Preston discussed later is one example of the type of project which the Department has undertaken.

The Department of Education and Science does, however, provide advice on design in their "Building Bulletins" and also publish statistics on such items as, cost per place, net cost per square foot of floor area and the area provided per place, in their annual report.

PROCEDURE FOR CONTROLLING EXPENDITURE IN UNIVERSITIES ADOPTED BY THE UNIVERSITY GRANTS COMMITTEE
(DEPARTMENT OF EDUCATION AND SCIENCE)

The University Grants Committee is responsible to the Secretary of State of Education and Science for:-

(a) The administration of grant-in-aid to universities voted annually by Parliament towards the expenditure on salaries, furniture, equipment, running costs and maintenance of buildings.

(b) Advice on the development of universities including expenditure on future building work.

Building proposals giving the order of priority and the approximate cost of each building are collected from each university by the University Grants Committee who in turn submit the total proposed building programme to the Department of Education and Science and The Treasury.

An allocation to each university is made by the University Grants Committee after they have been informed by the Department of Education and Science of the total sum of money agreed.

Grants for expenditure on university buildings are divided into major and minor works in a similar form to that adopted by the Department of Education and Science for schools, the main difference being, that each university is an independent body responsible for its own building development and for the application of funds obtained from the University Grants Committee, private resources and benefaction.

The total annual grant distributed by the University Grants Committee for building work is in the order of £40-50 million per annum of which the separate block grant for minor works covering projects under £20,000 accounts for between one and a half and two million pounds.

Each university can carry out items of work not exceeding £20,000 under the heading of minor works without seeking agreement from the University Grants Committee in the same way that local education authorities are allowed to carry out work on schools and colleges of further education.

COST CONTROL OF BUILDINGS

Expenditure limits on major works are applied in one of two forms,

(i) Residential Cost Units and

(ii) Cost per square foot of floor area

(a) Residential Cost Units were first introduced by the University Grants Committee in 1959. They are applied in exactly the same way as for student residences attached to Colleges of Further Education and are of equal value ie £985 per residential cost unit.

(b) Costs per square foot of floor area for all non-residential buildings were first introduced in 1961, two years after the University Grants Committee introduced cost limits on residential buildings and eleven years after they had been introduced by the Ministry of Education for school buildings.

The cost limit in 1969 was 107s 6d per square foot (£57.86 per square metre) for non-specialised accommodation which included lecture theatres and classrooms and 102s 6d per square foot (£55.17 per square metre) for specialised accommodation.

Additions are allowed to the basic expenditure limit to cover abnormal work, such as piled foundations, special structural and services work and there is also an overall allowance of between 2.% and 7½% for external works.

A Building Sub Committee under the control of the Vice Chancellors and Principals of Universities collects and analyses items of university expenditure thereby providing a cost information service to the main committee.

CONTROL OF FLOOR AREAS

The gross area of non residential building is determined by making a percentage addition to each item of usable floor area (referred to as a "balance allowance") in the following proportions:-

	Area per Working place		Balance Allowance
	Sq ft	Sq m	percentage
Lecture theatres with close seating	10	0.929	60
Professorial rooms	200	18.581	45
Tutorial Teaching staff	150	13.936	45
Non-Tutorial teaching staff	75	6.968	45
Clerical & Typing staff	75	6.968	45
General Teaching and Seminar rooms	20	1.858	30
Drawing offices for advanced work	50	4.645	30

	Area per Working place		Balance allowance
	Sq ft	Sq m	percentage
Geography	40	3.716	30
Drawing offices with imperial or smaller boards	30	2.787	30
SCIENCE LABORATORIES			
Elementary or intermediate	40	3.716	60
First and second year honours and general	45	4.181	60
Final year honours	60	5.574	60
Research students in groups of four or more	80	7.432	60
Advanced or individual research	120	11.148	60
Research and prep room	15% of lab. area	-	60
LIBRARIES			
Reading space	25 per work space	2.323	40
Bookshelves including gangways	60 per 1000 Books	5.574	50

The area to be provided in residential buildings is 145 sq ft (13.471 sq m) per residential cost unit, with an addition of 120 sq ft (11.148 sq m) per residential cost unit for dining areas and 125 sq ft (11.613 sq m) per residential cost unit for kitchens.

A diagramatic presentation of the procedure adopted by the University Grants to control expenditure is shown in figure 75.

UNIVERSITY GRANTS COMMITTEE PROCEDURE FOR CONTROLLING EXPENDITURE

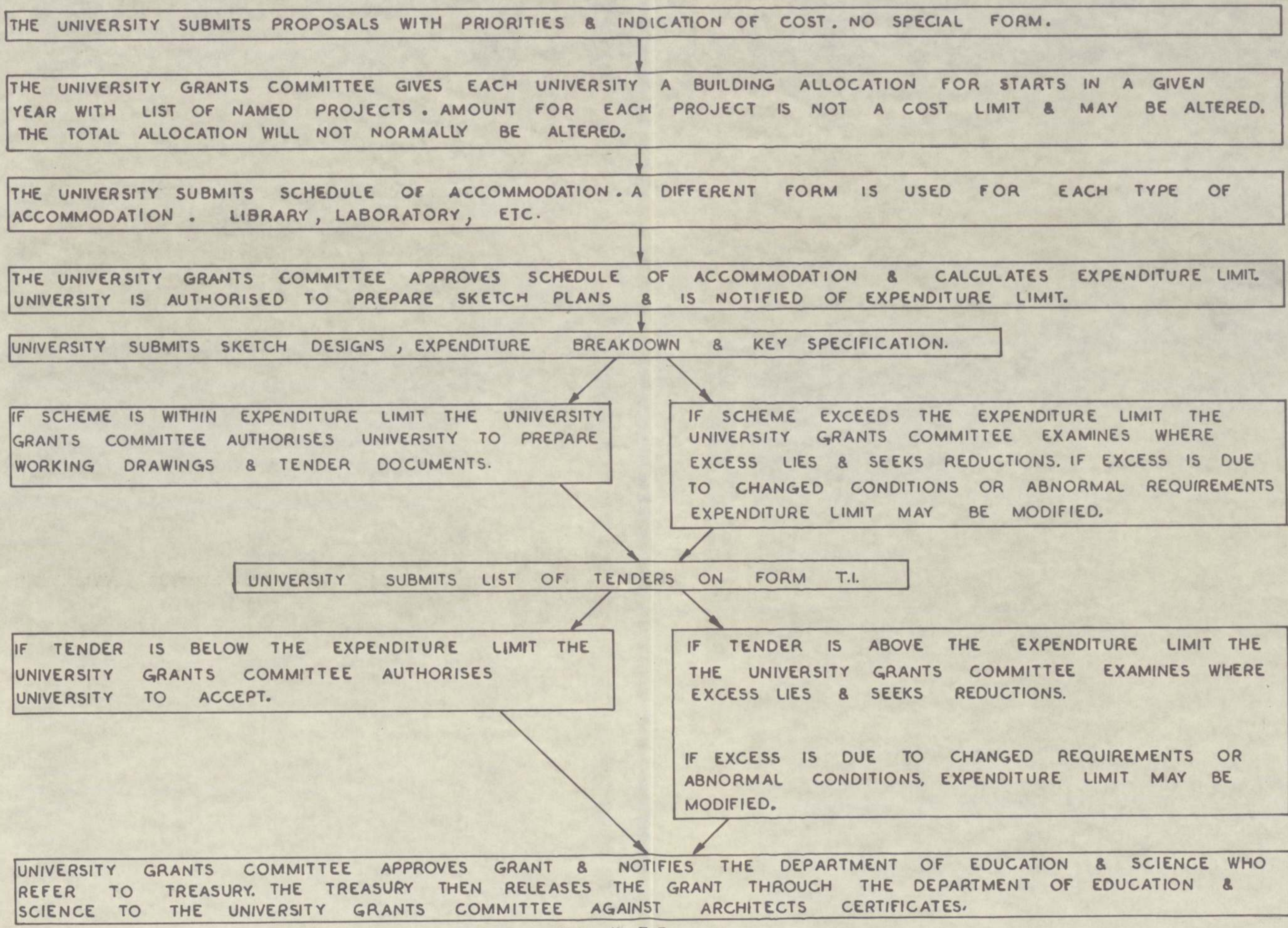


FIG No. 7.5.

UNIVERSITY FINANCE IN AMERICA

One of the main reasons why there is very much/ more student unrest in America than in the United Kingdom, could be attributed to the method by which the universities in both countries obtain their income.

There is no equivalent to the University Grants Committee or the United Kingdom Research Councils in America and therefore a very high percentage of university income in America is provided by government agencies such as the Department of Defence, NASA, the Atomic Energy Commission and the Department of Health and Welfare, financing research projects.

It obviously follows that at establishments such as the Massachusetts Institute of Technology where more than half of the total budget is accounted for by two projects for the armed forces, that the Federal Agencies must exercise a control which will inevitably affect the independence of the universities and can also conflict with the ethics of at least some of the students and staff.

The proportion of university income in this country from Research Council grants and research contracts is in the order of twelve percent and the terms under which the grants are awarded are such that there are a very limited number of cases where restrictions are placed on publicity, or where accusations could be made of the deminution of university independence.

It would seem therefore that although criticisms could be made about the way in which we cater for university expenditure, it has distinct advantages over the system by which the American universities obtain their finance.

CHAPTER VIII

ANNUAL EXPENDITURE

TECHNICAL COLLEGE EXPENDITURE

Figures 8.1 to 8.5 show in graphical form, details of college expenditure for each year between 1962 and 1967 and are produced from statistics collected by Mr W R Tuson, Chief Education Officer for Preston.

Figure 8.1 shows the average expenditure for the 23 colleges which supplied the information, the shaded portions indicating the range between maximum and minimum expenditures.

Figures 8.2 to 8.5 are examples of four colleges representing both ends of the expenditure scale.

One of the most obvious features of figures 8.1 to 8.5 is the very large expenditure on salaries of academic staff and the relatively small expenditure on items such as maintenance, fuel, light and cleaning. It is therefore surprising that these latter items attract so much attention when the summation accounts for approximately 10 per cent of the teaching bill.

The annual equivalent of the initial cost represents 6 to 8 per cent of the annual expenditure on salaries for academic staff or alternatively the capital costs could be doubled if this resulted in a saving of one teacher in every fourteen

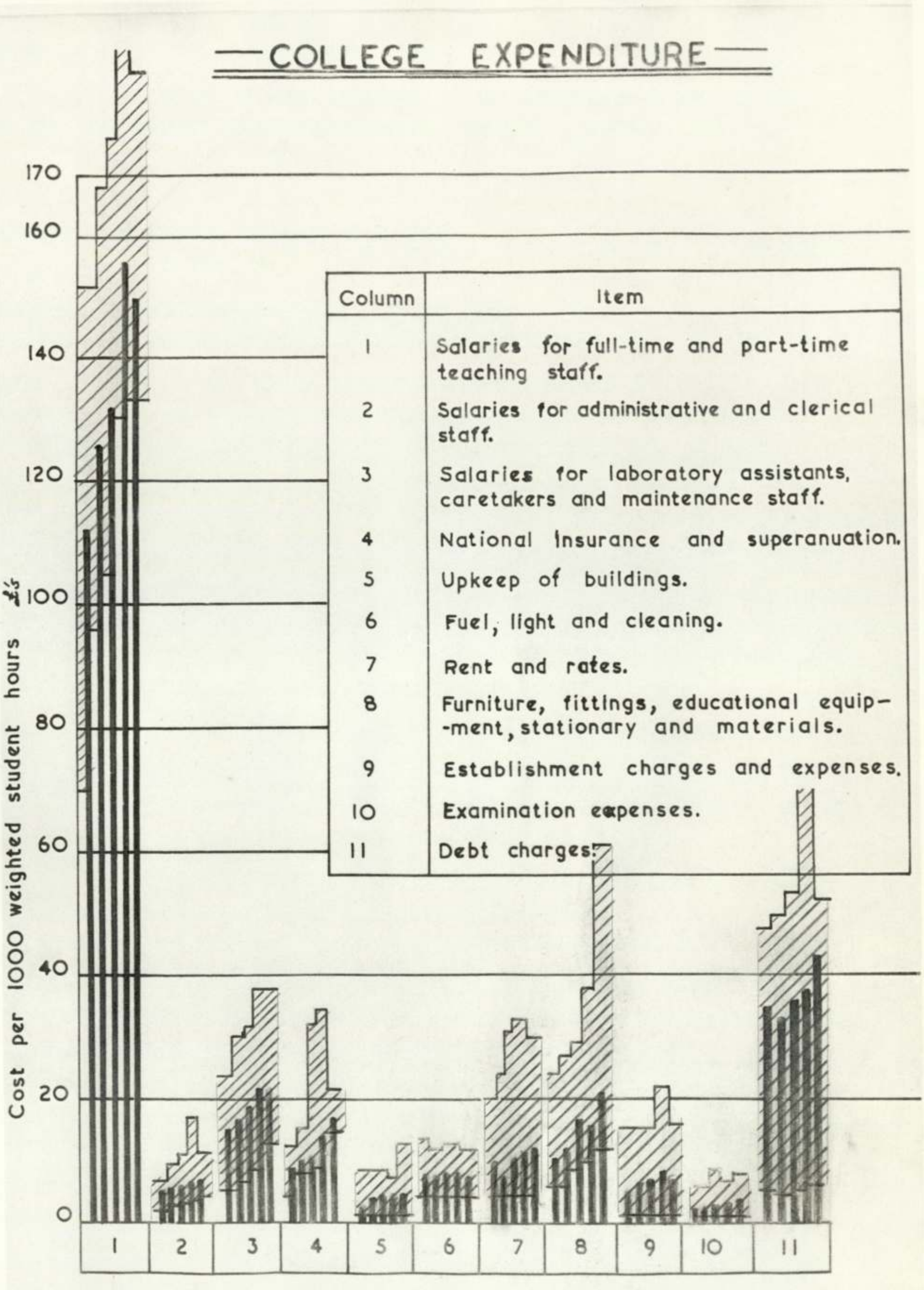

COLLEGE EXPENDITURE
Cost per 1000 weighted student hours £'s
170
160
140
120
100
80
60
40
20
0
Column
Item
1
Salaries for full-time and part-time teaching staff.
2
Salaries for administrative and clerical staff.
3
Salaries for laboratory assistants, caretakers and maintenance staff.
4
National Insurance and superanuation.
5
Upkeep of buildings.
6
Fuel, light and cleaning.
7
Rent and rates.
8
Furniture, fittings, educational equip-ment, stationary and materials.
9
Establishment charges and expenses.
10
Examination expenses.
11
Debt charges.
1 2 3 4 5 6 7 8 9 10 11

Figure 8.1.

EXPENDITURE FOR THE CIVIC COLLEGE, HALIFAX. 1962 TO 1967

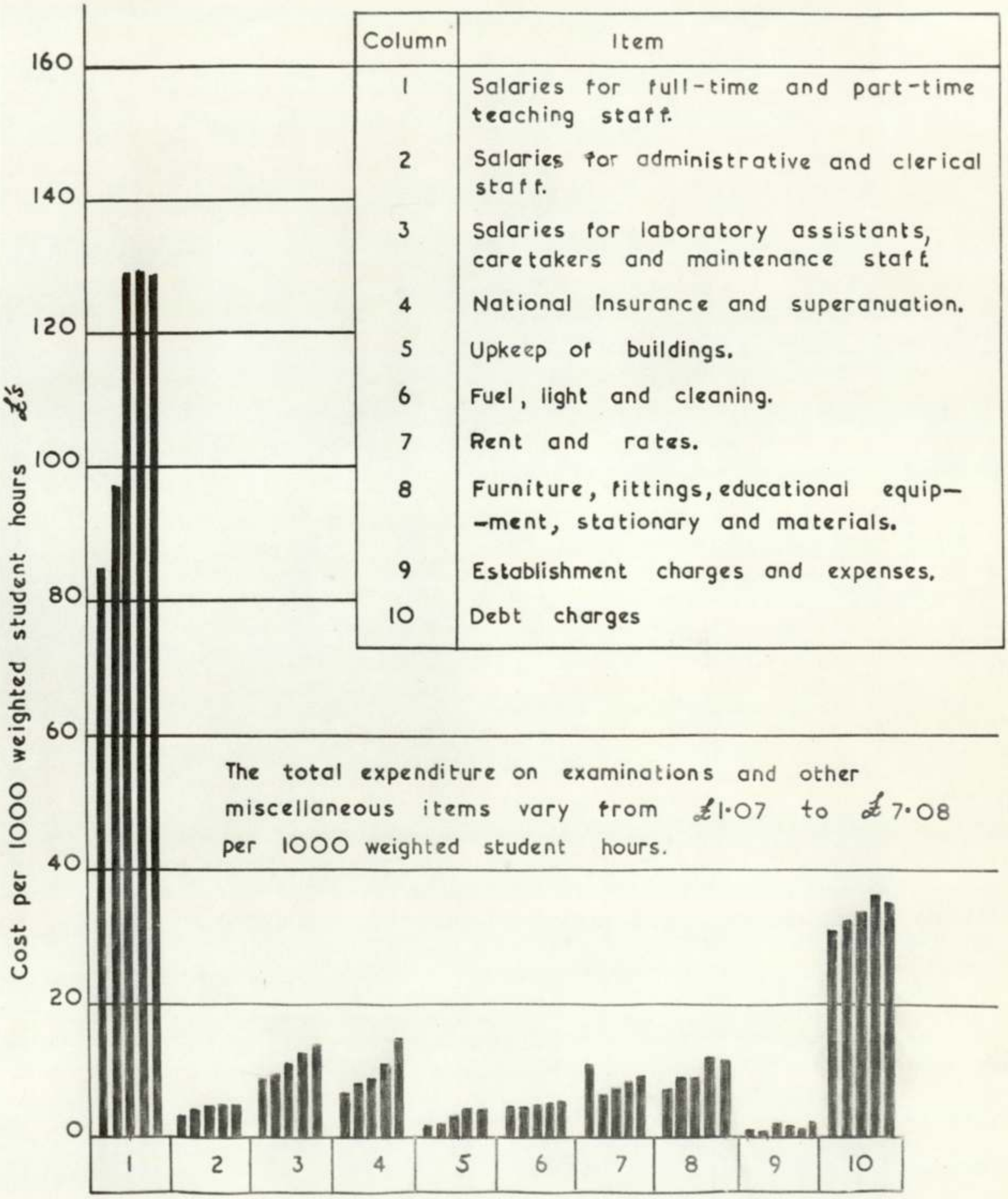


Figure 8.2

EXPENDITURE FOR SOUTHPORT TECHNICAL COLLEGE. 1962 TO 1967

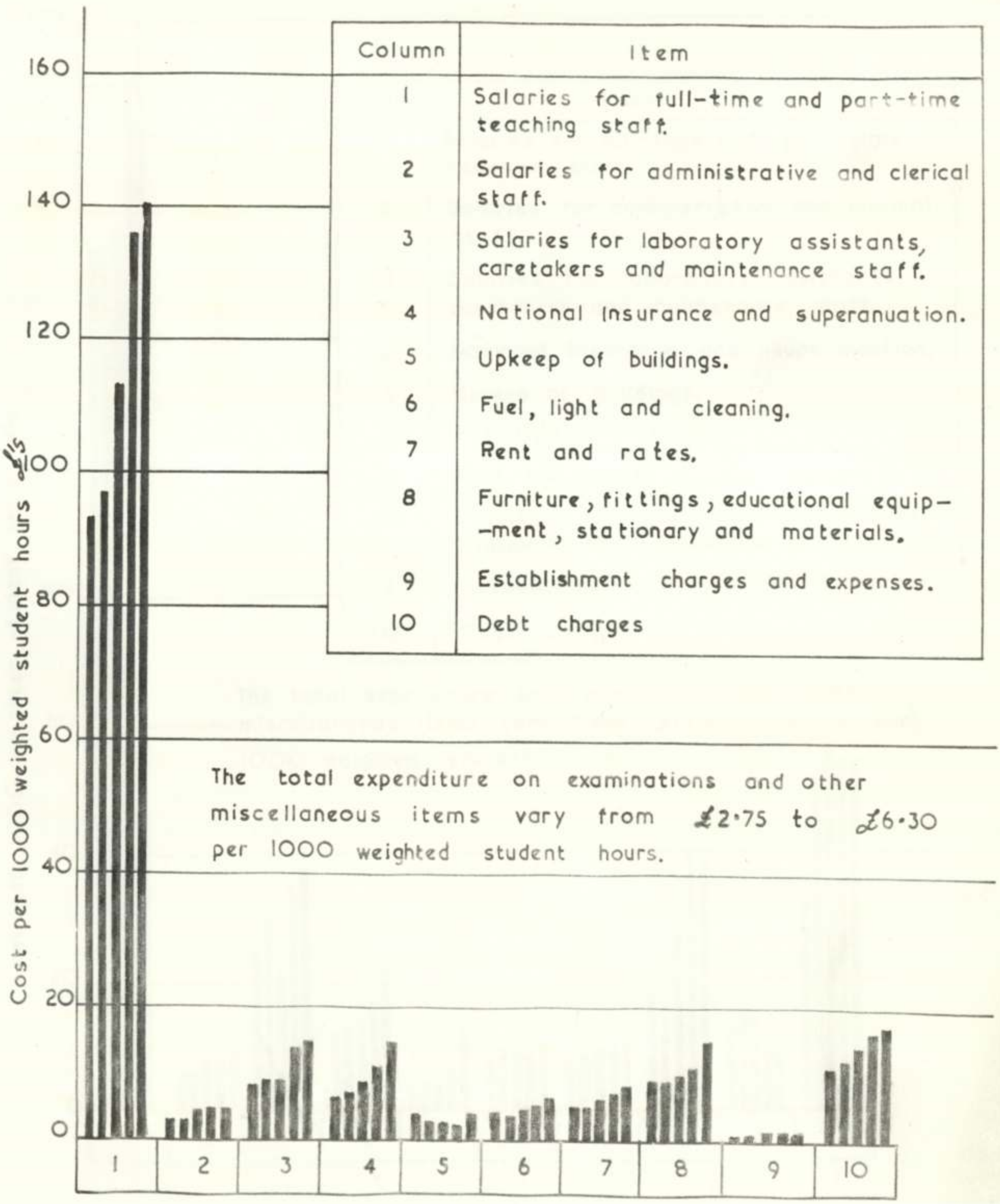


Figure 8.3.

SUNDERLAND TECHNICAL COLLEGE.
EXPENDITURE 1962 TO 1967

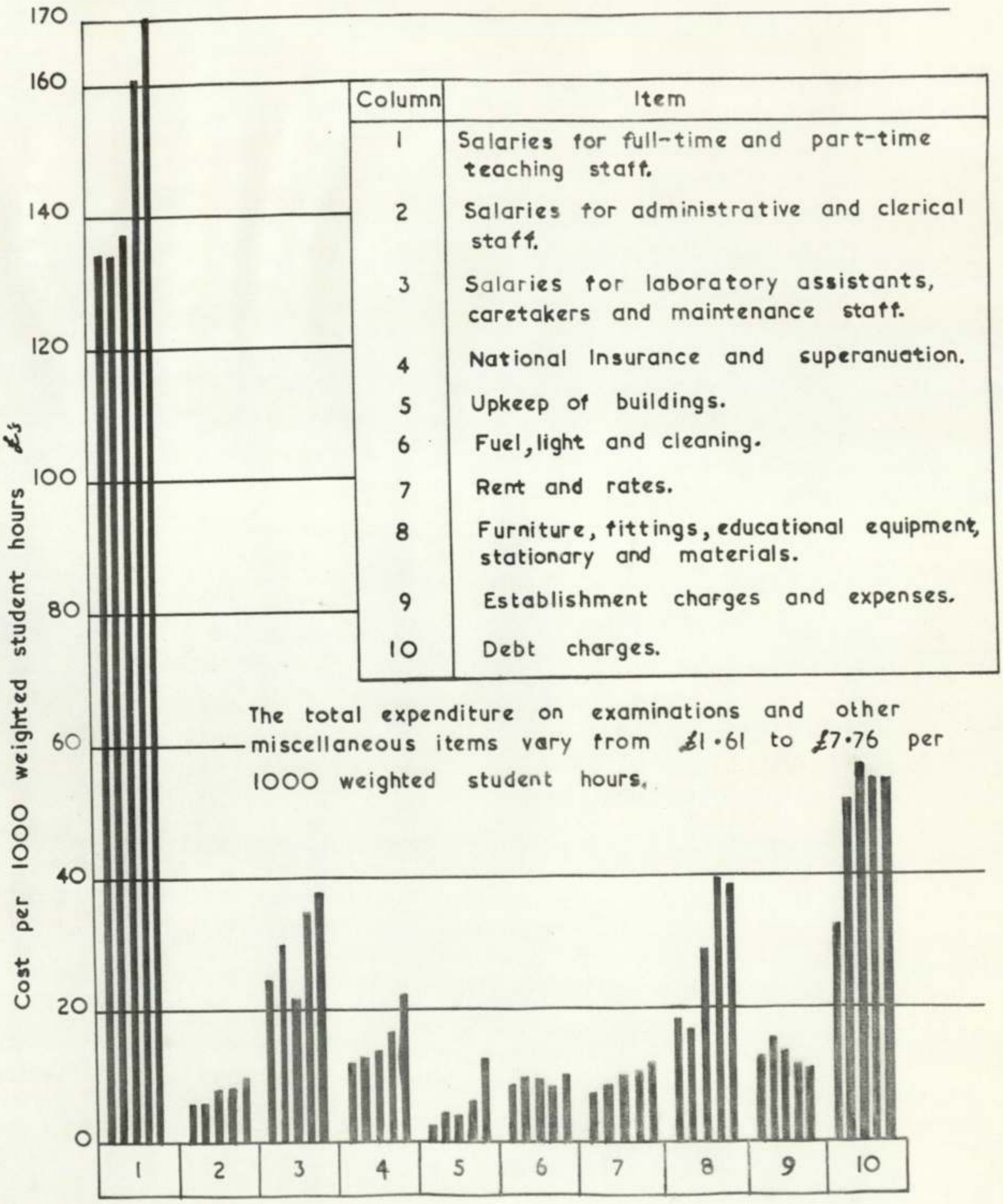


Figure 8.4.

PERCIVAL WHITLEY COLLEGE OF FURTHER EDUCATION, HALIFAX 1962 TO 1967

EXPENDITURE

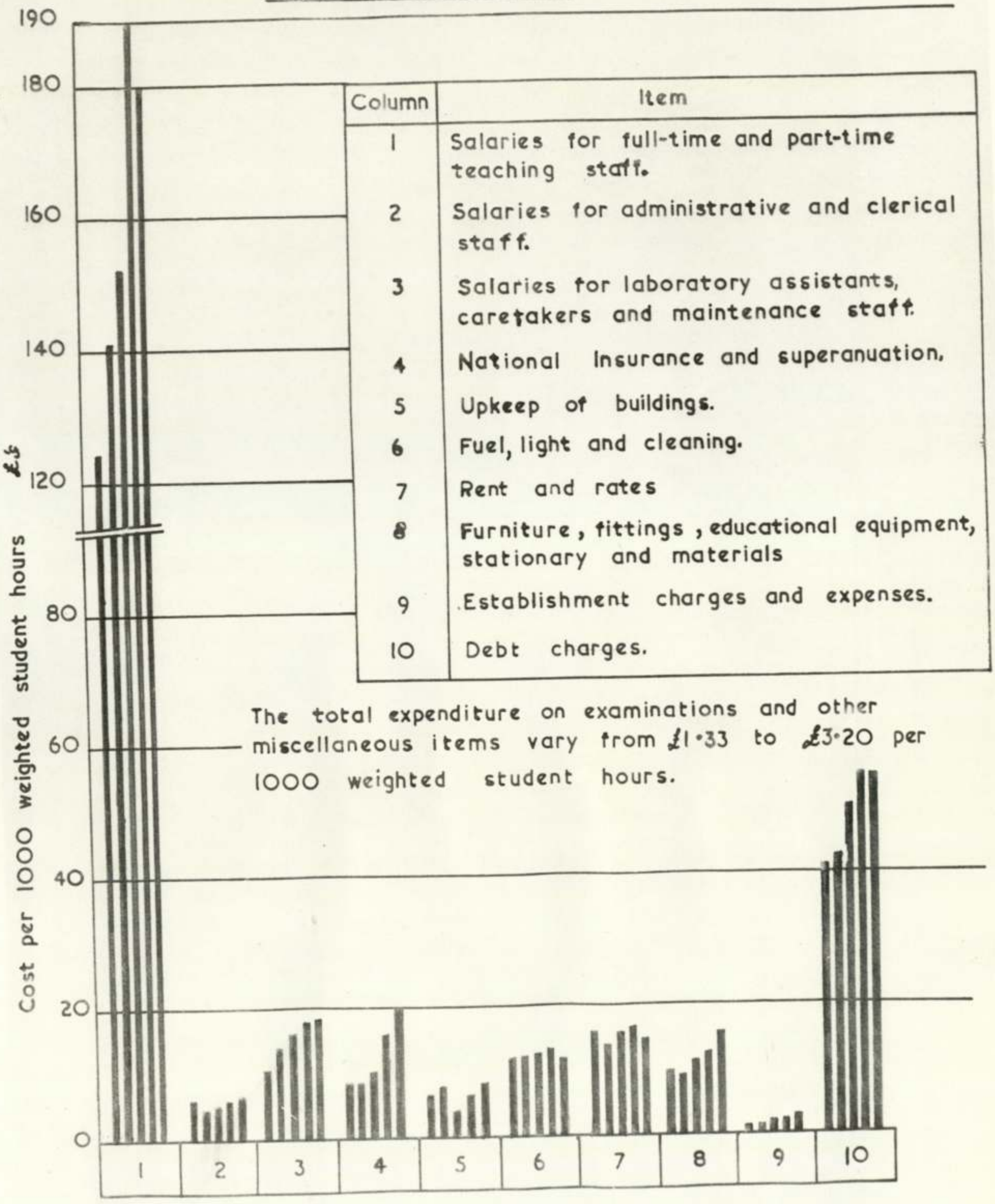


Figure 8.5.

employed. The economics of the situation is even more startling when it is realised that inflation causes a continual increase in teaching salaries, whereas, the interest rate on capital borrowed is the only factor which can seriously affect the annual equivalent.

The main theme running through this thesis has been the need for flexibility in our educational buildings, in order to make the most economic use of the academic staff. The factors discussed above illustrate this point.

Nevertheless although the expenditure on initial costs, maintenance, heating, lighting and cleaning represent such a relatively small proportion of the annual expenditure, the design team must provide the most economic structure possible and at the same time ensure that the educational processes can be efficiently carried out in a controlled environment.

USER REQUIREMENTS

It is understandable that when considering maintenance costs of university buildings, the experience and opinion of those responsible for carrying out this work should be solicited and in fact this has been done by the Working Party on Maintenance Costs, which is a sub-committee of the Committee of Vice-Chancellors and Principals of Universities.

The survey covered 24 universities and a study of the statements made, indicate the nature of the problem which exists. One resident architect is reported to have said that there is always a conflict between capital and maintenance costs and questioned whether any developer could afford sufficient of the former to reduce the latter to a truly efficient minimum.

The falacy of this argument is that providing an assessment can be made of the consequences of using a particular material or form of construction and a cost-in-use study shows that the annual equivalent (which of course includes interest on capital borrowed) is less than the annual expenditure due to the adoption of lower standards, then it is uneconomic for the developer to make savings on the initial cost and it is the duty of the design team to advise the developer of this situation.

This type of survey always produces the reiteration of the widely held opinion amongst professions in the construction industry, that architects do not arrive at the most effieient use of capital, due either to inadequate knowledge of the properties of materials or alternatively because of insufficient cost consciousness. It is not surprising therefore that this statement should be repeated during this survey. One superintendent also stated that it was more than possible for waterproof basements to leak and he suggested that the only way to eliminate this problem was to use an asphalt membrane. The Directorate of Civil Engineering Development of the Department of the Environment have, what I consider, a better alternative. They have recognised that the use of waterproof membranes, rendering, plaster or other finishes on basement floors and walls disguises the true location of leaks in the structural concrete and in order that the sealing of the leaks may be readily dealt with, the structural concrete should be the sole material resisting the ingress of water. The internal surfaces should be completely accessible for the repair of leaks appearing during the life of the structure. Participants in the survey gave many examples where the reduction in initial costs have resulted in very high maintenance costs. The following examples are provided because of the abvious uneconomic use of materials, however, cost-in-use studies allows a quantitative analysis to be made in which alternative forms of construction can be examined in detail.

EXAMPLES OF UNECONOMIC USE OF MATERIALS

1 Painted common bricks used for external walling instead of a good quality facing brick.

2 Timber cladding used for external surfaces of buildings which requires continual treatment. There is not a satisfactory method at present which provides a durable natural finish of timber for external use.

3 Painted wall surfaces in toilets instead of glazed tiles or fair face brickwork.

4 The poor sound insulation of partition walls because of the substitution of lightweight materials for brickwork, resulting in the inefficient use of classrooms.

5 Underfloor heating, which is cheap to install, but expensive to operate.

6 The provision of poor quality heating and ventilating equipment which entail high replacement or maintenance

costs. The use of spray taps in cloakrooms although having a higher initial cost than the conventional taps provide an economy in the amount of hot water used and also avoid that ever present problem of the missing waste plug.

ECONOMICS OF FLOOR COVERINGS

There is still need for an extensive study on the use of floor materials for educational establishments. This should combine cost-in-use with the provision of a satisfactory environment and various forms of floor coverings should be compared. For example various qualities of vinyl sheet, polished hardwood, cork and carpet could be compared, for various intensities of traffic and location. Noise absorption and the possible damage by dropped cigarettes, chemicals and the problems associated with cleaning would be important considerations.

MAINTENANCE COSTS OF LOCAL AUTHORITY HOUSES

A study of maintenance costs carried out by W J Reiners, B.Sc. and published in the Chartered Surveyor in March, 1962 on local authority houses can be used to give some indication of the areas where an improved specification can result in reduced maintenance costs, provided an allowance is made for the different forms and functions of the building being compared.

FIG. 8.6

LOCAL AUTHORITY HOUSES

COMPONENTS OF MAINTENANCE AND INITIAL COSTS AT 1955 LEVELS OF COST

	Maintenance Costs		Initial Cost	Total Cost	Maintenance as a % of Initial Cost
	Annual	Capitalized			
	£	£	£	£	£
Water Service	1.90	42	50	92	84
Sanitary Fittings	0.50	11	50	61	22
Heating Cooking and Lighting	1.50	33	100	133	33
Internal structure and Finishings	1.50	33	500	533	7
Main Structure	1.15	26	500	526	5
External Services and Site Works	0.90	20	100	120	20
External Painting	3.55	80	80	160	100
	11.00	245	1380	1625	

The estimates in the above table are, fairly rough, the main point is clearly established that there is a wide range in the ratio of maintenance to initial cost among the various elements.

For the structure, maintenance represents only a small proportion of the initial cost and it is unlikely that any saving in maintenance costs by an improved specification could justify additional initial expenditure.

The cost of external painting over the life of the house is as much as the cost of the material it protects and it is here where it may be more economic to spend more initially to reduce painting costs.

Plumbing and heating are also cases of relatively high maintenance costs which might be reduced by an improved specification.

ANNUAL EXPENDITURE FOR SLOUGH COLLEGE OF TECHNOLOGY AND THE UNIVERSITY OF BIRMINGHAM

Details of expenditure are compiled differently by the various universities and colleges making direct comparisons difficult, and therefore items have to be chosen to cover a very wide range, which means that a lot of detail is lost, or alternatively we run the risk of making incorrect comparisons.

Two examples of expenditure for the year 1967/68 follow. Figure 8.7 gives details of expenditure for the Slough College of Technology which I obtained by kind permission of the Chief Education Office for Buckinghamshire, Mr Roy P Harding.

Figure 8.8 gives details of expenditure compiled from figures prepared by Mr C P Thompson, for the Works and Maintenance Committee of the Committee of Vice Chancellors and Principals of Universities.

Mr C P Thompson gave separate accounts of expenditure for the years 1962 to 1968, but as he showed the variation in cost for a given floor area was relatively small, I have based my example upon the 1967/68 figures only.

FIG. 8.7

DETAILS OF EXPENDITURE FOR SLOUGH COLLEGE OF TECHNOLOGY

Item	Actual Expenditure £	Percentage of total Expenditure %
Repairs and maintenance to buildings	10,625	1.66
Alterations and improvements	2,108	0.33
Repairs and maintenance to grounds	94	0.01
Fuel and light	17,464	2.74
Cleaning materials and water	3,492	0.55
Furniture and fittings	1,925	0.32
Rent	1,271	0.20
Rates	22,767	3.56
Salaries & Wages		
Maintenance staff	3,217	0.50
Caretakers and cleaners	19,149	3.00
Groundsmen and gardeners	1,784	0.28
Refectory, domestic and catering staff	14,741	2.31
Academic staff		
Full-time teachers	496,404	77,69
Part-time teachers	43,658	6.85

Some of the major items included in the above details of expenditure are:-

(i) Contract for window cleaning at approximately £350 per annum.

(ii) Internal and external decoration averaging out at approximately £5,000 per annum.

(iii) Repairs and replacement of services averaging £1250 per annum.

The two important items of expenditure missing from the above details are:-

(i) Salaries of clerical and administrative staff.

(ii) Expenditure on equipment and materials for teaching purposes.

Examination of the details presented above shows that the expenditure on materials and wages for maintenance, lights, fuel and cleaning is equal to 10.4 per cent of the teaching bill.

FIG. 8.8

DETAILS OF ANNUAL EXPENDITURE FOR THE ACADEMIC BUILDINGS OF THE UNIVERSITY OF BIRMINGHAM

Item	Total Cost £	Cost/M^2 £	Percentage of Total Cost %
Gas	7,250	0.028	0.115
Electricity	118,000	0.475	1.900
Water	17,500	0.071	0.282
Other fuel	35,150	0.428	0.565
Central heating station	70,750)		1.137
Stores and repair	11,000)	0.603	0.177
Wages	18,120)		0.292
Total for Utilities	277,770	1.605	4.468
Repairs:			
Buildings	107,450	0.433	1.728
Electrical	47,000	0.185	0.755
Furniture	2,500	0.010	0.040
Mechanical	39,000	0.157	0.625
Tools, plant and hire	3,000	0.012	0.048
Total for repairs	198,950	0.797	3.196
Porter N.W wages	67,623	0.272	1.091
Control Clerks	44,703	0.180	0.721
Cleaners' wages	131,439	0.530	2.113
Materials etc	25,535	0.102	0.411
Total	269,300	1.084	4.336
GRAND TOTAL	745,020	3.486	12.000
Floor area at the beginning of the year			225,389 m^2
Floor area added			34,355 m^2
Floor area at the end of the year			259,744 m^2
Average value used for costs			248,051 m^2

The grand total of £745,020 is equal to 12 percent of the University's expenditure and we can therefore use this figure to express the other items as a percentage of the total recurrent expenditure.

Figures 8.7 and 8.8 can be used to examine the major items of annual expenditure on buildings. It will be seen that these are:-

(i) Fuel and light

(ii) Building maintenance

(iii) Cleaning and portering costs

An examination of the costs in more detail show that the major items of expenditure on building maintenance are:-

(a) Glazing, internal and external painting accounting for 60 per cent of the expenditure on buildings.

(b) Internal woodwork and flooring accounting for 12 percent.

(c) General building maintenance accounting for about 9 percent.

(d) Internal plumbing accounting for 6 percent.

(e) Roofs accounting for approximately 3 percent.

(f) The remaining 10 percent is accounted for by work on external brickwork, woodwork, plumbing, gates, fences, roads, paths, internal plastering and transport costs.

Electrical maintenance and replacement accounts for approximately the same expenditure as item (a) above. General mechanical work, including maintenance of heating and ventilation equipment, accounts for between 60 and 70 percent of the expenditure on item (d).

Reiners showed that painting, plumbing and heating were the items which justified an improved specification in the local authority housing section in order to reduce maintenance costs.

My study restricted to educational establishments has shown that the major items of maintenance are painting, electrical and mechanical work, including heating and ventilating.

In Chapter IX the effect of flexibility upon the initial cost of the building is discussed, however, the major items of annual expenditure on buildings is also examined in order to determine what proportion of the total cost of the building is accounted for by these items.

CHAPTER IX

CHAPTER IX

THE EFFECT OF DESIGN DECISIONS UPON THE INITIAL COST OF THE BUILDING

THE STRUCTURAL FRAMEWORK

Comparison of structural forms are difficult because a number of alternatives are available, many of which are competitive in cost provided they are used efficiently. It is therefore important when making economic comparisons not to restrict one structural form by design considerations necessary to achieve an economic solution when considering a different structural form. Each structural form has its own advantages and disadvantages, for example, steel frame spans in one direction and therefore a rectangular column grid is most appropriate, whereas a reinforced concrete frame building is usually designed to span in two directions and therefore a square grid provides the most economic solution. Similar comparisons can be made to include load bearing brickwork.

If we were to restrict our economic comparisons to the consideration of the building only, we would find that the cost of construction increases as the size of the column grid increases and also as the number of storeys increase but as we have seen earlier, the expenditure of salaries for academic staff, make it more economic to provide efficient teaching areas at the expense of increasing the initial cost of construction.

The simplest form of construction is a lightly cladded steel frame with a pitched roof but additions have to be made to this form of construction in order to maintain the required internal environment. These additions will vary depending upon the function which the building is to serve.

Increasing the span of a simple steel frame from 10 m to 30 m or alternatively increasing the height from 3.5 m to 6.0 m results in an increased initial cost of approximately 10 percent.

Normal reinforced concrete is not generally competitive with steel for simple structures, although precast concrete buildings can be provided at a competitive price and the maintenance costs of these precast concrete frame buildings will be less than the equivalent steel frame building, although modifications to standard buildings are usually expensive.

Reinforced concrete frame construction can be cheaper than encased steel construction, the argument advanced that the steel frame is quicker to erect than the equivalent reinforced concrete frame would seem to depend as much upon site organisation, methods of construction and structural detail as on differences between the two materials.

Very often in the past features such as fire resistance, loading, or column grid, dictated the type of material used, but today, because of the developments in the knowledge and properties of materials together with improved constructional techniques, most materials can be used economically to meet the particular structural requirements encountered in the normal type of building.

ECONOMICS OF VARIOUS FORMS OF CONSTRUCTION

Within the limits discussed above, some generalisations can be made of the various structural forms as follows:

1 The pitch roof provides the cheapest form of roof construction.

2 The north light or saw-tooth roof, in which the nearly vertical side is glazed, provides a more uniform distribution of light, for an additional cost in the order of 20 percent.

3 Flat roofs avoid the triangular portions within the roof space, which is a feature of the two previous forms and monitor roof lights can be provided in order to obtain some natural light throughout the depth of the building. The main disadvantages of the flat roof is that it is more costly than the two previous forms of construction and maintenance costs can be high due to problems associated with drainage and rain penetration.

Lattice girders normally provide the most economic form of flat roof construction; even then, the initial cost of the complete roof including monitors is of the order of 50 percent more than for a complete pitch roof.

4 Concrete and steel portal frames compare very reasonably in cost with the type of simple steel frame discussed in items 1 and 2 for short spans. The clean lines and the additional headroom are attractive features of this type of construction; however, the initial cost rises steeply for spans over 15 metres to approximately 60

percent more than simple steel frames for spans in the order of 30 metres.

5 The clean sweeping lines of barrel vault roofs, which are free from obstructions, provide good reflective surfaces which do not collect dirt, however, the initial costs are approximately two or three times more than simple pitch roofs.

ALTERATIONS, MAINTENANCE AND CLEANING

The type of structure can affect the future efficiency of those who will work within the building and some thought should be given to future developments and to maintenance and cleaning costs. For example alterations and additions are more easily carried out on steel frame buildings than on reinforced concrete frame buildings.

When a light exposed steel frame is required it will be found that a tubular steel frame will provide a cleaner structure than one composed of steel angles and in addition cleaning and maintenance costs will be less.

Rivetted construction has now been almost completely replaced by welded construction and it will be found that comparisons between rivetted and welded construction is unnecessary.

INDUSTRIALISED AND NON-TRADITIONAL BUILDING

When considering industrialised systems of building we must first determine which sectors of the industry are most likely to be affected.

For example, speculative house building which allows a large degree of standardisation, would seem to be the ideal sector in which to develop industrialised systems. The main problem in this sector is to provide a house, at a competitive price, which when viewed as a unit, or collectively on an estate has an acceptable appearance.

When considering other buildings such as offices, factories and educational buildings the client quite often has specific requirements which cannot be fulfilled within the limitations of a completely industrialised system. We must therefore consider the development of industrialised systems and other methods of non-traditional building under two headings:-

(i) The development of complete buildings.

(ii) The development of individual components.

(i) If there is to be any future at all for completely industrialised buildings it would seem to be in domestic building; however, this type of building introduces a degree of standardisation which the majority of home buyers, at present, are not prepared to accept. There is an additional factor in that the wide-spread acceptance of industrialised buildings would require the re-examination of the structure and training within the industry.

(ii) As with completely industrialised buildings the component approach becomes more efficient as the degree of standardisation increases; however, individual developers are allowed some degree of flexibility by varying the arrangement of components and by introducing alternative materials for various sections of the building.

This approach does not affect the structure and training within the industry to the same extent as is required for completely industrialised buildings.

COMPARISON OF TRADITIONAL AND NON-TRADITIONAL SYSTEMS

Most forms of dry construction, especially those used for external walls are at least as expensive as traditional materials and usually cost more to maintain. In addition, the sound and heat insulation properties are often of a lower standard than can be obtained by traditional construction and the appearance of bricks is often preferred to the type of finish produced by industrialised systems.

The recent developments in dimensional co-ordination, which have been assisted by the introduction of the metric system, have helped in the development of the component approach, to some extent; however, there are still many problems to be solved, not least of which is a satisfactory solution to the jointing problem.

It would seem therefore that in periods when the supply of traditional materials and manpower are adequate, non-traditional systems will not be in great demand and this is borne out by the difficulties which that sector of the industry is facing at the present time.

THE USE OF INDUSTRIALISED SYSTEMS FOR EDUCATIONAL BUILDING

During the period 1967-1968, 41.7 percent of all new school building and 8.6 percent of further educational building in England and Wales was constructed using some form of industrialised system.

Of the above total 84 percent was carried out by local authorities acting in consortia and only 16 percent by contractors offering their own private systems on a package deal basis.

2.6 percent of new university building was constructed using industrialised systems in the year 1965 to 1966, this percentage increased to 9.4 for the year 1966 to 1967 but fell back to 6.8 for the year 1967-1968.

SHORT LIFE BUILDINGS

Although short life buildings are normally built using some industrialised system, industrialised building is not restricted to short life buildings.

The life of the building is more closely associated with the material used for the fabric rather than to the method of construction.

We must therefore consider whether it is more economic to attempt to reduce initial costs by using materials which have a relatively short life or to accept higher initial costs and at the same time extend the useful life of our buildings.

The different requirements due to changes in educational thought and practices discussed in previous chapters should also be borne in mind.

Examination of building systems on a cost per square metre of floor area basis, shows that short life buildings cost approximately the same as long life buildings and in addition the annual maintenance costs of some short life buildings can be higher than for long life buildings.

Reference to the breakdown in initial costs later in this chapter shows that the expenditure on work below ground floor level, services, finishes and fittings represent more than 50 percent of the total of the initial costs and it will be obvious that these items are necessary in much the same form irrespective whether the building is a long or short life one.

It would seem therefore that short life buildings will not provide a satisfactory alternative in the forseeable future.

ROOF TOP BOILER ROOMS

Reference to the details of initial costs in figures 9.1 to 9.27 show that the provision of heating and ventilation equipment can account for more than 10 percent of the total cost of the structure. In addition it was shown in Chapter VIII that maintenance on heating and ventilating equipment was one of the major items of annual expenditure.

It is not surprising therefore that this is one of the areas which is often examined in order to improve overall efficiency.

The need for the right quality and quantity of heat together with the determination of heat requirements was discussed in Chapter VII.

It therefore remains to discuss the provision and location of the heating installation which at once suggests the consideration of roof top boiler rooms.

The advantages of installing a boiler at roof level are:-

(i) The height of the chimney is relatively small when compared with boilers at basement or ground floor level. When a chimney is constructed within the perimeter walls of a building, there can be a wastage of up to 3 square metres of floor area on every floor through which the chimney passes.

(ii) Condensation problems are reduced.

(iii) The lift plant room, cold water storage and boiler house can be combined, thereby reducing costs.

(iv) The ventilation of the boiler room is easier.

(v) As boilers at roof level are not subject to the very high hydro-static pressures as are boilers at basement or ground floor level, a very much thinner boiler section can be used.

(vi) When boilers have to be repaired or drained there is a very much reduced quantity of water to be drained off as the level of the boiler is above the level of the heating circuit.

The disadvantages are:-

(i) Repair and Maintenance work could prove to be more difficult and could also be responsible for disrupting other work within the building.

(ii) Due to heat transfer from the boiler house to other parts of the building, ventilated boiler bases are required.

(iii) In order to prevent noise and vibration being transmitted throughout the building, the boilers have to be mounted on an anti-vibration frame; floating floors or a thicker boiler room floor should be provided. During a visit to the recently completed five storey reinforced concrete framed building for the Hertfordshire College of Building, I had the opportunity of inspecting a roof top boiler installation and saw the difficulties which lecturers were trying to overcome in classrooms near to and under the boiler house caused by inadequate sound insullation.

(iv) As the hot water circulation system is not a gravitational one, as is the basement or ground floor installation controls must be arranged to shut down the boilers immediately, should pump failure occur.

There are no particular problems with regard to fuel supply, but it seems that gas is the preferred fuel for roof top boiler installations.

COMPARISON OF INITIAL COSTS FOR EDUCATIONAL BUILDINGS

In this thesis the standard elements used in the Building Cost Information Service of the Royal Institution of Chartered Surveyors amplified analysis has been adopted.

An element is defined as a major component common to most buildings which usually fulfills the same function irrespective of its construction or specification.

Elemental costs compiled from information published in the Architect's Journal and Department of Education and Science publications are published in the following form:-

Figure Number	Number of Buildings	Description
		Further Education and Technical Colleges Details of actual costs
9.1	11	College of Further Education, St Albans
9.2	8	Harris College, Preston
9.3 & 9.4	11	Further Educational Buildings at various locations
9.5 to 9.7		The above cost information inflated to January 1968 prices
9.8 to 9.14		All of the above cost information presented in graphical form
		University Buildings Details of actual costs
9.15	9	Residential buildings
9.16	7	Ancillary buildings
9.17	4	Laboratory buildings

Table (Continued)

Figure Number	Number of Buildings	Description
9.18	5	Classroom and Lecture Theatres
9.19 to 9.22		University building cost information inflated to January 1968 prices
9.23 to 9.27		All university building cost information presented in graphical form

ELEMENT NO.1 PRELIMINARIES

This element is made up of a large number of variables which include the provision of special scaffolds for nominated sub-contractors, all forms of site accommodation, sanitary arrangements, temporary screens, telephones, protection of the public, all necessary insurances to be taken out by the contractor, artificial lighting, watchmen, general attendance upon nominated sub-contractors and all such items not covered by the rates elsewhere in the Bill of Quantities.

It will be obvious therefore that the very wide range of site conditions and the nature of the buildings being erected will result in a broad scatter in the cost of this element.

The percentage of the total cost attributable to preliminaries in my small survey varied from 0.34 per cent for the Bedford College of Physical Education, gymnasium, to 20.10 percent for the residential building at the Edinburgh College of Physical Education.

Tender Date - March 1958

Fig. 9.1.

D	Admin Block E		Eng. Science block F		Gas Fitting Block G		Machine Shop block H		Building Workshop block J		Classroom block K		Gym block L		Average	
	2 £33,862		2 £44,613		1 £7,606		1 £13,342		1 £41,339		2 £26,625		1 & 2 £28,165		1 to 4 £316,984	
m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m
4.87	8,648	803.40	10,920	1014.47	1,700	157.93	3,588	333.33	10,047	933.37	6,760	628.00	6,701	622.52	77,987	7244.99
1.85	4,324	401.70	5,460	507.23	1,700	157.93	3,588	333.33	10,047	933.37	3,380	314.00	4,757	441.93	49,313	4581.18
/sq m	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £
919	1 8½	0.919	1 8½	0.919	1 8½	0.919	1 8½	0.919	1 8½	0.919	1 8½	0.919	1 8½	0.919	1 8½	0.919
323	2 5½	1.323	2 5½	1.323	2 5½	1.323	2 5½	1.323	2 5½	1.323	2 5½	1.323	2 5½	1.323	2 5½	1.323
602	2 9¼	1.492	2 4½	1.278	5 8½	3.072	4 5½	2.400	4 6¾	2.456	2 5½	1.322	6 1¾	3.307	3 6½	1.905
344	6 11¼	3.734	6 6½	3.520	9 10½	5.314	8 7½	4.642	8 8¾	4.698	6 7½	3.564	10 3¾	5.549	7 8½	4.147
200	9 9	5.247	10 0	5.382	7 3	3.902	8 4¾	4.519	7 10¼	4.227	10 3½	5.539	12 2½	6.570	10 2¾	5.505
505	1 8¼	0.908	1 8	0.897	-	-	-	-	-	-	1 8	0.897	11½	0.516	1 2½	0.650
															4 4½	2.355
971)	4 5½	2.400)	4 10¾	2.635)	10 4¼	5.573)	10 3½	5.539)	10 1	5.427)	4 3½	2.310)	7 0	3.767)	1 6¼	0.818
572	7	0.314	11½	0.516	-	-	-	-			9¼	0.415	10½	0.471	11¼	0.505
331)	14 4¾	7.748)	12 5¼	6.693)	19 0¾	10.260)	13 8	7.356)	10 3	5.517)	16 1½	8.678)	16 11	9.104)	14 10¼	7.995)
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
926)	4 11½	2.669)	4 10¾	2.635)	2 1½	1.143)	1 6	0.807)	3 4	1.794)	3 7¾	1.963)	3 6¼	1.895)	4 1¼	2.209)
594	6¾	0.303	3¾	0.168	3	0.135	3	0.135	5	0.224	4	0.179	4¼	0.191	6¼	0.280
099	36 4¾	19.589	35 2	18.926	39 0½	21.013	34 1¼	18.356	31 11¼	17.189	37 1½	19.981	41 10	22.514	37 9	20.317
545	4 3	2.288	3 9¾	2.052	1 1½	0.605	1 2¾	0.661	2 0	1.076	3 6	1.884	4 10½	2.624	3 8¼	1.985
963	3 6½	1.907	3 11½	2.131	1 3¾	0.706	1 4	0.717	1 3	0.673	3 9¼	2.030	1 11	1.031	3 1	1.660
919	1 4¼	0.729	1 3¼	0.684	1 1¾	0.616	10½	0.471	11½	0.516	1 1	0.583	1 1¾	0.617	1 2½	0.650
591	11 5¾	6.178	12 1¼	6.514	4 10¼	2.613	4 2¾	2.276	12 7¼	6.783	9 3½	5.001	4 11¾	2.679	8 6	4.575
18	20 7½	11.102	21 1¾	11.381	8 5¼	4.540	7 8	4.125	16 9¾	9.048	17 7¾	9.498	12 11	6.951	16 5¾	8.870
52)	1 5¾	0.796)	2 3¼	1.222)	7¾	0.348)	10¼	0.460)	11½	0.516	1 6¼	0.818)	3 1¾	1.693)	1 9½	0.964)
15)	7 8¼	4.137)	8 4½	4.508)	12 10½	6.929)	8 9	4.709)	13 7¼	7.322	7 11½	4.283)	7 11½	4.283)	9 1¾	4.922)
23	-	-	5¾	0.258	8 1¾	4.384	1 6¾	0.841	10¼	0.460	11	0.493	11	0.493	8¾	0.392
90	3 7¼	1.940	6 1¾	3.307	8 10½	4.777	11 2¾	6.043	7 9¾	4.204	5 4¾	2.904	5 4¾	2.904	5 8¼	3.061
52	1 7	0.852	1 7	0.852	1 7	0.852	1 7	0.852	1 7	0.852	1 7	0.852	1 7	0.852	1 7	0.852
32	14 4¼	7.725	18 10¼	10.147	32 1½	17.290	23 11¾	12.905	24 9¾	13.354	17 4½	9.350	19 0	10.225	18 11¼	10.191
93	78 3¾	42.150	81 8½	43.974	89 5¾	48.157	74 4½	40.028	82 3½	44.289	78 9¼	42.393	84 0¾	45.239	80 10½	43.525
															7 10	4.216

Fig. 9.2.

HARRIS COLLEGE, PRESTON - ACTUAL TENDER PRICES - TENDER DATE - 13th January, 1960

	Building Workshops		Mech. Eng. Workshops		Heavy Eng. Lab.		Classroom Block	
	£23 934		1 £47 255		1 £25 500		3 £65 506	
	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.
	7 823	726.78	14 225	1321.54	7 055	655.43	18 102	1681.73
			14 225	1321.54	7 055	655.43	6 034	560.58
	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £
rances	4 3¾	2.321	4 3¾	2.321	4 9½	2.579	4 3	2.288
	1 5	0.762	1 6¼	0.818	1 8½	0.919	1 10¼	0.998
	8 7½	4.642	12 0½	6.480	17 2¼	9.250	5 10½	3.162
3	14 4¼	7.725	17 10½	9.619	23 8¼	12.748	11 11¾	6.448
	8 6½	4.598	8 1¼	4.362	9 11¼	5.349	7 4½	3.969
	1½	0.067					3 1¾	1.693
	4 8¼	2.523	4 4	2.332	4 3¼	2.299	2 4¼	1.267
	3 2¾	1.738	4 0	2.153	4 1¼	2.209	7	0.314
	8	0.359					1 6	0.807
	3 7	1.929	2 2½	1.188	2 10¼	1.537	3 1½	1.682
	1 4¾	0.750	1 4¼	0.729	11¼	0.505	(5 2¼	2.792)
							(	)
lls								
	2 0¾	1.110	2 2¼	1.177	2 9½	1.503	3 5¼	1.850
	1 3½	0.695	8½	0.381	9½	0.426	2 3¾	1.244
ements	25 7	13.769	22 10¾	12.322	25 8¼	13.828	29 0¼	15.618
	3 2	1.705	4 2¼	2.254	1 3½	0.695	1 9¾	0.975
	3 0¾	1.649	2 2¼	1.177	4 4¼	2.344	4 5½	2.400
	8¼	0.370	8¼	0.370	9½	0.426	4 3¼	2.299
	2 5½	1.323	2 6¾	1.379	2 11¼	1.582	1 10¾	1.020
	2 11¾	1.604	2 3	1.211	2 5	1.300	1 9½	0.964
fittings	12 4¼	6.651	11 10½	6.391	11 9½	6.347	14 2¾	7.658
	3 1¼	1.671	1¾	0.079			3½	0.157
w pipes	1 3¾	0.706	2 3½	1.233	1 10	0.987	3 5¾	1.873
	1 1	0.583	2 3	1.211	1 1¾	0.617	4½	0.202
	6 0½	3.251	6 1¼	3.284	6 3	3.363	6 8¼	3.599
	7	0.314	5¼	0.235	6¼	0.280	2½	0.112
	7 3¼	3.913	13 10½	7.468	12 0	6.458	7 9¼	4.182
	1¼	0.078	5¾	0.258	4½	0.202		
	19 6½	10.516	25 7	13.768	22 1½	11.907	18 9¾	10.125
works s	71 10	38.661	78 2¾	42.100	83 3½	44.830	74 0½	39.849
	1 5¼	0.773	1 5¼	0.773	1 5¼	0.773	1 5¼	0.773

	Classroom Block		Games Hall		Communal Block		Boiler House	
	4 £212 921		1 £30 738		£130 746		1 £9 955	
	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.
	48 530	4508.59	6 916	642.52	32 134	2985.35	2 409	223.81
	12 133	1127.15	6 916	642.52			2 409	223.81
	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £
rances	5 1	2.736	5 2½	2.803	4 10½	2.624	4 10¾	2.634
	2 2	1.166	1 7	0.852	1 10½	1.009	1 9	0.942
	4 9¾	2.590	14 11½	8.051	9 10¼	5.326	19 10¾	10.708
3	12 0¾	6.492	21 9	11.706	16 7¼	8.959	26 6½	14.284
	7 3¾	3.935	2 3	1.211	7 6¾	4.070		
	4 3	2.288			2 4¾	1.289		
	1 3¼	0.684	10 3	5.515	5 1	2.736	13 0¼	7.008
	5	0.248	6 6	3.500	1 1¼	0.594		
	1 2	0.628			10¼	0.450		
	2 10¼	1.538	10 0¾	5.416	5 9¼	3.106	13 7¾	7.346
	4 4½	2.354)	2 1¼	1.132)	4 8¼	2.523)	4 2	2.242)
		)		)		)		)
lls								
	3 9½	2.040			2 2½	1.188	3 3¼	1.761
	2 5¾	1.334	1 0½	0.561	1 9½	0.964	4¼	0.191
ements	27 11½	15.049	32 2½	17.335	31 5½	16.930	34 5½	18.548
	1 8¼	0.908	3 4¼	1.806	3 2½	1.727	2¾	0.123
	4 11	2.646	6 0¾	3.263	5 0¾	2.725	1 2½	0.650
	4 2	2.242	7 4¾	3.980	4 9	2.556		
	1 7¼	0.863	1 11	1.031	1 10½	1.009	8¼	0.370
	3 11¼	2.121	4¼	0.191	2 3½	1.233		
fittings	16 3¾	8.780	19 1	10.271	17 2¼	9.250	2 1½	1.143
	3	0.135			5½	0.246		
w pipes	6 5¼	3.463	2¼	0.101	4 1	2.200		
	2 10½	1.549	4 3¾	2.321	1 10	0.986		
	5 5½	2.938	5 10¾	3.173	7 0¾	3.800		
	7¾	0.348			1½	0.067		
	14 8¾	7.927	8 0	4.306	5 11	3.185	1 3¾	0.706
	1 11¼	1.043			5½	0.246	21 3¾	11.467
	32 4	17.403	18 4¾	9.901	19 11¼	10.730	22 7½	12.173
works s	88 8	47.724	91 5¼	49.213	85 2¾	45.869	85 9	46.148
	1 5¼	0.773	1 5¼	0.773	1 5¼	0.773	1 5¼	0.773

Fig. 9.3

FURTHER EDUCATION AND TECHNICAL COLLEGES - ACTUAL TENDER PRICES

Element Number	Name of Establishment	College of F.E., Oswestry				College of F.E., Slough				College of Technology, Derby				Bedford Tech. College	
		Workshop Block		Classroom Block		Classroom and Laboratory Block		Workshop Block		Classrooms and Laboratories		Workshop Block		Classroom Block	
	Number of storeys Tender date Total cost	Mainly 1 June 1958 £33 230		Mainly 2 October 1954 £67 517		6 October 1955 £118 561		1 October 1955 £13 923		8 May 1956 £354 816		1 May 1956 £76 743		8 June 1954 £282 510	
		Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.
	Total floor area	11 690	1086.00	20 474	1902.03	27 815	2584.01	3 760	349.30	74 943	6962.20	19 060	1770.68	63 096	5861.62
	Ground floor area	11 330	1052.56	8 641	802.75	4 636	430.68	3 760	349.30	3 565	331.19	19 060	1770.68	6 278	583.23
	Element	Cost/sq.ft s. d.	Cost/sq.m £	Cost/sq.ft s. d.	Cost/sq.m £	Cost/sq.ft s. d.	Cost/sq.m £	Cost/sq.ft s. d.	Cost/sq.m £	Cost/sq.ft s. d.	Cost/sq.m £	Cost/sq.ft s. d.	Cost/sq.m £	Cost/sq.ft s. d.	Cost/sq.m £
1	Preliminaries and Insurances	(2 11	1.569)	(2 10¾	1.558)	5 8	3.049	5 8	3.049	6 0¼	3.239	(6 7¾	3.575)	2 3¾	1.244
2	Contingencies	(	)	(	)	1½	0.067	1½	0.067	2 6½	1.368	(	)	1 10¾	1.020
3	Work below G.F. finish	4 11½	2.667	7 5½	4.012	1 10½	1.009	6 5	3.452	3 0¼	1.625	9 10	5.290	1 8½	0.919
	Total of elements 1 to 3	7 10½	4.236	10 4¼	5.570	7 8	4.125	12 2½	6.568	11 7	6.233	16 5¾	8.865	5 11	3.183
4	Frame	6 4¼	3.420	1 0	0.538	9 2½	4.956	5 3½	2.848	9 6	5.113	7 5¾	4.025	3 7½	1.951
5	Upper floors	2¼	0.123	3 2	1.705	3 6½	1.907			6 10¾	3.711			6 2½	3.341
6	Roof	5 5	2.916	5 4½	2.893	1 0	0.538	4 11½	2.669	1 6	0.830	5 8½	3.072	2 0¾	1.110
7	Roof lights	3 9¼	2.030	1½	0.067			4 6	2.422			2 3½	1.233	3¼	0.146
8	Staircases			2¼	0.101	4 0½	2.175			1 2¾	0.661			2 2½	1.188
9	External walls	1 3½	0.695	4 3	2.288	5 11¾	3.218	6 10	3.678	2 4¼	1.267	2 2	1.166	6 2	3.319
10	Windows	11¾	0.527	5 11½	3.207	11 8½	6.301	1 10	0.987	6 11¼	3.734	5 0½	2.713	6 3½	3.386
11	External doors	7	0.314					6	0.269	0¼	0.011	3¾	0.168	1½	0.067
12	Internal structural walls														
13	Partitions	3 2¾	1.738	2 3¼	1.222	1 7¼	0.863	2 6¾	1.379	2 10½	1.548	3 1¾	1.693	1. 9½	0.964
14	Internal doors	1 6¼	0.818	8½	0.381	10½	0.471	1 6	0.807	10½	0.471	5½	0.247	10	0.449
15	Ironmongery	2½	0.112	4¼	0.191	7	0.314	6¼	0.280	1 0	0.538	8¼	0.370	7	0.314
	Total of structural elements	23 7	12.693	23 4¾	12.593	38 6½	20.743	28 6	15.339	33 2¾	17.884	27 3½	14.687	30 2	16.235
16	Wall finishes	5¼	0.235	2 5	1.300	2 5	1.300	1 4	0.717	1 9¼	0.952			2 9½	1.503
17	Floor finishes	2 2½	1.188	5 5¼	2.926	3 1½	1.682	3 6	1.884	3 11¾	2.142	3 10½	2.086	4 8	2.512
18	Ceiling finishes	4 10½	2.624	1 9½	0.964	3 1½	1.682			2 8	1.426	3 0¼	1.626	1 9½	0.964
19	Decoration	1 5¼	0.773	1 5¼	0.773	1 7	0.852	2 0	1.076	1 9¾	0.975	1 6¼	0.841	1 9¼	0.953
20	Fittings	1 7½	0.874	2 9	1.480	5 7¾	3.039	3 0	1.615	11 5¼	6.155	2 2½	1.188	1 8	0.897
	Total of finishes and fittings	10 7	5.694	13 10	7.443	15 10¾	8.555	9 10	5.292	21 8	11.661	10 8	5.741	12 8¼	6.829
21	Sanitary fittings	(	)		( )	(	)			(	)	0½	0.023	(	)
22	Waste, soil and overflow pipes	(7¾	0.348	3 3¾	(1.783)	(2 10½	1.548)	1 9½	0.964	(4 9	2.556)	2 5¼	1.311	(3 7¼	1.940)
23	Cold water services				( )	(	)			(	)			(	)
24	Hot water services				( )	(	)			(	)			(	)
25	Ventilation services	(	)	(	)							(	)	(	)
26	Heating services	(4 1¾	2.231)	(6 9	3.632	(7 5½	4.014)	(9 3	4.979)			(7 6	4.036)	(14 7¾	7.883)
27	Gas	9¾	0.437	1	0.045	(	)	(	)	1 1¾	0.617	8¼	0.370	1 1	0.583)
28	Electrical services	8 3	4.441	5 6	2.960	7 1	3.812	11 5	6.144	7 6¾	4.068	12 4½	6.660	8 8¼	4.676
29	Special services			3	0.135	4 6	2.422			5 2¼	2.792			5 6¼	2.971
30	Drainage	11¼	0.505	2 5½	1.323	1 0¾	0.572	1 0¾	0.572	0½	0.023	6	0.269	4½	0.202
	Total of services	14 9½	7.962	18 4¼	9.878	22 11¾	12.368	23 6¼	12.659	18 8¼	10.056	23 6½	12.669	33 11	18.255
	Total unit cost Cost excldg ext. works Area inside ext. walls														
	External works													1 2	0.628

Fig. 9.4.

FURTHER EDUCATION AND TECHNICAL COLLEGES

Element Number	Name of Establishment	Redcar Tech. College Classrooms, workshops and Gymnasium		N.E. Essex Technical College Classrooms & Laboratories		King Edward VI School Totnes Sports Hall		Cement and Concrete Association Lecture theatre block	
	Number of storeys	3		5		1		2	
	Tender date	Feb. 1955 and Oct. 1956		March 1956		February 1967		April 1965	
	Total cost	£272 108		£179 138		£22 707		£44 232	
		Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.	Sq.ft.	Sq.m.
	Total floor area	74 062	6880.36	42 150	3915.74	8 313	772.28	6 633	616.21
	Ground floor area	51 994	4830.24	8 303	771.35	7 172	666.28	2 568	238.57
	Element	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £	Cost/sq.ft. s. d.	Cost/sq.m. £
1	Preliminaries and Insurances	6 4	3.407	4 6	2.421	3 10½	2.086	25 3½	13.612
2	Contingencies	1 7½	0.874	1 10½	1.009	1 9¾	0.975	4 9	2.556
3	Work below G.F. finish	5 4	2.869	5 8½	3.071	6 6¾	3.532	5 6¼	2.971
	Total of elements 1 to 3	13 3½	7.150	12 1	6.501	12 3	6.593	35 6¾	19.139
4	Frame	7 5½	4.012	(11 11¾	6.445)	7 8¾	4.160	4 2½	2.265
5	Upper floors	2 10¼	1.535	(	)	1 0½	0.561	15 6¼	8.353
6	Roof	3 10¼	2.073	(11	0.493)	6 10¾	3.711	15 6	8.342
7	Roof lights	8½	0.381	3	0.135				
8	Staircases	5½	0.246	2 9½	1.502	1¾	0.078	2 4¾	1.289
9	External walls	9 4½	5.044	5 3½	2.847	8 5¼	4.541	10 2¼	5.505
10	Windows	1 4½	0.740	4 8½	2.533	1 4¾	0.751	4 8¾	2.545
11	External doors	1	0.045	8½	0.381	5	0.224	5¼	0.235
12	Internal structural walls							5 5¾	2.949
13	Partitions	2 1¼	1.132	(3 9¾	2.051)	1 0½	0.561		
14	Internal doors	7	0.314	(	)	3½	0.157	1 4¼	0.729
15	Ironmongery	6¼	0.280	1 0	0.538	6½	0.292	1 5½	0.785
	Total of structural elements	29 4½	15.802	31 5½	16.925	27 11¼	15.036	61 3¾	32.997
16	Wall finishes	1 6	0.807	11¼	0.504	6½	0.292	1 7	0.852
17	Floor finishes	4 6	2.331	6 0¼	3.239	2 2¼	1.176	1 10¼	0.998
18	Ceiling finishes	1 9½	0.964	1 11¼	1.042	0¾	0.034	2 7	1.390
19	Decoration	1 2	0.628	2 6½	1.367	8	0.359	1 5¾	0.796
20	Fittings	4 2¼	2.253	4 11¼	2.656	7¾	0.348	1 9	0.942
	Total of finishes and fittings	12 11¾	6.983	16 4½	8.808	4 1¼	2.209	9 3	4.978
21	Sanitary fittings	(	)	(	)			4	0.179
22	Waste, soil and overflow pipes	(3 11	2.107)	(4 11¾	2.679)	1 5¼	0.773	3 7¾	1.962
23	Cold water services	(	)	(	)				
24	Hot water services	(	)	(	)				
25	Ventilation services	(	)	(	)			9 7¾	5.192
26	Heating services	(8 0¾	4.338)	(6 11¾	3.755)	3 3½	1.773		
27	Gas	7½	0.336	4	0.179				
28	Electrical services	5 0¾	2.724	5 3	2.825	4 5½	2.399	11 2½	6.032
29	Special services	2½	0.101	6 5¼	3.463	1½	0.067		
30	Drainage	2 2	1.166	8	0.359	1 0¼	0.549	1 9	0.942
	Total of services	20 0½	10.772	24 7¾	13.260	10 4	5.561	26 7	14.307
	Unspecified Items								
	Total unit cost: Cost excluding ext. works / Area inside ext. walls	75 8	40.707	84 6¾	45.494	54 8	29.399	132 8½	71.421
	External works	3 3	1.750	6 8	3.588	1 7¾	0.886		

Fig. 9.6.

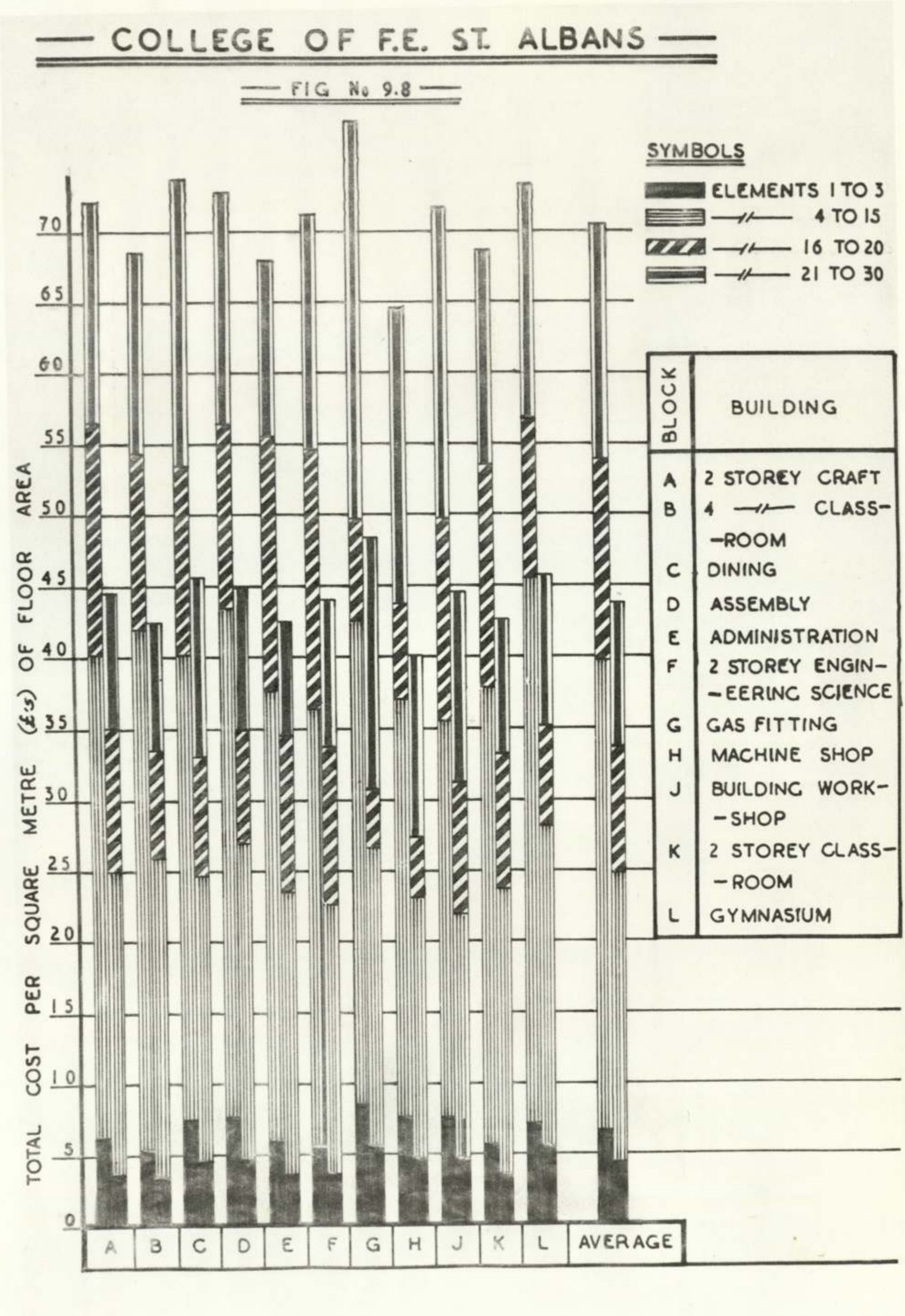
HARRIS COLLEGE - PRESTON (Costs/m^2 of floor area at January 1968 prices) Indice 1.528

Element Number	Element	Building Workshops	Mechanical Engineering Workshops	Heavy Engineering Laboratory	3 Storey Classroom Block	4 Storey Classroom Block	Games Hall	Communal Block	Boiler House
1	Preliminaries & Insurance	3.546	3.546	3.941	3.496	4.181	4.283	4.009	4.025
2	Contingencies	1.164	1.25	1.404	1.525	1.782	1.302	1.542	1.439
3	Work below G.F. finish	7.093	9.901	14.134	4.832	3.958	12.302	8.138	16.362
	Total of elements 1 to 3	11.803	14.697	19.479	9.853	9.921	17.887	13.689	21.826
4	Frame	7.026	6.665	8.173	6.065	6.013	1.850	6.219	
5	Upper floors	0.102			2.587	3.496		1.970	
6	Roof	3.855	3.563	3.513	1.936	1.045	3.427	4.181	10.708
7	Roof lights	2.656	3.290	3.375	0.480	0.379	5.348	0.908	
8	Staircases	0.549			1.233	0.960		0.703	
9	External walls	2.948	1.815	2.349	2.570	2.350	8.276	4.746	11.225
10	Windows	1.146	1.114	0.772	4.266	3.597	1.730	3.855	3.426
11	External doors								
12	Internal structural walls								
13	Partitions	1.696	1.798	2.297	2.827	3.117		1.815	
14	Internal doors	1.062	0.582	0.651	1.901	2.038	0.857	1.473	2.691
15	Ironmongery								0.292
	Total of structural elements	21.040	18.827	21.130	23.865	22.995	26.488	25.870	28.342
16	Wall finishes	2.605	3.444	1.062	1.490	1.387	2.760	2.639	0.188
17	Floor finishes	2.520	1.798	3.582	3.667	4.043	4.986	4.164	0.993
18	Ceiling finishes	0.570	0.565	0.651	3.513	3.426	6.081	3.906	
19	Decoration	2.022	2.107	2.417	1.559	1.319	1.575	1.542	0.565
20	Fittings	2.451	1.850	1.986	1.473	3.241	0.292	1.884	
	Total of finishes and fittings	10.168	9.765	9.698	11.702	13.416	15.694	14.135	1.746
21	Sanitary fittings	2.553	0.121		0.240	0.206		0.376	
22	Waste, soil & overflow pipes	1.079	1.884	1.508	2.862	5.291	0.154	3.362	
23	Cold water services								
24	Hot water services								
25	Ventilation services	0.891	1.850	0.943	0.309	2.367	3.546	1.507	
26	Heating services	4.968	5.018	5.139	5.499	4.489	4.848	5.806	
27	Gas	0.480	0.359	0.428	0.171	0.532		0.102	
28	Electrical services	5.980	11.411	9.868	6.390	12.112	6.580	4.867	1.079
29	Special services	0.119	0.394	0.309		1.594		0.376	17.525
30	Drainage								
	Total of Services	16.070	21.037	18.195	15.471	26.591	15.128	16.396	18.604
	Total Unit Cost = Cost excluding ext. works / Area inside ext. walls	57.70	65.50	69.90	62.10	72.923	76.50	71.50	70.518
	External works	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18

Fig. 9.7.

Further Education and Technical Colleges (Costs/m^2 of floor area at January 1968 prices)

	College of F.E. Oswestry		College of F.E. Slough		College of Technology Derby		Bedford Technical College	Redcar Technical College	N.E. Essex Technical College	King Edward VI School, Totnes	Cement & Concrete Association
	Workshop Block	Classroom Block	Classroom & Laboratory Block	Workshop Block	Classroom & Laboratory Block	Workshop Block	Classroom Block	Shops and Gymnasium	Classroom & Laboratory Block	Sports Hall	Lecture Theatre Block
	1.620	1.768	1.682	1.682	1.654	1.654	1.820	1.689	1.70	1.636	1.087
	2.542)	2.755)	5.128	5.128	5.357	5.913	2.264	5.754	4.116	3.413	14.796
	)	)	0.113	0.113	2.263		1.856	1.476	1.715	1.595	2.778
	4.321	7.093	1.697	5.806	2.689	8.750	1.673	4.846	5.221	5.778	3.229
	6.863	9.848	6.938	11.047	10.309	14.663	5.793	12.076	11.052	10.786	20.803
	5.540	0.951	8.336	4.790	8.457	6.657	3.551	6.776	10.957)	6.806	2.462
	0.199	3.014	3.208		6.138		6.081	2.593	)	0.918	9.080
	4.722	5.115	0.905	4.489	1.373	5.081	2.021	3.501	0.838)	6.071	9.068
	3.289	0.118		4.074		2.039	0.266	0.644	0.230		
		0.179	3.658		1.093		2.162	0.415	2.553	0.128	1.401
	1.126	4.045	5.413	6.186	2.096	1.929	6.041	8.519	4.840	7.429	5.984
	0.854	5.670	10.598	1.660	6.176	4.487	6.163	1.250	4.306	1.229	2.766
	0.509			0.452	0.018	0.278	0.122	0.076	0.648	0.366	0.255
											3.206
	2.816	2.160	1.452	2.319	2.560	2.800	1.754	1.912	3.487)	0.918	
	1.325	0.674	0.792	1.357	0.779	0.409	0.817	0.530	)	0.257	0.792
	0.181	0.338	0.528	0.471	0.890	0.612	0.571	0.473	0.915	0.478	0.853
	20.561	22.264	34.890	25.798	29.580	24.292	29.548	26.689	28.774	24.600	35.867
	0.381	2.298	2.187	1.206	1.576		2.735	1.363	0.857	0.478	0.926
	1.925	5.173	2.829	3.169	3.543	3.450	4.572	3.937	5.506	1.924	1.085
	4.251	1.704	2.829		2.375	2.689	1.754	1.628	1.771	0.056	1.511
	1.252	1.367	1.433	1.810	1.613	1.391	1.734	1.061	2.324	0.587	0.865
	1.416	2.617	5.112	2.716	10.180	1.965	1.633	3.805	4.515	0.569	1.024
s	9.225	13.159	14.390	8.901	19.287	9.495	12.428	11.794	14.973	3.614	5.411
						0.038					0.195
	0.564)	3.152	2.604	1.621	4.228	2.168	3.531 }	3.559 }	4.554 }	1.265 }	2.133
	)										5.643
	3.614	6.421	6.752 }	8.375 }		6.676 }	14.347 }	7.327 }	6.384 }	2.901	
	0.708	0.080			1.021	0.612	1.061	0.568	0.304		
	7.194	5.233	6.412	10.334	6.728	11.016	8.510	4.601	4.803	3.925	6.557
		0.239	4.074		4.618		5.407	0.171	5.887	0.110	
	0.818	2.339	0.962	0.962	0.038	0.445	0.368	1.969	0.610	0.898	1.024
	12.898	17.464	20.804	21.292	16.633	20.955	33.224	18.195	22.542	9.099	15.552
	49.547	62.735	77.022	67.038	75.809	69.405	80.993	68.754	77.341	48.099	77.633
	—	—	—	—	—	—	1.143	—	6.100	1.449	—



— COLLEGE OF F.E. ST. ALBANS —
— FIG No 9.8 —
SYMBOLS
ELEMENTS 1 TO 3
—//— 4 TO 15
—//— 16 TO 20
—//— 21 TO 30
BLOCK
BUILDING
A 2 STOREY CRAFT
B 4 —//— CLASS-ROOM
C DINING
D ASSEMBLY
E ADMINISTRATION
F 2 STOREY ENGINEERING SCIENCE
G GAS FITTING
H MACHINE SHOP
J BUILDING WORKSHOP
K 2 STOREY CLASSROOM
L GYMNASIUM
TOTAL COST PER SQUARE METRE (£'s) OF FLOOR AREA
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
A
B
C
D
E
F
G
H
J
K
L
AVERAGE

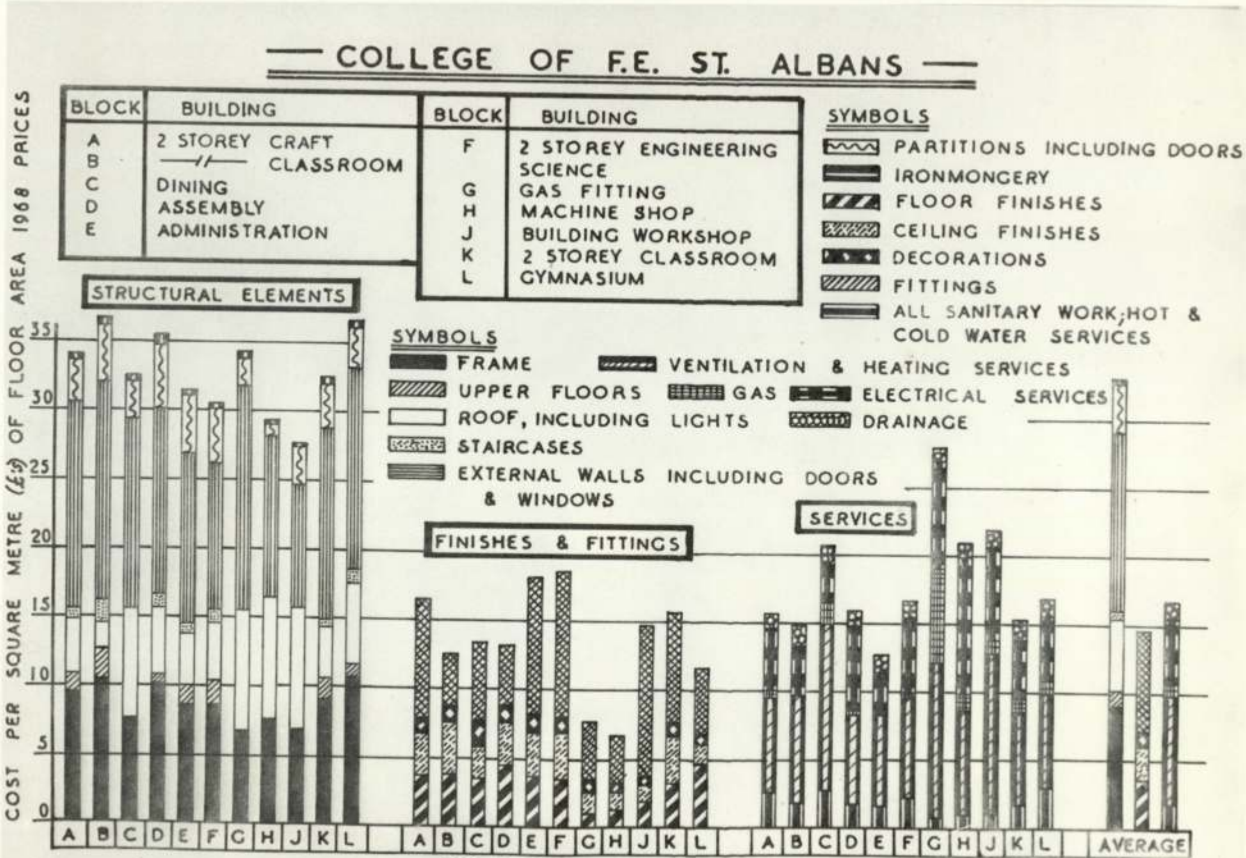

COLLEGE OF F.E. ST. ALBANS
BLOCK | BUILDING
A 2 STOREY CRAFT
B —//— CLASSROOM
C DINING
D ASSEMBLY
E ADMINISTRATION
BLOCK | BUILDING
F 2 STOREY ENGINEERING SCIENCE
G GAS FITTING
H MACHINE SHOP
J BUILDING WORKSHOP
K 2 STOREY CLASSROOM
L GYMNASIUM
SYMBOLS
PARTITIONS INCLUDING DOORS
IRONMONGERY
FLOOR FINISHES
CEILING FINISHES
DECORATIONS
FITTINGS
ALL SANITARY WORK; HOT & COLD WATER SERVICES
STRUCTURAL ELEMENTS
SYMBOLS
FRAME
UPPER FLOORS
ROOF, INCLUDING LIGHTS
STAIRCASES
EXTERNAL WALLS INCLUDING DOORS & WINDOWS
VENTILATION & HEATING SERVICES
GAS
ELECTRICAL SERVICES
DRAINAGE
FINISHES & FITTINGS
SERVICES
COST PER SQUARE METRE (£'s) OF FLOOR AREA 1968 PRICES
0
5
10
15
20
25
30
35
A B C D E F G H J K L
A B C D E F G H J K L
A B C D E F G H J K L
AVERAGE

FIG No 9.9

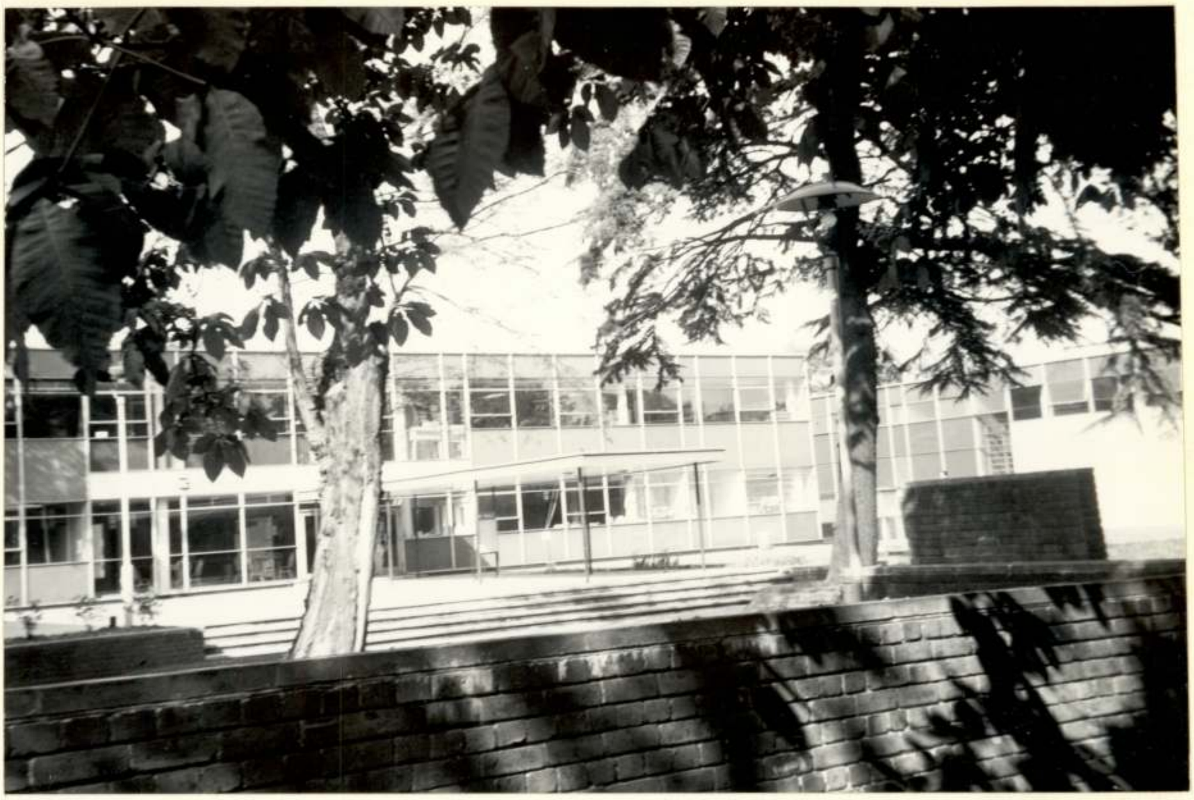


Plate No. 9.1 Administration and Library. Block "E"

Plate No. 9.2 Classrooms and Laboratories. Block "K"

COLLEGE OF FURTHER EDUCATION, ST. ALBANS

Plate No. 9.3   Classrooms and Engineering Science.   Blocks "B" and "F"

Plate No. 9.4   Classrooms.   Block "B"

Plate No. 9.5 "The Dustbin Problem"

THE HERTFORDSHIRE COLLEGE OF BUILDING

Plate No. 9.6 Front Elevation

Plate No. 9.7 Rear Elevation - The "Dustbin Problem" remains

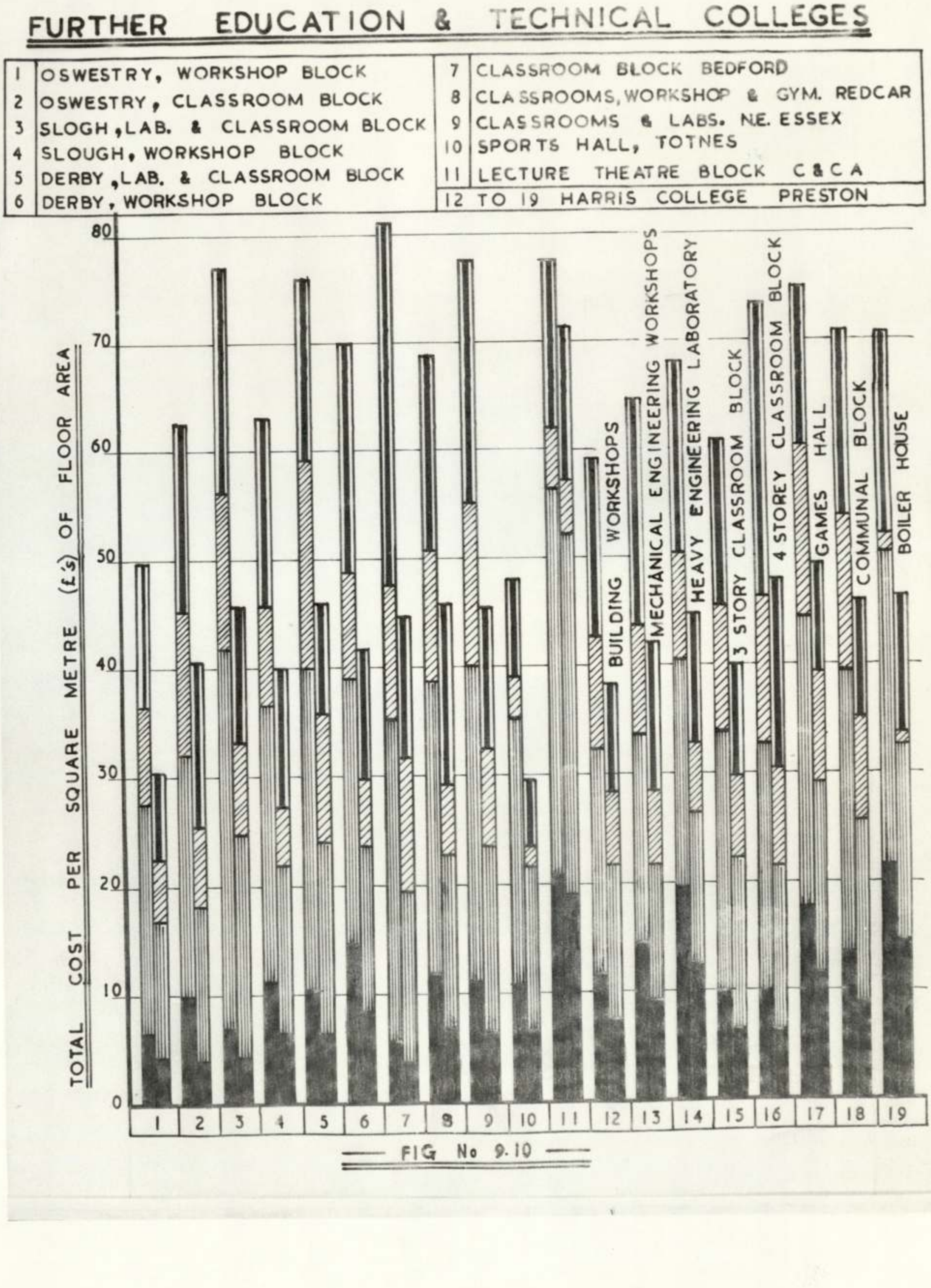

FURTHER EDUCATION & TECHNICAL COLLEGES
1 OSWESTRY, WORKSHOP BLOCK
2 OSWESTRY, CLASSROOM BLOCK
3 SLOGH, LAB. & CLASSROOM BLOCK
4 SLOUGH, WORKSHOP BLOCK
5 DERBY, LAB. & CLASSROOM BLOCK
6 DERBY, WORKSHOP BLOCK
7 CLASSROOM BLOCK BEDFORD
8 CLASSROOMS, WORKSHOP & GYM. REDCAR
9 CLASSROOMS & LABS. N.E. ESSEX
10 SPORTS HALL, TOTNES
11 LECTURE THEATRE BLOCK C & C A
12 TO 19 HARRIS COLLEGE PRESTON
TOTAL COST PER SQUARE METRE (£'s) OF FLOOR AREA
0
10
20
30
40
50
60
70
80
BUILDING WORKSHOPS
MECHANICAL ENGINEERING WORKSHOPS
HEAVY ENGINEERING LABORATORY
3 STORY CLASSROOM BLOCK
4 STOREY CLASSROOM BLOCK
GAMES HALL
COMMUNAL BLOCK
BOILER HOUSE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

FIG No 9.10

FURTHER EDUCATION & TECHNICAL COLLEGES

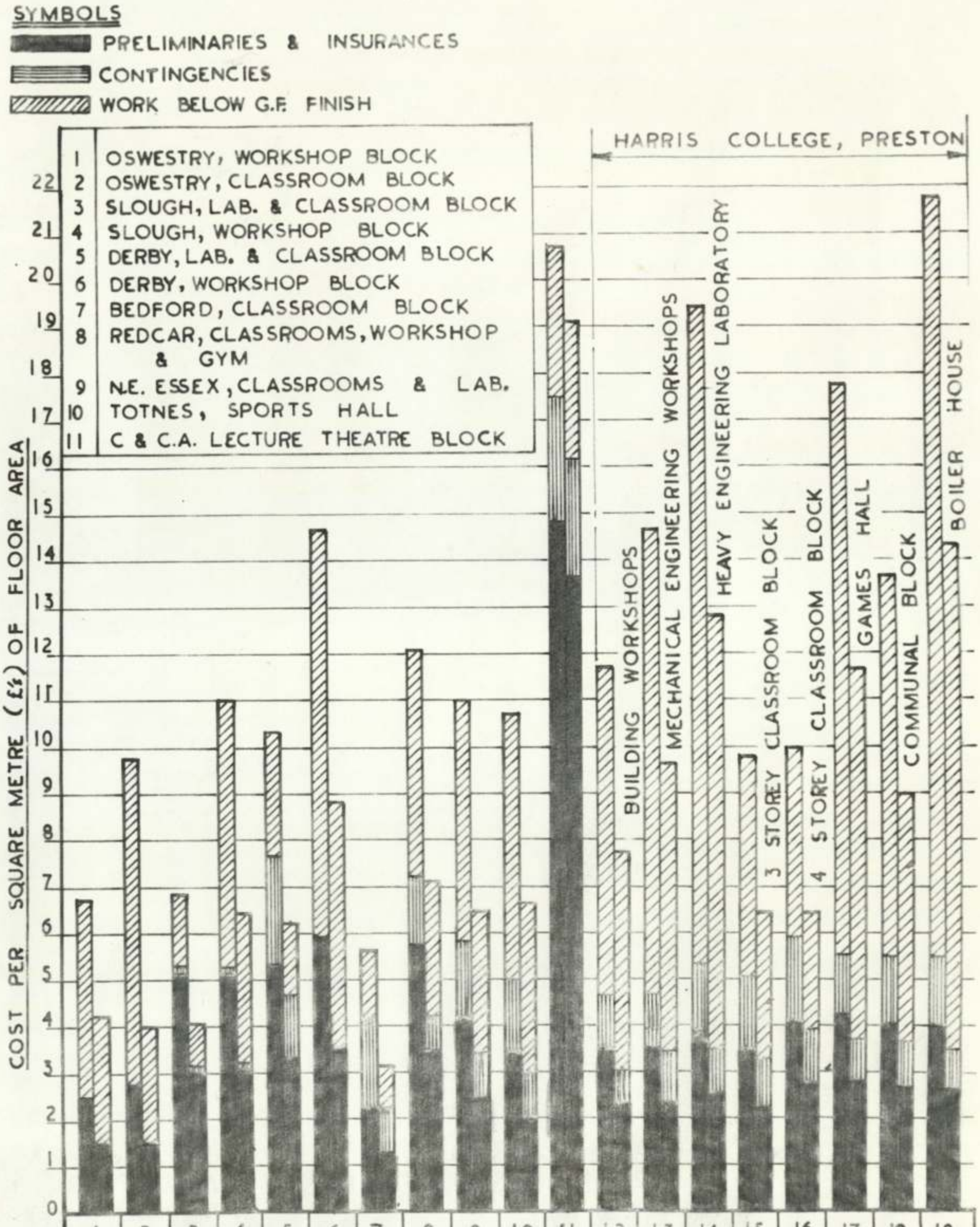


FIG No 9.11

FURTHER EDUCATION & TECHNICAL COLLEGES

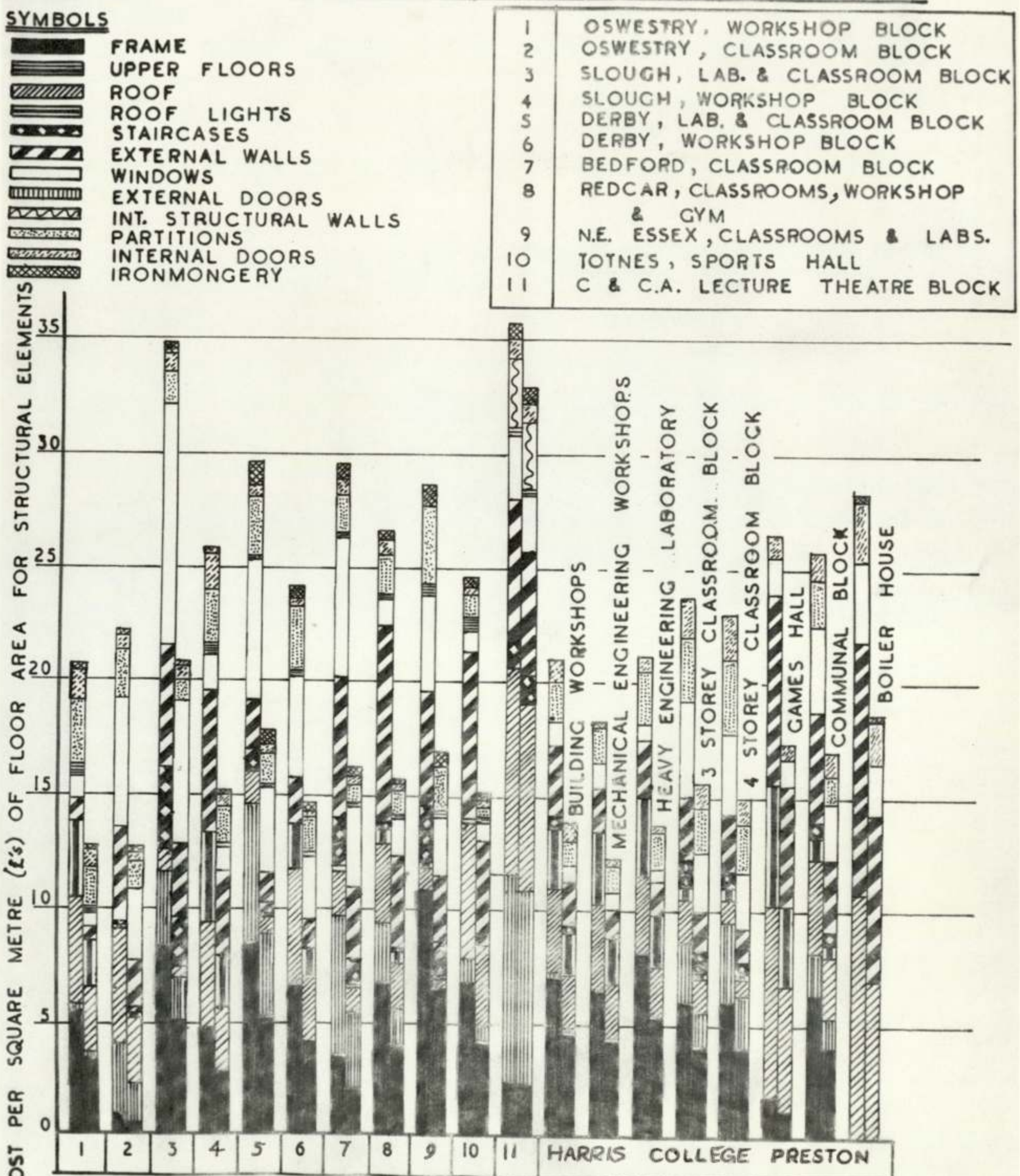
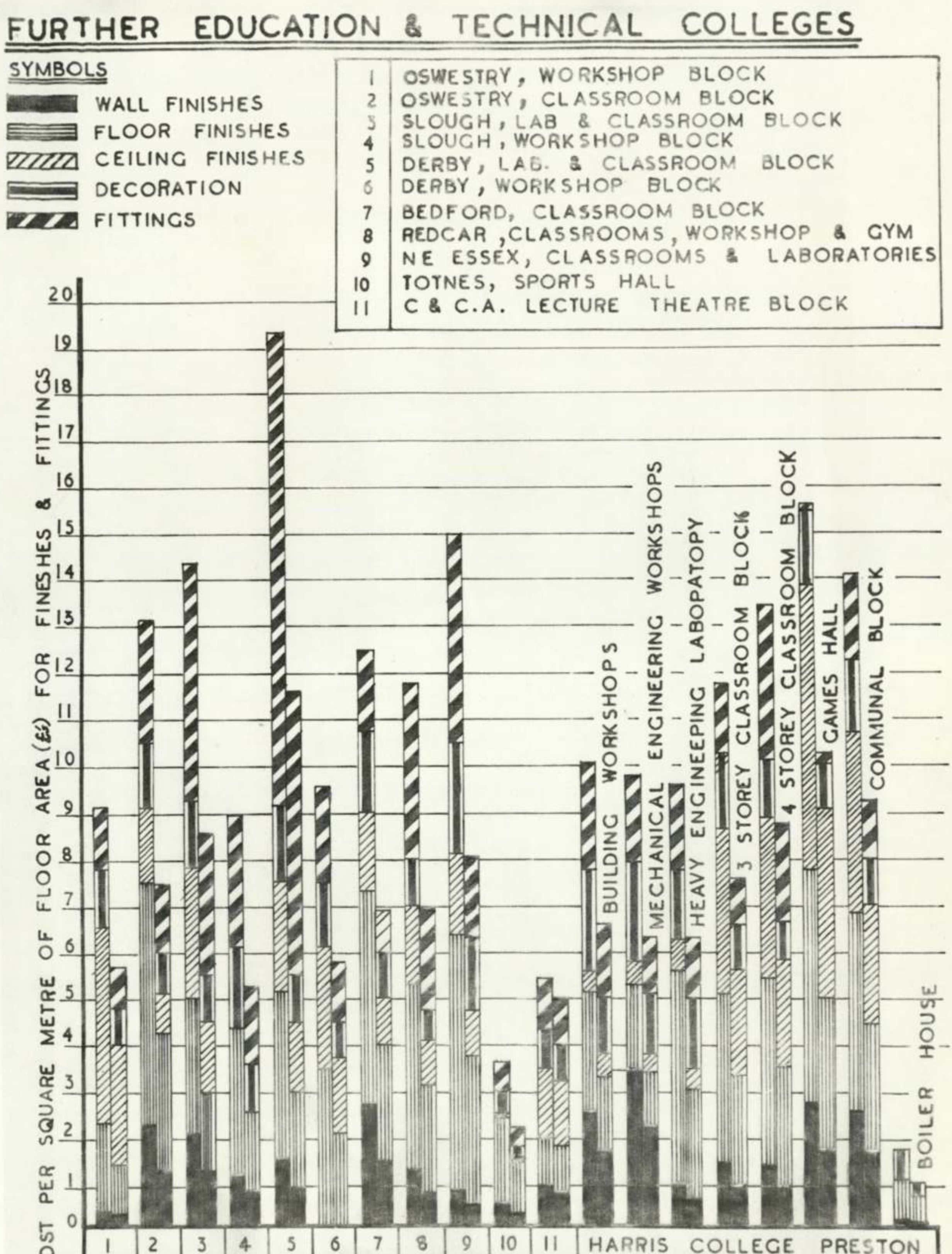


FIG No 9.12


FURTHER EDUCATION & TECHNICAL COLLEGES
SYMBOLS
WALL FINISHES
FLOOR FINISHES
CEILING FINISHES
DECORATION
FITTINGS
1 OSWESTRY, WORKSHOP BLOCK
2 OSWESTRY, CLASSROOM BLOCK
3 SLOUGH, LAB & CLASSROOM BLOCK
4 SLOUGH, WORKSHOP BLOCK
5 DERBY, LAB. & CLASSROOM BLOCK
6 DERBY, WORKSHOP BLOCK
7 BEDFORD, CLASSROOM BLOCK
8 REDCAR, CLASSROOMS, WORKSHOP & GYM
9 NE ESSEX, CLASSROOMS & LABORATORIES
10 TOTNES, SPORTS HALL
11 C & C.A. LECTURE THEATRE BLOCK
COST PER SQUARE METRE OF FLOOR AREA (£s) FOR FINESHES & FITTINGS
0
1
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20
BUILDING WORKSHOPS
MECHANICAL ENGINEERING WORKSHOPS
HEAVY ENGINEEPING LABOPATOPY
3 STOREY CLASSROOM BLOCK
4 STOREY CLASSROOM BLOCK
GAMES HALL
COMMUNAL BLOCK
BOILER HOUSE
1
2
3
4
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7
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9
10
11
HARRIS COLLEGE PRESTON

FIG No 9.13

FURTHER EDUCATION & TECHNICAL COLLEGES

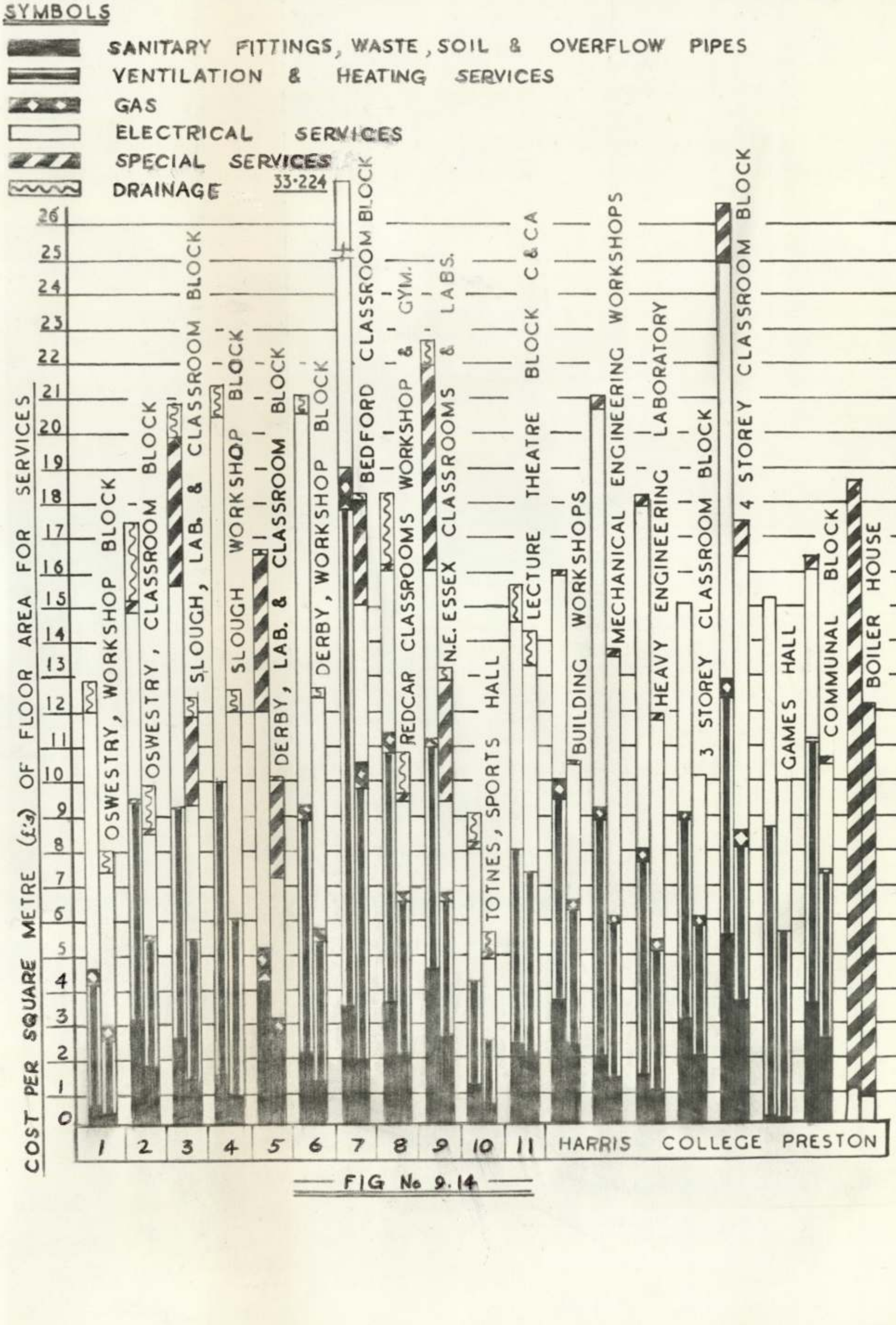


FIG No 9.14

Fig. 9.15.

Residential Buildings - Actual Costs

nt	Hall of Residence Reading University		Hall of Residence Glasgow University		Communal Block Glasgow University		Housing Block Glasgow University	
	2 & 3 Sept. 1961 £291,121		1 & 4 March 1962 £154,949		March 1962 £26,750		1 March 1962 £14,302	
	sq.ft.	sq.m.	sq.ft.	sq.m.	sq.ft.	sq.m.	sq.ft.	sq.m.
	62,153	5774.21	40,587	3770.65	5,727	532.06	3,558	330.55
	30,637	3032.08	12,082	1122.45	5,319	494.15	3,558	330.55
	Cost/sq.ft s d	Cost/sq.m £	Cost/sq.ft s d	Cost/sq.m £	Cost/sq.ft s d	Cost/sq.m £	Cost/sq.ft s d	Cost/sq.m £
nces	4 8	2.512	8 2	4.396	10 1	5.427	8 7	4.620
	2 3	1.211	2 8	1.436	3 3	1.750	2 10	1.526
	6 7½	3.565	-	-	13 11	7.490	6 6	3.498
3	13 6½	7.288	10 10	5.832	27 3	14.667	17 11	9.644
	-	-	4 10	2.602	-	-	-	-
	2 10½	1.548	-	-	9	0.403	-	-
	7 2	3.857	3 1	1.660	12 8	6.818	10 6	5.651
	7½	0.336	-	-	2 2	1.166	-	-
	8½	0.381	1 4	0.717	1 4	0.717	-	-
	5 6½	2.983	5 2	2.781	9 1	4.889	13 8	7.356
	(2 5½)	1.323)	1 10	0.987	1 8	0.897	2 9	1.480
	( )	)	6	0.269	3	0.135	1 0	0.538
lls	8	0.359	3 1	1.660	2 11	1.570	2 5	1.300
	2 6	1.345	2 4	1.255	9	0.403	-	-
	2 10	1.526	2 1	1.121	1 8	0.897	1 7	0.852
	8	0.359	2 1	1.121	1 1	0.583	1 10	0.987
ements	26 0½	14.017	26 4	14.173	34 4	18.478	33 9	18.164
	4 8¼	2.523	3 4	1.794	2 0	1.076	2 5	1.300
	5 1	2.736	4 0	2.153	4 9	2.556	4 1	2.198
	3 6½	1.907	11	0.493	3 5	1.839	2 11	1.570
	3 4¾	1.828	1 11	1.031	2 0	1.076	1 8	0.897
	5 0¾	2.725	5 1	2.736	1 10	0.987	4 6	2.422
ttings	21 9¼	11.719	15 3	8.207	14 0	7.534	15 7	8.387
	1 10¼	0.998	2 4	1.255	8	0.359	1 2	0.628
pipes	2 2½	1.188	1 2	0.628	1	0.045	3	0.135
	1 5½	0.785	1 11	1.031	2 9	1.480	9	0.403
	2 9	1.480	1 1	0.583	1 3	0.673	9	0.403
	-	-	1 3¼	0.684	1¾	0.078	7½	0.336
	6 11¼	3.734	3 3½	1.772	3 2	1.705	3 5	1.839
	0½	0.022	-	-	-	-	-	-
	4 7	2.467	7 5½	4.014	9 0¼	4.855	6 1¼	3.285
	2 10½	1.548	4	0.179	7	0.314	-	-
	2 8	1.436	1	0.045	2	0.090	1	0.045
	25 4½	13.658	18 11¼	10.191	17 10	9.599	13 1¾	7.074
rks	86 8¾	46.676	71 4¼	38.405	93 5	50.278	80 4¾	43.268
	4 8	2.512	9 4	5.023	9 4	5.023	9 4	5.023

	Students Accommodation Chichester		Southampton University Glen Eyre Halls of Residence		Corpus Christi College		College of Physical Education Edinburgh		Cement & Concrete Association Study Bedroom Block	
	3 & 4 March 1963 £67,349		January 1966 £451,198		7 April 1963 £72,852		November 1963 £119,024		4 April 1965 £126,206	
	sq ft	sq m	sq ft	sq m	sq ft	sq m	sq ft	sq m	sq ft	sq m
	12,243	1137.41	77,564	7205.92	11,654	1082.69	26,363	2449.20	19,780	1837.63
	3,672	341.05			1,746	162.21	6,084	565.22	5,771	436.14
	Cost/sq ft	Cost/sq m	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £
nces	18 5½	9.935	3 3¾	1.783	19 0¾	10.260	18 1¾	9.766	24 2½	13.028
	1 7½	0.874	3 1½	1.682	4 9¼	2.568	-	-	4 6¾	2.456
	5 9¼	3.106	9 4¾	5.057	3 3	1.750	5 11	3.184	5 9	3.095
3	25 10¼	13.915	15 10	8.522	27 1	14.578	24 0¾	12.950	34 6¼	18.579
	2 9¼	1.492	(34 6	18.568)	12 10¾	6.940			29 10¾	16.090
	8 8½	4.687	(	)	6 1	3.274	4 7¾	2.5	5	0.224
	4 6½	2.445	(	)	3 10	2.064	3 1	1.659	4 2¾	2.276
	2 4¾	1.289	(	)	2	0.090	-	-	1¼	0.056
	10½	0.471	(6½	0.292)	2 9¼	1.492	1 2¼	0.639	2 3¼	1.222
	13 6¼	7.277	(	)	8 6	4.575	4 9¼	2.568	2 6	1.345
	2 3½	1.233	3 5	1.839	12 0¼	6.469	3 8½	1.996	2 9	1.480
	11	0.493	4½	0.202	3¾	0.168	½	0.022	6	0.269
lls	1 8¾	0.930	-	-	-	-	2 7¾	1.424		
	1 9½	0.964	3 7¾	1.963	5 0	2.691	1 3¼	0.684	7 1	3.812
	1 5	0.762	6 0½	3.251	2 4	1.255	2 3¾	1.245	4 3	2.287
	1 6	0.807	-	-	11	0.493	1 9¼	0.953	2 8¾	1.469
ements	42 5½	22.850	48 6¼	26.115	54 10	29.511	25 5¼	13.690	56 8¾	30.530
	11¾	0.527	with clg		1 5	0.762	3 1½	1.682	2 4½	1.278
	5 0¾	2.725	3 7¼	1.940	4 9¾	2.590	2 5½	1.323	1 11¾	1.065
	1 4½	0.740	1 11	1.031	1 11¼	1.043	1 1¼	0.594	3	0.135
	2 1	1.121	2 3½	1.233	1 7	0.852	2 1¾	1.155	3 3½	1.772
	7 8½	4.148	-	-	7 4½	3.969	11 4	6.100	1 9¾	0.975
ttings	17 2½	9.261	7 9¾	4.204	17 1½	9.216	20 2	10.854	9 8½	5.225
	1 6¾	0.842	(5 7¾	3.039)	1 3½	0.695	2 2¾	1.200	4 2¾	2.276
pipes	10¼	0.460	(3 7¾	1.963)	1 0½	0.560	1 7½	0.875	8 5¾	4.563
	1 3¾	0.706	(-	-)	1 6	0.807	(3 10	2.063)		
	2 1¼	1.132	-	-	1 11¼	1.043	(	)		
	-	-	-	-		-				
	9 0¾	4.878	22 3	11.975	9 1¼	4.900	7 4	3.947	1 2	0.628
	-	-	-	-		-				
	7 11¾	4.294	5 9	3.094	9 6½	5.136	4 2¾	2.276	5 6½	2.983
	-	-	1 9	0.941	2¾	0.123	1¾	0.077	5 9	3.095
	1 7½	0.874	2 3	1.211	1 4	0.717	1 2¾	0.662	1 6	0.807
	24 6	13.186	41 3½	22.223	25 11¾	13.981	20 7½	11.100	26 8	14.352
rks	110 0¼	59.186	113 5½	61.064	125 0¼	67.288	90 3½	48.595	127 7½	68.686
	6 8½	3.610	5 5	2.922	7 4¼	3.958				

ANCILLARY UNIVERSITY BUILDINGS - ACTUAL COSTS - FIG 9.16

ment ber	Name of Establishment	Admin and Domestic Block Glasgow University		Edinburgh University - Agricultural College				Sheffield University Refectories, Kitchens and Common Rooms		Sheffield University Library		College of Physical Education, Bedford Gymnasium		Trinity College Dublin Library	
				Hall & Canteen Block		Administration Block									
	Number of Storeys Tender Date Total Cost	 March 1962 £94,460		Mainly 1 December 1956 £50,241		3 December 1956 £60,862		3 and 5 November 1959 £548,898		3 October 1955 £512,042		Mainly 1 January 1954 £23,580		4 September 1967 £561,586	
		Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m
	Total Floor Area	15,436	1434.00	9,413	874.47	15,182	1410.41	95,320	8855.23	104,840	9739.64	9,306	864.53	76,502	7107.04
	Ground Floor Area	8,498	789.46	7,695	714.87	3,796	352.65	26,797	2489.44	23,174	2152.86	7,314	679.47	13,251	1231.02
	Element	Cost/Sq ft s. d.	Cost/Sq m £	Cost/Sq ft s. d.	Cost/Sq m £	Cost/Sq ft s. d.	Cost/Sq m £	Cost/Sq ft s. d.	Cost/Sq m £	Cost/Sq ft s. d.	Cost/Sq m £	Cost/Sq ft s. d.	Cost/Sq m £	Cost/Sq ft s. d.	Cost/Sq m £
1.	Preliminaries and Insurances	12. 5	6.682	4. 0½	2.175	2. 8¼	1.446	1. 2½	0.650	2. 11¼	1.582	2	0.090	9. 9	5.247
2.	Contingencies	4. 1	2.198	-	-	-	-	2. 1¼	1.132	4. 9¼	2.568	1. 6	0.807	3. 9¼	2.029
3.	Work below GF Finish	9. 11½	5.360	6. 0½	3.251	3. 8¼	1.984	13. 3	7.132	7. 9¾	4.203	4. 8	2.511	12. 4¼	6.649
	Total of Elements 1 to 3	26. 5½	14.240	10. 1	5.426	6. 4½	3.430	16. 6¾	8.914	15. 6¼	8.353	6. 4	3.408	25. 10½	13.925
4.	Frame	4	0.179	22. 3¾	12.008	5. 6¼	2.971	5. 9¼	3.106	10. 11¾	5.909	2. 11	1.570	11. 11½	6.436
5.	Upper Floors	4. 2	2.243	3. 11¼	2.120	4. 2¼	2.254	5. 0¾	2.725	6. 4	3.408	1. 5	0.762	4. 8¾	2.545
6.	Roof	10. 5	5.606	14. 0¼	7.546	5. 10¾	3.173	3. 11¼	2.120	3. 1½	1.682	4. 10	2.602	8. 6¾	4.608
7.	Roof Lights	1. 2	0.628	2¼	0.101	-	-	0¼	0.011	1. 2½	0.650	4	0.179	8. 4¼	4.496
8.	Staircases	2. 4	1.255	2. 4¼	1.267	1. 9¼	0.953	4. 4½	2.355	1. 8¾	0.930	7	0.314	1. 3	0.673
9.	External Walls	10. 7½	5.718	7. 8	4.126	6. 8¼	3.599	3. 6¼	1.895	5. 7¾	3.039	5. 0	2.691	9. 9½	5.270
0.	Windows	2. 4	1.255	1. 5¼	0.773	3. 3½	1.772	10. 1½	5.449	(8. 3¾	4.474)	3. 0	1.615	10. 3¼	5.528
1.	External Doors	8	0.359	3¼	0.146	4¾	0.213	0½	0.023	(	)	1	0.045	8¼	0.370
2.	Internal Structural Walls	3. 5	1.839	-	-	-	-	1. 7	0.852						
3.	Partitions	1. 4	0.717	4. 3	2.288	2. 0½	1.098	5. 10	3.140	1. 5½	0.785	9	0.404	8¼	0.370
4.	Internal Doors	1. 5	0.762	8	0.359	1. 1½	0.605	1. 2¼	0.639	8¾	0.392	3½	0.157	11¾	0.527
5.	Ironmongery	1. 1	0.583	9	0.404	7¼	0.325	9¼	0.414	3½	0.157	2	0.090	3¼	0.146
	Total of Structural Elements	39. 3½	21.144	57. 10¼	31.138	31. 6¼	16.963	42. 2¾	22.729	39. 9¾	21.426	19. 4½	10.429	57. 6½	30.969
.	Wall Finishes	2. 5	1.300	2. 3¾	1.244	1. 11¼	1.043	6. 6	3.498	3. 11	2.108	1. 9	0.940	1. 5½	0.785
.	Floor Finishes	5. 1	2.736	4. 9½	2.579	4. 10¾	2.635	5. 3½	2.848	2. 9	1.480	5. 1	2.736	5. 2¼	2.792
.	Ceiling Finishes	2. 3	1.211	3. 1	1.660	3. 3¼	1.761	6. 1½	3.296	1. 4¾	0.751	4	0.179	9¼	0.415
.	Decoration	1. 5	0.762	1. 4¼	0.729	2. 6¼	1.356	1. 0¾	0.572	1. 1¼	0.594	1. 3	0.673	1¾	0.078
.	Fittings	3. 1¾	1.693	1. 3¼	0.684	5. 1½	2.758	4. 6½	2.445	8. 5¾	4.564	5. 5	2.916	20. 3¼	10.910
	Total of Finishes and Fittings	14. 3¾	7.702	12. 9¾	6.896	17. 9	9.553	23. 6¼	12.659	17. 7¾	9.497	13. 10	7.444	27. 10	14.98
.	Sanitary Fittings	11	0.493	7¼	0.325			(	)	(8)	0.359)	(1. 4	0.717)	3¾	0.168
.	Waste, Soil and Overflow Pipes	5	0.224	5	0.224	11	0.493	(4. 3	2.288)	( )	)	(	)	4¾	0.213
.	Cold Water Services	1. 10	0.987	4¼	0.191	1. 1½	0.605	(	)	( )	)	(	)	10¼	0.460
.	Hot Water Services	1. 5	0.762	5¾	0.258	2½	0.112	(	)	( )	)	(	)	6¼	0.280
.	Ventilation Services	1. 2½	0.650	3	0.135	10¼	0.460	7. 9¾	4.204	(12. 10	6.907)			7. 2¾	3.891
.	Heating Services	12. 5	6.682	7. 4	3.946	9. 7	5.158	7. 11½	4.283	(	)	5. 11	3.184	6. 3¼	3.375
.	Gas	-	-	2	0.090	-	-	2¾	0.123	-	-	1	0.045		
.	Electrical Services	17. 4½	9.351	9. 1¼	4.900	4. 8¼	2.522	8. 11½	4.822	8. 8¼	4.676	1. 8	0.897	9. 2¾	4.968
.	Special Services	6. 7	3.543	5. 8½	3.072	6. 0¾	3.263	2. 2¾	1.199	2. 6¾	1.379			5. 0¼	2.702
.	Drainage	2	0.090	1. 7	0.852	1. 1¾	0.617	11½	0.516	6¼	0.280	1. 4	0.717	8¾	0.392
	Total of Services	42. 4	22.783	26. 0	13.993	24. 7	13.230	32. 4¾	17.435	25. 3¼	13.601	10. 4	5.560	30. 6¾	16.449
	Total Unit Cost Cost excluding External Walls / Area inside External Walls	122. 4¾	65.869	106. 9	57.453	80. 2¾	43.176	114. 8½	61.737	98. 3	52.877	49. 10½	26.841	141. 9¾	76.323
	External Works	9. 4	5.023	4. 3¾	2.320	4. 3¾	2.320	6. 1	3.273	2. 0	1.076	10	0.448	1. 9	0.942

UNIVERSITY LABORATORY BUILDINGS - ACTUAL COSTS - FIG 9.17

Element Number	Name of Establishment	Physics Building University of Hull		Leicester University Research Block		Liverpool University Physics Building		Edinburgh University Teaching Laboratories	
	Number of stories	3		3		Varies		10	
	Tender date	July 1960		January 1958		June 1957		May 1963	
	Total cost	£320,869		£156,820		£473,097		£781,335	
		Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m	Sq ft	Sq m
	Total floor area	48 000	4 459.2	19 110	1 775.32	87 923	8 168.05	90 000	—
	Ground floor area	18 320	1 701.93	8 467	786.58	53 594	4 978.88	10 750	998.675
	Element	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £	Cost/sq ft s d	Cost/sq m £
1	Preliminaries & Insurances	8 2¼	4.407	8 7½	4.640	6 9¾	3.665	11 1¼	5.976
2	Contingencies	2 6	1.345	3 6½	1.905	1 5	0.762	5 0½	2.713
3	Work below GF finish	10 3	5.517	5 9½	3.116	6 6¾	3.533	6 8	3.588
	Total of elements 1 to 3	20 11¼	11.269	17 11½	9.662	14 9½	7.960	22 9¾	12.277
4	Frame	13 7¼	7.322	3 0½	1.637	8 0¾	4.340	11 2¼	6.022
5	Upper floors	5 4¼	2.882	4 0	2.152	3 2½	1.727	8 8½	4.687
6	Roof	6 4½	3.431	7 0¾	3.80	3 5½	1.862	1 11	1.032
7	Roof lights	2	0.090			2 4½	1.278	5	0.224
8	Staircases	1	0.045	1 9	0.942	1 0	0.538	3 5	1.839
9	External wall	1 9¾	0.975	3 6	1.883	9 1¼	4.900	10 0½	5.404
10	Windows	8 7	4.620	6 5½	3.474	6 0½	3.251	12 9½	6.884
11	External doors	3	0.135	2	0.09	7¾	0.348	2½	0.112
12	Internal structural walls	4	0.179	1 0	0.538				
13	Partitions	2 0½	1.098	2 11½	1.591	1 6¼	0.818	4 0	2.153
14	Internal doors	1 8	0.897	1 2¾	0.661	9½	0.426	8¾	0.392
15	Ironmongery	11	0.493	1 5¼	0.773	4¾	0.213	1 1¼	0.594
	Total of structural elements	41 2¼	22.167	32 7	17.541	36 7¼	19.701	54 6¼	29.343
16	Wall finishes	1 8¾	0.930	1 0	0.538	4 6¼	2.433	4 1¾	2.231
17	Floor finishes	4 10½	2.624	4 11½	2.669	5 6½	2.983	4 10½	2.624
18	Ceiling finishes	6 4¾	3.442	2 0½	1.099	2 2¼	1.177	4 5	2.377
19	Decoration	1 11½	1.054	4 0¾	2.186	1 3½	0.695	2 2½	1.189
20	Fittings	5 6	2.960	18 1½	9.754	13 1	7.041	30 10½	16.616
	Total of finishes & fittings	20 5½	11.010	30 2¼	16.246	26 7½	14.329	46 6¼	25.037
21	Sanitary fittings	6	0.269	2¼	0.101	(3 7¾	1.963)	(2 0¾	1.11)
22	Waste, soil & overflow pipes	1 11½	1.054			(	)	(	)
23	Cold water services	3 5¾	1.873	3 11½	2.131	(	)	(	)
24	Hot water services	1 2¾	0.661	7 0¾	3.801	(	)	(	)
25	Ventilation services	7 4	3.946	21 10	11.751	(	)	12 11	6.952
26	Heating services	11 8½	6.301	8 2½	4.418	(11 10	6.369)	7 0	3.767
27	Gas	9¾	0.437	1 4	0.717	7½	0.336	11½	0.516
28	Electrical services	17 10½	9.620	11 0	5.920	5 7¼	3.016	13 8½	7.378
29	Special services	4 11½	2.669	2 0¾	1.110	3 8¼	1.984	9 0	4.844
30	Drainage	1 3	0.673	2 5¼	1.311	1 9	0.941		
	Total of services	51 1¼	27.504	58 1	31.260	27 1¾	14.609	45 7¾	24.567
	Total unit cost Cost excluding ext works Area inside ext walls	133 8¼	71.950	138 9¾	74.709	105 2	56.599	169 6	91.224
	External works			5 10½	3.162	4 10¼	2.613		

LASSROOMS AND LECTURE THEATRES - ACTUAL COSTS - UNIVERSITIES FIG. 9.18

ement nber	Name of Establishment	EDINBURGH UNIVERSITY Lecture Theatre			EDINBURGH UNIVERSITY Agricultural College Teaching Block			GLASGOW UNIVERSITY Maths & Science Block			LEICESTER UNIVERSITY Teaching Block			JEWS THEOLOGICAL COLLEGE LONDON		
	Number of Stories	10			3			4			4			6		
	Tender Date	May 1963			May 1955 - August 1956			September 1966			January 1958			Bovis Contract (Between May 1956 & August 1957)		
	Total Cost	£159,402			£411,726			£352,852			£412,529			£127,325		
		Sq.ft		Sq.m	Sq.ft		Sq.m	Sq.ft		Sq.m	Sq.ft		Sq.m	Sq.ft		Sq.m
	Total floor area	18 000		1 672.2	86 338		8 020.8	46 758		4 343.818	67 400		6 261.46	26 500		2 461.85
	Ground floor area	3 990		370.671	34 140		3 171.606				13 762		1 278.49	4 300		399.47
	Element	Cost/Sq.ft s	d	Cost/Sq.m £	Cost/Sq.ft s	d	Cost/Sq.m £	Cost/Sq.ft s	d	Cost/Sq.m £	Cost/Sq.ft s	d	Cost/Sq.m £	Cost/Sq.ft s	d	Cost/Sq.m £
1	Preliminaries & Insurances	12	0½	6.481	3	4	1.793	13	10	7.446	6	1¼	3.285	7	6½	4.057
2	Contingencies	5	1¾	2.769		–	–	4	0	2.153	2	9	1.480	2	3	1.211
3	Work below GF finish	9	9¼	5.259	3	8	1.974	10	10½	5.853	4	11¼	2.658	3	2	1.704
	Total of elements 1 to 3	26	11½	14.509	7	0	3.767	28	8½	15.452	13	9½	7.423	12	11½	6.972
4	Frame		–	–	4	9¾	2.590	14	7	7.849	4	6	2.422	7	2	3.856
5	Upper floors	13	5¼	7.232	4	9½	2.579	10	2	5.472	5	8¼	3.061	7	2	3.856
6	Roof	5	10½	3.162	5	11¼	3.218	2	0	1.076	4	3¾	2.321	2	2¼	1.177
7	Roof lights	2	8	1.435		6½	0.292		–	–		1¼	0.056		2¼	0.101
8	Staircases	1	11½	1.054	1	5	0.762		–	–		9½	0.426	2	7¾	1.425
9	External walls	24	0¼	12.951	4	8	2.512	15	5	8.297	2	5½	1.323	7	6½	4.059
0	Windows	2	7	1.390	2	5¾	1.334	3	0	1.615	5	4	2.870	9	11	5.337
	External doors		3	0.135		2¼	0.101	included in int doors				3¼	0.146		3½	0.157
2	Internal structural walls		–	–		–	–					10¾	0.482			
3	Partitions		9¼	0.415	1	10¾	1.020	3	2½	1.727	2	10¼	1.537	2	10¼	1.537
4	Internal doors	1	5¾	0.796	1	4¾	0.751	4	1	2.198		9½	0.426	1	3	0.673
5	Ironmongery	1	6½	0.830		8¼	0.370		–	–		6½	0.292		8¼	0.370
	Total of structural elements	54	7½	29.400	28	10¼	15.529	52	5½	28.234	28	6½	15.362	41	10¾	22.548
6	Wall finishes	7	1¾	3.846	2	3¾	1.247	4	7½	2.489	1	3	0.673	4	6¼	2.433
	Floor finishes	6	4¾	3.442	4	5	2.375	6	10	3.678	5	4½	2.893	6	7¼	3.554
	Ceiling finishes	6	1	3.274	3	6½	1.907	5	8	3.050	1	5¼	0.796	2	3	1.211
	Decoration	2	4	1.256	1	10½	1.009	1	9	0.941	3	4	1.793	4	10¾	2.635
	Fittings	32	8½	17.603	20	5¾	11.022		10	0.449	14	9½	7.961	1	3	0.673
	Total of finishes & fittings	54	8	29.421	32	7½	17.560	19	8½	10.607	26	2¾	14.116	19	6¼	10.506
	Sanitary fittings	(2	4	1.256)				(6	9	3.632)		5	0.224			
	Waste soil & overflow pipes	(		)		7½	0.336	(		)	8	10¾	4.788			
	Cold water services	(		)	(4	4	2.331)	(		)	6	8¾	3.621	5	3¾	2.859
	Hot water services	(		)	(		)	(		)	2	4¾	1.289			
	Ventilation services	14	6½	7.826	8	6¾	4.609	(13	10	7.446)	10	10¾	5.864	(		)
	Heating services	1	2¾	0.661	6	2½	3.341	(		)	15	8¾	8.462	(10	2½	5.494)
7	Gas		11½	0.516		2¾	0.124		–	–		9¼	0.415		0¼	0.011
8	Electrical services	13	2½	7.109	6	6¼	3.508	9	3	4.979	5	8	3.050	4	0¾	2.187
9	Special services		1¼	0.056	1	4½	0.740	2	4	1.255		11¼	0.505	3	4¾	1.828
0	Drainage				1	9¾	0.975	3	0	1.615		10¾	0.482		5½	0.247
	Total of services	32	4½	17.424	29	8	15.964	35	2	18.927	53	4	28.700	23	5½	12.626
	Total Unit Cost)	168	7½	90.755	98	1½	52.818	136	0½	73.220	121	10¼	65.601	97	10	52.652
	Cost excluding ext works) Area inside ext walls)															
	External works		–	–	4	3¾	2.321	4	10	2.602	2	4¾	1.289	4	8½	2.534

RESIDENTIAL BUILDINGS - (COSTS/M² OF FLOOR AREA AT JANUARY 1968 PRICES - FIG 9.19

Name of Establishment	Hall of Residence Reading University	Hall of Residence Glasgow University	Communal Block Glasgow University	Housing Block Glasgow University	Students' Accommodation Chichester	Southampton Univ. Glen Eyre Halls of Residence	Corpus Christi College Cambridge	College of Physical Education Edinburgh	Cement and Concrete Asscn Study Bedroom Block
Indice	1.35	1.29	1.29	1.29	1.215	1.08	1.218	1.209	1.087
Element	£	£	£	£	£	£	£	£	£
Preliminaries & Insurances	3.391	5.671	7.001	5.960	12.071	1.926	12.497	11.807	14.161
Contingencies	1.635	1.852	2.258	1.968	1.062	1.817	3.128	-	2.670
Work below GF finish	4.813	-	9.662	4.510	3.774	5.462	2.132	3.850	3.364
Total of Elements 1 to 3	9.839	7.523	18.921	12.438	16.907	9.205	17.757	15.657	20.195
Frame	-	3.357	-	-	1.813	20.053)	8.453	-	17.490
Upper Floors	2.090	-	0.520	-	5.695	)	3.988	3.023	0.243
Roof	5.207	2.141	8.796	7.290	2.971	)	2.514	2.006	2.474
Roof Lights	0.454	-	1.504	-	1.566	)	0.110	-	0.061
Staircases	0.514	0.925	0.925	-	0.572	0.315 (	1.817	0.773	1.328
External Walls	4.027	3.587	6.307	9.489	8.842	)	5.572	3.105	1.462
Windows	1.786)	1.273	1.157	1.909	1.498	1.986	7.879	2.413	1.609
External Doors	)	0.347	0.174	0.694	0.599	0.218	0.205	0.027	0.292
Internal Structural Walls	0.485	2.141	2.025	1.677	1.130	-	-	1.722	-
Partitions	1.816	1.619	0.52	-	1.171	2.120	3.278	0.827	4.144
Internal Doors	2.060	1.446	1.157	1.099	0.926	3.512	1.529	1.505	2.486
Ironmongery	0.483	1.446	0.752	1.274	0.981	-	0.600	1.152	1.597
Total of Structural Elements	18.922	18.282	23.837	23.432	27.764	28.204	35.945	16.553	33.186
Wall Finishes	3.406	2.314	1.388	1.677	0.640	-	0.928	2.034	1.389
Floor Finishes	3.694	2.778	3.298	2.835	3.311	2.095	3.155	1.600	1.158
Ceiling Finishes	2.574	0.636	2.372	2.025	0.899	1.113	1.270	0.718	0.147
Decoration	2.468	1.330	1.388	1.157	1.362	1.332	1.038	1.396	1.926
Fittings	3.677	3.530	1.274	3.125	5.040	-	4.834	7.375	1.06
Total of Finishes & Fittings	15.819	10.588	9.720	10.819	11.252	4.540	11.225	13.123	5.680
Sanitary Fittings	1.347	1.619	0.463	0.810	1.022	3.282)	0.847	1.451	2.474
Waste, Soil & Overflow Pipes	1.604	0.810	0.058	0.174	0.559	2.120 (	0.682	1.058	4.960
Cold Water Services	1.060	1.330	1.909	0.520	0.858	)	0.983	2.494)	-
Hot Water Services	1.998	0.752	0.868	0.520	1.376	-	1.270	)	-
Ventilation Services	-	0.882	0.101	0.433	-	-	-	-	0.683
Heating Services	5.041	2.286	2.199	2.374	5.927	12.933	5.968	4.772	-
Gas	0.030	-	-	-	-	-	-	-	-
Electrical Services	3.330	5.178	6.263	4.238	5.217	3.342	6.256	2.752	3.243
Special Services	2.090	0.231	0.405	-	-	1.016	0.150	0.093	3.364
Drainage	1.938	0.058	0.115	0.058	1.062	1.308	0.873	0.800	0.877
Total of Services	18.438	13.146	12.381	9.127	16.021	24.001	17.029	13.420	15.601
Total Unit Cost Cost excluding Ext. Works / Area inside Ext. Walls	63.018	49.539	64.859	55.816	71.944	65.950	81.956	58.753	74.662
External Works	3.391	6.480				3.156	4.821		

ANCILLARY UNIVERSITY BUILDINGS - (COSTS/m^2 OF FLOOR AREA AT JANUARY 1968 PRICES) FIG. 9.20

ent er	Name of Establishment	Administration and Domestic Block Glasgow University	Edinburgh University Agricultural College Hall and Canteen Block	Edinburgh University Agricultural College Admin. Block	Sheffield University Refectories, Kitchens and Common Rooms	Sheffield University Library	College of Physical Education, Bedford Gymnasium	Trinity College Dublin Library
	Indice	1.29	1.688	1.688	1.532	1.682	1.820	1.025
	Element	£	£	£	£	£	£	£
	Preliminaries & Insurances	8.620	3.671	2.441	0.996	2.661	0.164	5.378
	Contingencies	2.835	-	-	1.734	4.319	1.469	2.080
	Work below G F finish	6.915	5.488	3.349	10.926	7.069	4.570	6.815
	Total of elements 1 to 3	18.37	9.159	5.790	13.656	14.049	6.203	14.273
	Frame	0.231	20.270	5.015	4.758	9.939	2.857	6.597
	Upper floors	2.893	3.579	3.805	4.175	5.732	1.387	2.609
	Roof	7.232	12.738	5.356	3.248	2.829	4.736	4.723
	Roof lights	0.810	0.170	-	0.017	1.093	0.326	4.608
	Staircases	1.619	2.140	1.609	3.608	1.564	0.571	0.690
	External walls	7.376	6.965	6.075	2.903	5.112	4.898	5.402
	Windows	1.619	1.304	2.991	8.348	7.525)	2.939	5.666
	External doors	0.463	0.246	0.36	0.035	)	0.082	0.379
	Internal structural walls	2.372	-	-	1.305	-	-	-
	Partitions	0.925	3.862	1.853	4.810	1.320	0.735	0.379
	Internal doors	0.983	0.606	1.021	0.979	0.659	0.286	0.540
	Ironmongery	0.753	0.681	0.549	0.634	0.264	0.164	0.150
	Total of structural elements	27.276	52.561	28.634	34.820	36.037	18.981	31.743
	Wall finishes	1.677	2.100	1.761	5.359	3.546	1.711	0.805
	Floor finishes	3.529	4.353	4.448	4.363	2.489	4.980	2.862
	Ceiling finishes	1.562	2.802	2.973	5.049	1.263	0.326	0.425
	Decoration	0.983	1.231	2.289	0.876	0.999	1.225	0.080
	Fittings	2.185	1.154	4.654	3.746	7.677	5.307	11.183
	Total of finishes & fittings	9.936	11.640	16.125	19.393	15.974	13.549	15.355
	Sanitary fittings	0.636	0.550	-	3.505)	0.604)	1.305)	0.172
	Waste, soil & overflow pipes	0.289	0.378	0.832	)	)	)	0.218
	Cold water services	1.273	0.322	1.021	)	)	)	0.472
	Hot water services	0.983	0.436	0.189	)	)	)	0.287
	Ventilation services	0.839	0.228	0.776	6.441	11.618)	-	3.988
	Heating services	8.620	6.661	8.707	6.562	)	5.795	3.459
	Gas	-	0.152	-	0.188	-	0.082	-
	Electrical services	12.063	8.271	4.257	7.387	7.865	1.633	5.092
	Special services	4.570	5.185	5.508	1.837	2.319	-	2.770
	Drainage	0.117	1.439	1.042	0.791	0.471	1.305	0.402
	Total of services	29.390	23.622	22.332	26.711	22.877	10.120	16.860
	Total unit cost Cost excluding ext. works. Area inside ext. walls	84.972	96.982	72.881	94.580	88.937	48.853	78.231
	External Works		3.916	3.916	5.014	1.810	0.815	0.966

UNIVERSITY LABORATORY BUILDINGS - (COSTS/M^2 OF FLOOR AREA AT JANUARY 1968 PRICES)

FIG. 9.21

Element Number	Name of Establishment	Physics Building University of Hull	Leicester University Research Block	Liverpool University Physics Building	Edinburgh University Teaching Laboratories
	Indice	1.486	1.604	1.636	1.209
	Element	£	£	£	£
1	Preliminaries of Insurances	6.459	7.443	5.998	7.225
2	Contingencies	1.999	3.056	1.247	3.280
3	Work below GF Finish	8.198	4.999	5.778	4.338
	Total of elements 1 and 3	16.746	15.498	13.023	14.843
4	Frame	10.880	2.626	7.100	7.281
5	Upper floors	4.283	3.452	2.825	5.667
6	Roof	5.098	6.095	3.046	1.248
7	Roof lights	0.134	-	2.091	0.271
8	Staircases	0.067	1.511	0.880	2.223
9	External walls	1.449	3.020	8.016	6.533
10	Windows	6.865	5.572	5.319	8.323
11	External doors	0.201	0.144	0.569	0.135
12	Internal structural walls	0.266	0.863		
13	Partitions	1.632	2.552	1.338	2.603
14	Internal doors	1.333	1.060	0.697	0.474
15	Ironmongery	0.733	1.241	0.348	0.718
	Total of structural elements	32.941	28.136	32.229	35.476
16	Wall finishes	1.382	0.863	3.980	2.697
17	Floor finishes	3.899	4.278	4.880	3.172
18	Ceiling finishes	5.115	1.763	1.926	2.874
19	Decoration	1.566	3.506	1.137	1.438
20	Fittings	4.399	15.641	11.519	20.089
	Total of finishes & Fittings	16.361	26.051	23.442	30.270
21	Sanitary fittings	0.400	0.162	3.211)	1.342)
22	Waste, soil and overflow pipes	1.566		)	)
23	Cold water services	2.783	3.415	)	)
24	Hot water services	0.982	6.095	)	)
25	Ventilation services	5.864	18.841	)	8.405
26	Heating services	9.362	7.083	10.420)	4.554
27	Gas	0.649	1.150	0.550	0.624
28	Electrical services	14.293	9.493	4.934	8.920
29	Special services	3.966	1.780	3.246	5.856
30	Drainage	1.000	2.103	1.539	-
	Total of services	40.865	50.122	23.900	29.701
	Total Unit Cost. Cost excluding ext. works / Area inside ext. walls	106.913	119.807	92.594	110.290
	External works	-	5.072	4.275	-

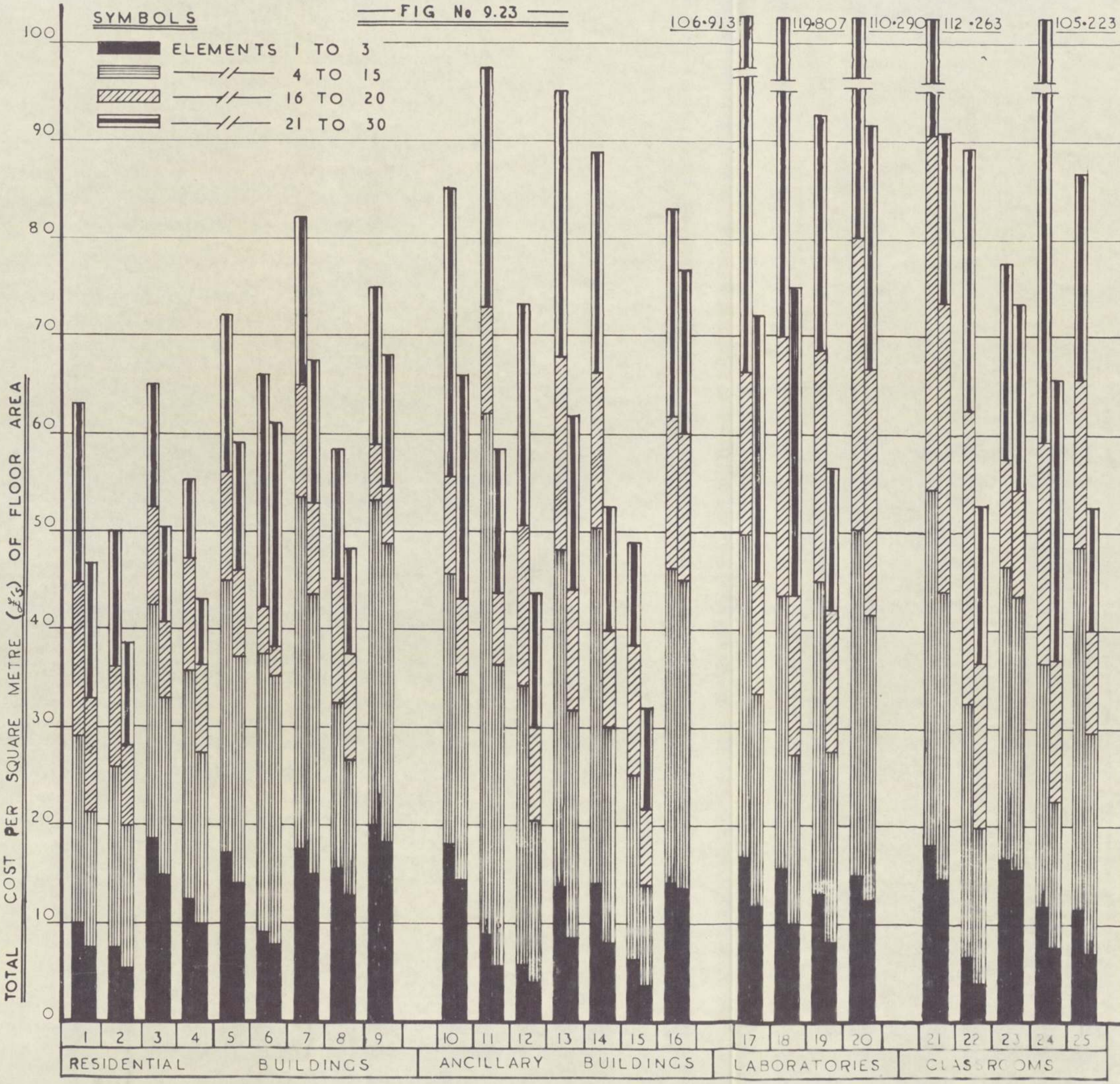
CLASSROOMS AND LECTURE THEATRES, UNIVERSITIES - (COST/M^2 OF FLOOR AREA AT JANUARY 1968 PRICES)

Fig. 9.22

Element Number	Name of Establishment	Edinburgh University Lecture Theatre	Edinburgh University Agricultural College Teaching Block	Glasgow University Maths & Science Block	Leicester University Teaching Block	Jews Theological College London
	Indice	1.237	1.688	1.059	1.604	1.645
	Element	£	£	£	£	£
1	Preliminaries and Insurances	8.017	3.027	7.885	5.270	6.674
2	Contingencies	3.425	---	2.280	2.374	1.992
3	Work below G.F. finish	6.505	3.332	6.198	4.263	2.803
	Total of elements 1 to 3	17.947	6.359	16.363	11.907	11.469
4	Frame	---	4.372	8.312	3.885	6.343
5	Upper floors	8.946	4.353	5.795	4.910	6.343
6	Roof	3.911	5.432	1.139	3.723	1.936
7	Roof lights	1.775	0.493	---	0.090	0.166
8	Staircases	1.304	1.206	---	0.683	2.344
9	External walls	16.020	4.240	8.787	2.122	6.677
10	Windows	1.719	2.252	1.710	4.603	8.779
11	External doors	0.167	0.170	---	0.234	0.258
12	Internal structural walls	---	---	---	0.773	---
13	Partitions	0.513	1.722	1.829	2.465	2.528
14	Internal doors	0.985	1.268	2.328	0.683	1.107
15	Ironmongery	1.027	0.625	---	0.468	0.609
	Total of structural elements	36.367	26.213	29.900	24.639	37.090
16	Wall finishes	4.758	2.105	2.636	1.079	4.002
17	Floor finishes	4.258	4.009	3.895	4.640	5.846
18	Ceiling finishes	4.050	3.219	3.230	1.277	1.992
19	Decoration	1.554	1.703	0.997	2.876	4.335
20	Fittings	21.775	18.605	0.475	12.769	1.107
	Total of finishes and fittings	36.395	29.641	11.233	22.641	17.282
21	Sanitary fittings	1.554)	---	3.846)	0.360	---
22	Waste, soil and overflow pipes	}	0.567	}	7.680	---
23	Cold water services	}	3.935)	}	5.808	4.703
24	Hot water services	}		}	2.068	---
25	Ventilation services	9.681	7.780	7.889)	9.406	9.038)
26	Heating services	0.818	5.640		13.573	)
27	Gas	0.638	0.209	---	0.666	0.018
28	Electrical services	8.794	5.922	5.273	4.892	3.598
29	Special services	0.069	1.249	1.329	0.810	3.007
30	Drainage	---	1.646	1.710	0.773	0.406
	Total of services	21.554	26.948	20.043	46.036	20.770
	Total unit cost Cost excluding external works Area inside external walls	112.263	89.161	77.539	105.223	86.611

FIG No 9.23

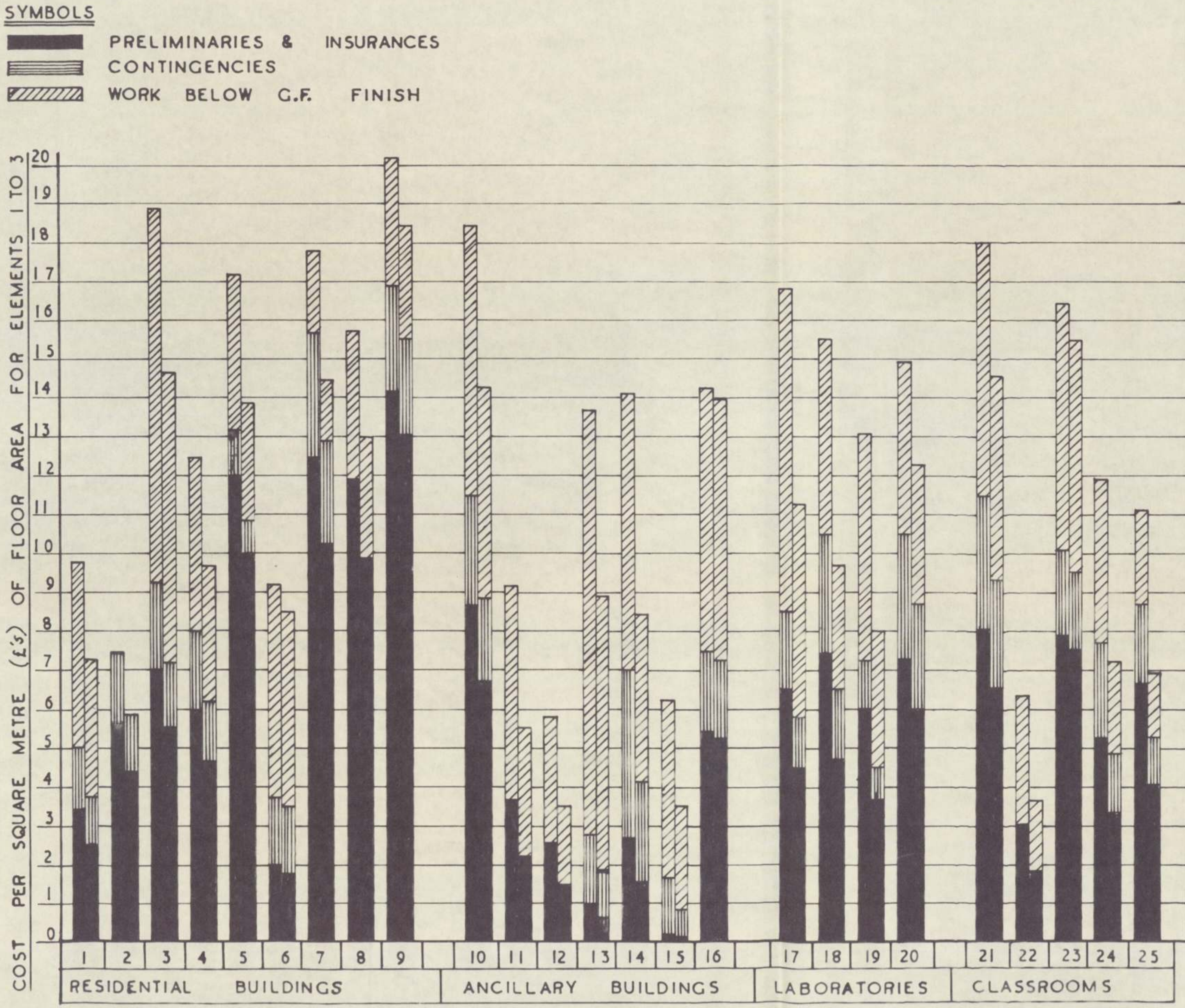
UNIVERSITY BUILDINGS



No	UNIVERSITY
	RESIDENTIAL BUILDINGS
1	HALL OF RESIDENCE, READING.
2	HALL OF RESIDENCE, GLASGOW.
3	COMMUNAL BLOCK, GLASGOW.
4	HOUSING BLOCK, GLASGOW.
5	STUDENTS ACCOMMODATION, CHICHESTER.
6	GLEN EYRE HALLS OF RESIDENCE SOUTHAMPTON.
7	CORPUS CHRISTI COLLEGE, CAMBRIDGE.
8	COLLEGE OF PHYSICAL EDUCATION EDINBURGH.
9	STUDY BEDROOM BLOCK, C&CA.
	ANCILLARY BUILDINGS
10	ADMINISTRATION & DOMESTIC BLOCK, GLASGOW
11	HALL & CANTEEN BLOCK AND
12	ADMINSTRATION BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
13	REFECTORIES, KITCHENS & COMMON ROOMS, SHEFFIELD.
14	LIBRARY, SHEFFIELD.
15	GYMNASIUM, COLLEGE OF PHYSICAL, EDUCATION, BEDFORD.
16	LIBRARY, TRINITY COLLEGE, DUBLIN.
	LABORATORIES
17	PHYSICS BUILDING, HULL.
18	RESEARCH BLOCK LEICESTER.
19	PHYSICS BUILDING LIVERPOOL.
20	TEACHING LABORATORIES, EDINBURGH.
	CLASSROOMS & LECTURE THEATRES
21	LECTURE THEATRE, EDINBURGH.
22	TEACHING BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
23	MATHS & SCIENCE BLOCK, GLASGOW.
24	TEACHING BLOCK, LEICESTER.
25	THEOLOGICAL COLLEGE LONDON

— UNIVERSITY BUILDINGS —

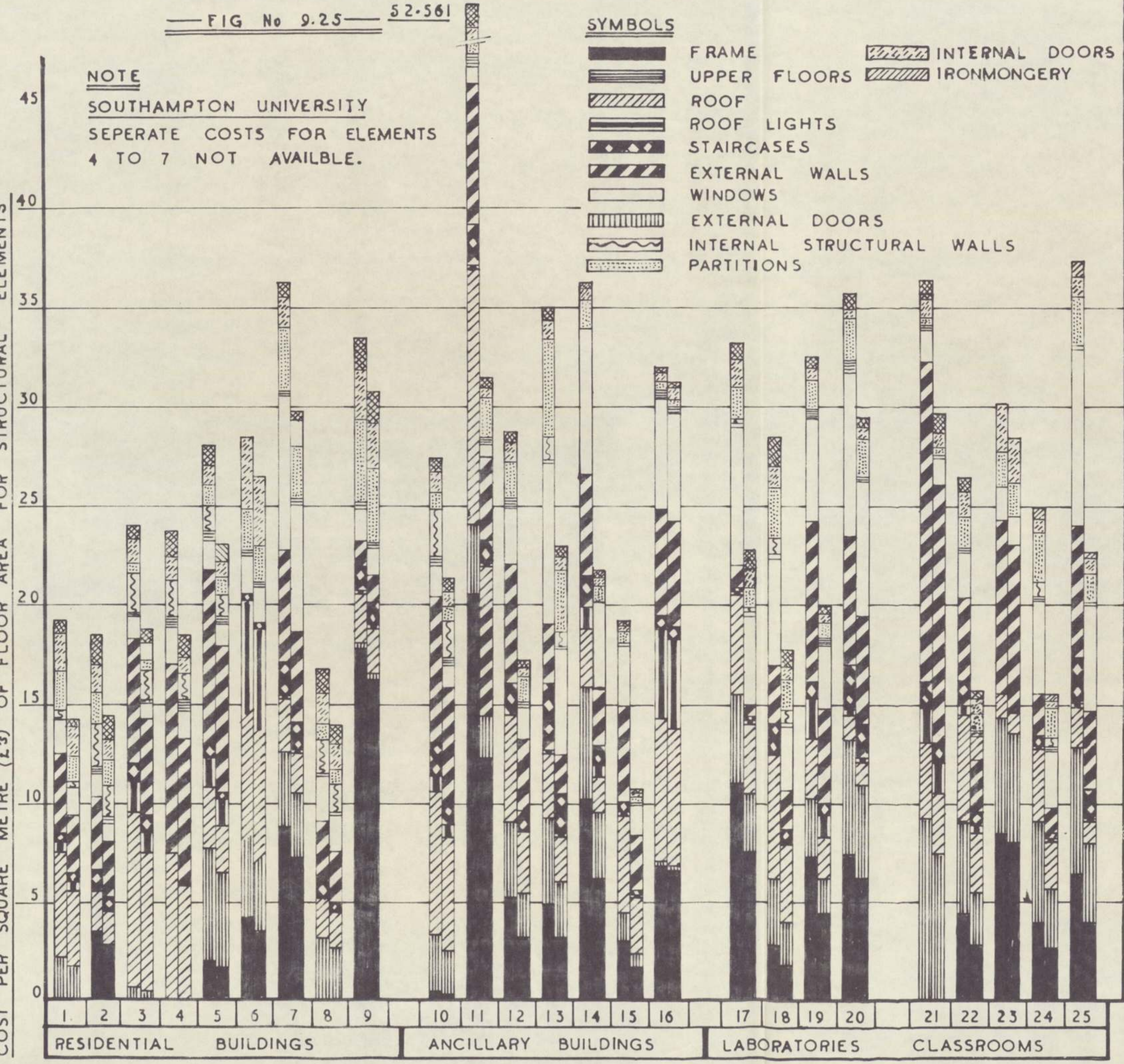
FIG No 9.24



No	UNIVERSITY
	RESIDENTIAL BUILDINGS
1	HALL OF RESIDENCE, READING.
2	HALL OF RESIDENCE, GLASGOW.
3	COMMUNAL BLOCK, GLASGOW.
4	HOUSING BLOCK, GLASGOW.
5	STUDENTS ACCOMMODATION, CHICHESTER.
6	GLEN EYRE HALLS OF RESIDENCE, SOUTHAMPTON.
7	CORPUS CHRISTI COLLEGE, CAMBRIDGE.
8	COLLEGE OF PHYSICAL EDUCATION, EDINBURGH.
9	STUDY BEDROOM BLOCK, C & C.A.
	ANCILLARY BUILDINGS
10	ADMINISTRATION & DOMESTIC BLOCK, GLASGOW.
11	HALL & CANTEEN BLOCK EDINBURGH
12	ADMINISTRATION BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
13	REFECTORIES, KITCHENS, & COMMON ROOMS, SHEFFIELD.
14	LIBRARY, SHEFFIELD.
15	GYMNASIUM, COLLEGE OF PHYSICAL EDUCATION, BEDFORD.
16	LIBRARY, TRINITY COLLEGE, DUBLIN.
	LABORATORIES
17	PHYSICS BUILDING, HULL.
18	RESEARCH BLOCK, LEICESTER.
19	PHYSICS BUILDING, LIVERPOOL.
20	TEACHING LABS. EDINBURGH.
	CLASSROOMS & LECTURE THEATRES
21	LECTURE THEATRE, EDINBURGH.
22	TEACHING BLOCK, AGRICULTURAL
23	MATHS & SCIENCE BLOCK, GLASGOW
24	TEACHING BLOCK, LEICESTER.
25	THEOLOGICAL COLLEGE, LONDON.

UNIVERSITY BUILDINGS

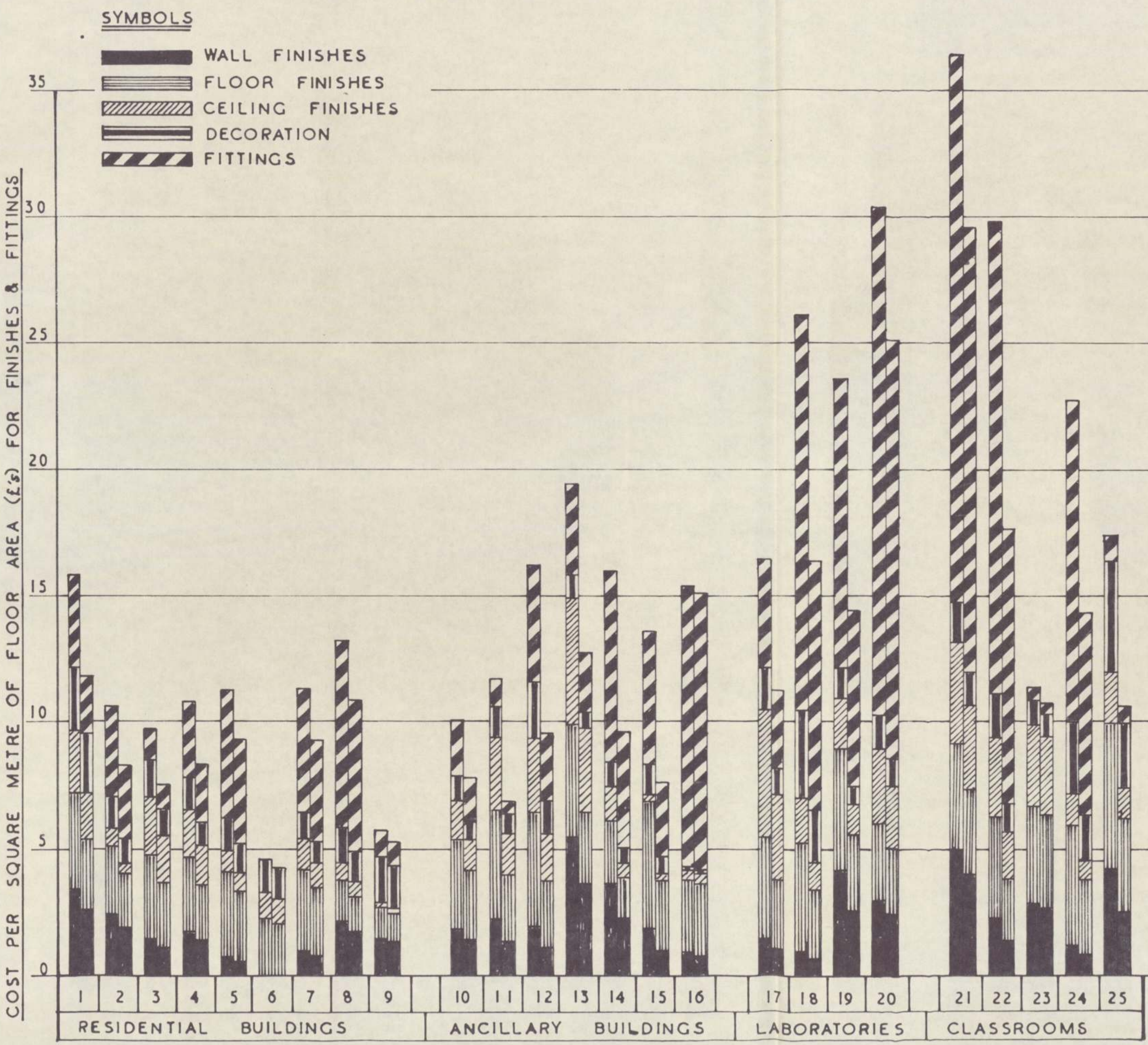
FIG No 9.25 — 52.561



No	UNIVERSITY
	RESIDENTIAL BUILDINGS
1	HALL OF RESIDENCE, READING.
2	HALL OF RESIDENCE, GLASGOW.
3	COMMUNAL, BLOCK, GLASGOW.
4	HOUSING BLOCK, GLASGOW.
5	STUDENTS ACCOMMODATION, CHICHESTER.
6	GLEN EYRE HALLS OF RESIDENCE, SOUTHAMPTON.
7	CORPUS CHRISTI COLLEGE.
8	COLLEGE OF PHYSICAL EDUCATION, EDINBURGH
9	STUDY BEDROOM BLOCK, C & C.A.
	ANCILLARY BUILDINGS
10	ADMINISTPATION & DOMESTIC BLOCK, GLASGOW.
11	HALL & CANTEEN BLOCK, EDINBURGH.
12	ADMINISTRATION BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
13	REFECTORIES, KITCHENS & COMMON ROOMS, SHEFFIELD.
14	LIBRARY, SHEFFIELD.
15	GYMNASIUM, COLLEGE OF PHYSICAL EDUCATION, BEDFORD.
16	LIBRARY, TRINITY COLLEGE, DUBLIN.
	LABORATORIES
17	PHYSICS BUILDING, HULL.
18	RESEARCH BLOCK, LEICESTER.
19	PHYSICS BUILDING, LIVEROOL.
20	TEACHING LABORATORIES, EDINBURGH.
	CLASSROOMS & LECTURE THEATRES
21	LECTURE THEATRE, EDINBURGH.
22	TEACHING BLOCK, AGRICULTURAL
23	COLLEGE, EDINBURGH.
23	MATHS & SCIENCE BLOCK, GLASGOW.
24	TEACHING BLOCK, LEICESTER.
25	THEOLOGICAL COLLEGE, LONDON.

UNIVERSITY BUILDINGS

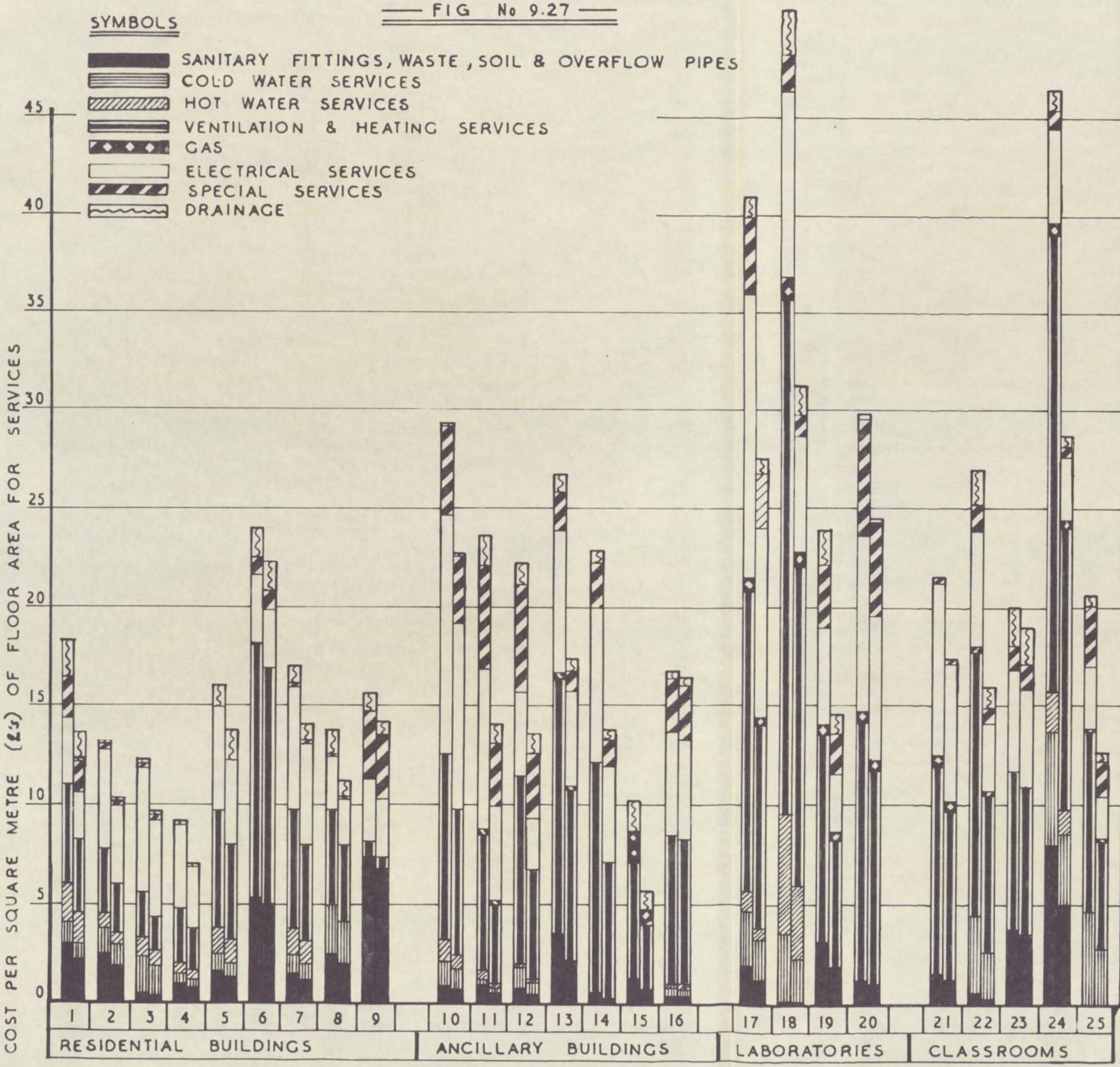
FIG No 9.26



No	UNIVERSITY
	RESIDENTIAL BUILDINGS
1	HALL OF RESIDENCE, READING.
2	HALL OF RESIDENCE, GLASGOW.
3	COMMUNAL BLOCK, GLASGOW.
4	HOUSING BLOCK, GLASGOW.
5	STUDENTS ACCOMMODATION, CHICHESTER.
6	GLEN EYRE HALLS OF RESIDENCE, SOUTHAMPTON.
7	CORPUS CHRISTI COLLEGE, CAMBRIDGE.
8	COLLEGE OF PHYSICAL EDUCATION, EDINBURGH.
9	STUDY BEDROOM BLOCK, C & C.A.
	ANCILLARY BUILDINGS
10	ADMINISTRATION & DOMESTIC BLOCK, GLASGOW.
11	HALL & CANTEEN BLOCK, EDINBURGH.
12	ADMINISTRATION BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
13	REFECTORIES, KITCHENS & COMMON ROOMS, SHEFFIELD.
14	LIBRARY, SHEFFIELD.
15	GYMNASIUM COLLEGE OF PHYSICAL EDUCATION, BEDFORD.
16	LIBRARY, TRINITY COLLEGE, DUBLIN.
	LABORATORIES
17	PHYSICS BUILDING, HULL.
18	RESEARCH BLOCK, LEICESTER.
19	PHYSICS BUILDING, LIVERPOOL.
20	TEACHING LABS. EDINBURGH.
	CLASSROOMS & LECTURE THEATRES
21	LECTURE THEATRE, EDINBURGH.
22	TEACHING BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
23	MATHS & SCIENCE BLOCK, GLASGOW.
24	TEACHING BLOCK, LEICESTER.
25	THEOLOGICAL COLLEGE, LONDON.

— UNIVERSITY BUILDINGS —

— FIG No 9.27 —



No	UNIVERSITY
	RESIDENTIAL BUILDINGS
1	HALL OF RESIDENCE, READING.
2	HALL OF RESIDENCE, GLASGOW.
3	COMMUNAL BLOCK, GLASGOW.
4	HOUSING BLOCK, GLASGOW.
5	STUDENTS ACCOMMODATION, CHICHESTER.
6	GLEN EYRE HALLS OF RESIDENCE, SOUTHAMPTON.
7	CORPUS CHRISTI COLLEGE,
8	CAMBRIDGE.
8	COLLEGE OF PHYSICAL EDUCATION, EDINBURGH.
9	STUDY BEDROOM BLOCK, C & C.A.
	ANCILLARY BUILDINGS
10	ADMINISTRATION & DOMESTIC BLOCK, GLASGOW.
11	HALL & CANTEEN BLOCK, EDINBURGH.
12	ADMINISTRATION BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
13	REFECTORIES KITCHENS & COMMON ROOMS, SHEFFIELD.
14	LIBRARY, SHEFFIELD.
15	GYMNASIUM, COLLEGE OF PHYSICAL EDUCATION, BEDFORD.
16	LIBRARY, TRINITY COLLEGE, DUBLIN.
	LABORATORIES
17	PHYSICS BUILDING, HULL.
18	RESEARCH BLOCK, LEICESTER.
19	PHYSICS BUILDING, LIVERPOOL.
20	TEACHING LABS. EDINBURGH.
	CLASSROOMS & LECTURE THEATRES
21	LECTURE THEATRE EDINBURGH
22	TEACHING BLOCK, AGRICULTURAL COLLEGE, EDINBURGH.
23	MATHS & SCIENCE BLOCK, GLASGOW
24	TEACHING BLOCK, LEICESTER.
25	THEOLOGICAL COLLEGE, LONDON.

The maximum and minimum costs at 1968 prices based upon unit floor area were £14.796/sq m for the lecture theatre block at the Cement and Concrete Association's Training Centre, Wexham Springs and £0.996/sq m for the refectory block at Sheffield University.

Figures 9.10; 9.11; 9.23 and 9.24 show the wide variation in the cost of this element, it will be seen that whilst the College of Physical Education has the highest percentage of preliminaries, the residential buildings at Cambridge, Chichester and the Cement and Concrete Association all have higher costs when compared on a cost per unit of floor area.

The average percentage of total cost and the cost per unit of floor area assigned to preliminaries for the various classes of buildings are as follows:-

Description	Percent of Total Cost %	Cost/Sq m of floor area at 1968 prices £
Universities		
Residential buildings	12	8.276
Ancillary buildings	4	5.378
Laboratories	6	6.804
Classrooms and lecture theatres	6	6.175
Further Education and Technical Colleges	6	5.197
St Alban's College of Further Education	2	1.481
Harris College, Preston	6	5.065

It is not possible to attach very great significance to the above figures because of the many variables of which the element is composed, the smallness of the sample and insufficient detailed information of expenditure, however, the conformity of the laboratory and classroom buildings and their relationship with the multi-storey residential buildings is worthy of note.

ELEMENT NO.2 CONTINGENCIES

This element covers expenditure on unforeseen works and varies from 0 to 4.86 percent of the total cost of the building. The average for all buildings in which an item was included for contingencies is approximately 3 per cent and the average cost per square metre of floor area varied from £1.489 to £2.400 for the various classes of building.

ELEMENT NO.3 WORK BELOW GROUND FLOOR FINISH

The load bearing capacity of the foundation, the nature of the site and the type of building to be erected are the three main factors which will affect the expenditure on this element.

It will be obvious therefore that there will be a large variation in the cost of this element between various buildings and this is verified by examination of detailed costs. There is however a problem of cost distortion caused by the way in which the information is presented. The expenditure on this element varied from 2 per cent to 23.20 per cent.

The average values of percentage of total cost and cost per unit floor area for the various classes of buildings are as follows:-

(See Table on next page)

Description	Percentage of Total Cost %	Cost/Sq m of floor area at 1968 prices £
Universities		
Residential buildings	6	4.174
Ancillary buildings	8	6.447
Laboratories	5	5.828
Classrooms and lecture theatres	6	4.620
Further Education and Technical Colleges	7	4.646
St Alban's College of Further Education	4	3.071
Harris College, Preston	13	9.590

This is one of the items in which the ratio of ground floor area to total floor area has a marked affect.

Consider the games hall, the two storey communal block, the three and four storey classroom blocks of the Harris College, Preston.

All these buildings were erected on the same site on in situ piles. Converting the cost of work below ground floor finish level from a cost per unit of total floor area to cost per unit of ground floor area gives the following results:-

Building	Number of Storeys	Cost/Sq m	
		Total floor area £	Ground floor area only £
Games Hall	1	8.051	8.051
Communal Block	2	5.326	10.652
Classroom Block	3	3.162	9.486
Classroom Block	4	2.590	10.330

Obviously the higher and heavier the building the more expensive will be the unit cost of the work below ground floor finish level, for any given site, however, the comparison just made, together with similar comparisons of other buildings show that the cost comparison of this element is more distorted when considered on a total floor area basis rather than on ground floor area only basis.

ELEMENT NOS 4; 5; 6; 9; 12 AND 13. THE MAIN STRUCTURAL ELEMENTS

The unit cost of the structural frame will be affected more by the height of the building and floor loadings than by distortion due to comparisons on either a total or ground floor area basis.

The expenditure on the structural frame ranged from 0 to 23.43 per cent of the total cost of the structure, it will be useful therefore, to examine more closely the constructional details and expenditure for a number of buildings.

FIGURE NO. 9.28

Building	Type of Construction	Expenditure on frame	
		Cost/Sq m of floor area at 1968 Price £	Percentage of Total Cost %
dy Bedroom Block for ent & Concrete Association	Proprietary pre-cast concrete structure (includes external walls) 4 storeys.	17.49	23.43
l and Canteen Block nburgh University	Concrete encased steel frame and steel roof truss. (Includes gallery frame.)	20.27	20.90
Block, College of ther Education, St Albans	4 Storey classroom block "CLASP" construction	10.63	15.49
East Essex Technical lege	5 Storey classroom and Laboratory block. Insitu RC frame, beams, floors, roof and walls.	10.96	14.17
dent Accommodation, chester	3 and 4 storey. Isolated 9 in dia RC columns. 6 in RC floors. Timber roof.	1.81	2.52
inistration & Domestic ck nburgh University	3 storey insitu RC columns and beams with steel frame roof.	5.02	0.27
ching block, Leicester versity	4 storey RC frame construction, with steel frame over plant room	3.89	3.69
ssroom block, Oswestry lege of Further cation	2 storey RC frame with prestressed pot floor, some load-bearing brickwork.	0.95	1.52
l of Residence ding University	No frame	Nil	Nil

RE NO.9.29

Y BEDROOM BLOCK FOR CEMENT AND CONCRETE ASSOCIATION

STRUCTURAL ELEMENTS

	Frame	Upper Floors	Roof	External Walls	Internal Structural Walls	Partitions	Total
entage of l Cost	23.43	0.33	3.39	1.96	-	5.55	34.66
/M² of r area (£)	17.49	0.24	2.54	1.46	-	4.14	25.87
AND CANTEEN BLOCK, EDINBURGH UNIVERSITY							
entage of l Cost	20.90	3.69	13.31	7.18	-	3.98	49.06
/M² of r area (£)	20.27	3.58	12.91	6.97	-	3.86	47.59
OREY CLASSROOM BLOCK, ST ALBANS COLLEGE OF FE							
entage of l Cost	15.49	2.98	2.42	21.76*	-	5.93	48.58
/M² of r area (£)	10.63	2.04	1.66	14.93	-	4.07	33.30
TOREY CLASSROOM BLOCK, NE ESSEX TECHNICAL COLLEGE							
entage of l Cost	14.17	Included with	1.38	6.26	-	4.51*	26.32
/M² of r area (£)	10.96	frame	1.07	4.84	-	3.49	20.36

E 9.29

STRUCTURAL ELEMENTS

	Frame	Upper Floors	Roof	External Walls	Internal Structural Walls	Partitions	Total
NT ACCOMMODATION, CHICHESTER							
ntage of Cost	2.52	7.92	6.31	12.29	1.57	1.63	32.24
M^2 of area (£)	1.81	5.70	8.67	8.84	1.13	1.13	27.32
ISTRATION AND DOMESTIC BLOCK, EDINBURGH UNIVERSITY							
ntage of Cost	6.88	5.22	7.35	8.34	-	2.54	30.33
M^2 of area (£)	5.02	3.81	5.36	6.08	-	1.85	22.12
ING BLOCK, LEICESTER UNIVERSITY							
ntage of Cost	3.69	4.67	3.63	2.02	0.74	2.34	17.08
M^2 of area (£)	3.89	4.91	3.81	2.12	0.77	2.47	17.97
ROOM BLOCK, OWESTRY COLLEGE OF FURTHER EDUCATION							
ntage of Cost	1.52	4.80	8.34	6.45	-	3.44	24.55
M^2 of area (£)	0.95	3.01	5.23	4.05	-	2.16	15.40

RE NO. 9.29 (Continued)

	Frame	Upper Floors	Roof	External Walls	Internal Structural Walls	Partitions	Total
OF RESIDENCE, READING UNIVERSITY							
entage of l Cost	-	3.32	8.98	6.39	0.77	2.88	22.34
/M^2 of r area (£)	-	2.09	5.66	4.03	0.49	1.82	14.09

In order to study the factors affecting frame costs, all of the main structural elements of the nine buildings compared in the Figure 9.28 are shown in Figure 9.29.

It will be seen that the cost of external walls for the study bedroom block at the Cement and Concrete Association's Training Centre is small in comparison with all other buildings except the teaching block at Leicester University.

Examination of the detailed specification shows that the external walls which are composed of 8 in (203 mm) and 10 in (254 mm) pre-cast white concrete have been included with the frame.

The relatively high cost of the external walls of the hall and canteen block of Edinburgh University highlights another variable, often referred to as a quantity factor.

As has been discussed earlier the shape of the building will affect the ratio of wall area to floor area, a narrow building having a larger value than a square building. The area of external wall will also be affected by the area of glazing and external doors.

A comparison between the hall and canteen block of Edinburgh University and the teaching block of Leicester University gives the following results:-

In order to study the factors affecting frame costs, all of the main structural elements of the nine buildings compared in the Figure 9.28 are shown in Figure 9.29.

It will be seen that the cost of external walls for the study bedroom block at the Cement and Concrete Association's Training Centre is small in comparison with all other buildings except the teaching block at Leicester University. Examination of the detailed specification shows that the external walls which are composed of 8 in (203 mm) and 10 in (254 mm) pre-cast white concrete have been included with the frame.

The relatively high cost of the external walls of the hall and canteen block of Edinburgh University highlights another variable, often referred to as a quantity factor.

As has been discussed earlier the shape of the building will affect the ratio of wall area to floor area, a narrow building having a larger value than a square building. The area of external wall will also be affected by the area of glaxing and external doors.

A comparison between the hall and canteen block of Edinburgh University and the teaching block of Leicester University gives the following results:-

Area in Square Metres			Quantity Factor		Cost/Sq m of floor area	
Total floor area	External walls	Windows	External walls	Windows	External Walls (£)	Windows (£)
LEICESTER UNIVERSITY						
6261.46	1264.22	820.33	0.202	0.131	2.122	4.603
EDINBURGH UNIVERSITY						
874.47	661.38	61.87	0.768	0.076	6.965	1.304

If the cost of the walls for each building and the proportion of wall occupied by windows is the same, the quantity factor would be responsible for making it appear that the external walls of Edinburgh University were 3.81 times as expensive as the external walls of Leicester University, however, it will be seen from Figure 9.30 that the actual cost of external walls for Leicester University is greater than those of Edinburgh University, which is the reverse of the impression given when making cost comparisons on the basis of unit floor area.

FIGURE NO.9.30

EXTERNAL WALLS

Item	Quantity Sq m	Cost £/M^2
LEICESTER UNIVERSITY		
5 in (127 mm) to 9 in (229 mm) RC wall	688.97	6.839
11 in (280 mm) brick cavity walls (facing bricks)		
£22.25/1000	334.45	5.460
9 in (229 mm) brick wall	240.81	2.938
Western red cedar cladding	127.08	7.759
Average = £5.90/M^2		
EDINBURGH UNIVERSITY		
11 in (280 mm) and 14 in (356 mm) cavity walls	484.96	2.108
Tyrolean rendered on outer face		
11 in (280 mm) and 14 in (356 mm) cavity walls with facing bricks	56.85	3.644
Hardwood glazed screens	119.56	9.261
Average = £3.52/M^2		

An additional adjustment can be made by applying the appropriate indice to allow for the date of construction, however, caution should be exercised in ensuring that the application of the indice represents the actual price movements for the components being considered.

The average cost of external walls for the two universities if the indices are applied are:-

Leicester: £5.90 x 1.604 = £9.44/M^2 of wall area

Edinburgh: £3.52 x 1.688 = £5.95/M^2 of wall area

Similar exercises must be carried out for each component before conclusions are drawn.

It will be obvious that the cost of the roof when expressed as a cost per unit of floor area will be greatly affected by the number of storeys.

All of the above comments can be summarised as follows: whilst the expenditure on components or elements of a building can be usefully expressed on the basis of a cost per unit of floor area for use in feasibility studies, distortion can occur by variables such as:-

- (i) The actual unit cost of the component.
- (ii) The shape of the building.
- (iii) The quantity factor.
- (iv) The year and place of construction.
- (v) Market forces at the time of tendering.
- (vi) The number of storeys.
- (vii) The incompatability of the elements being compared.

The actual costs, given on the basis of a cost per unit floor area, and a comparison of the relative order of magnitude of the various elements can be obtained from figures 9.1 to 9.27 however, because of the factors discussed in the preceding paragraphs the main structural elements; frame, upper floors, external walls, windows, internal structural walls and partitions, cannot be compared individually unless the buildings are identical and as the remaining components represent a small expenditure, in comparison to the main structural elements, only the totals of the items 4 to 15 will be compared in Figure 9.31.

RE NO.9.31

	Cost/Sq m of floor area at 1968 prices £			Cost expressed as a percentage of Total cost %		
	Maximum	Minimum	Average	Maximum	Minimum	Average
ERSITIES						
dential buildings	35.945	16.553	25.125	44.45	28.17	39
llary buildings	52.561	18.981	32.865	40.58	32.09	40
ratories	35.476	28.136	32.196	34.67	23.48	33
srooms and lecture atres	37.090	24.639	30.842	42.82	23.42	31
HER EDUCATION AND NICAL COLLEGES						
lbans College of						
her Education	36.852	27.708	32.751	53.71	38.81	47
is College, Preston	25.870*	18.827	23.570	38.43	28.74	35

*Cost of Structural Elements of Boiler House = £28.342/M^2

NOTE: The average cost per sq m of floor area, at 1968 prices, for the main structural elements only, in the same order as in the above table, are as follows: £27.000; £30.083; £28.991; £27.102; £30.167 and £21.976. The above table shows that the cost per unit of floor area and the proportion of expenditure on structural elements varies from £52.561/sq m of floor area to £16.553/sq m of floor area and from 53.71 per cent to 23.42 per cent respectively.

It will be appreciated that building costs are often expressed as a cost per square metre of floor area or as a percentage of total cost, however, as is shown in the above table the maximum and minimum values of cost and percentage do not always coincide and this is due to variation in expenditure on other elements.

ELEMENT NOS 16 TO 20 FINISHES AND FITTINGS

Detailed costs and a graphical presentation is shown in Figures 9.1 to 9.26 where it will be seen that the two items which account for the greatest expenditure are fittings and floor finishes. There is good agreement between the items for all buildings except for fittings which show a wide variation but which is easily accounted for by the requirements of laboratories and lecture theatres.

It is also worth noting at this point that there is no expenditure on wall finishes for the St Albans College of Further Education and that the initial cost of the external walls for this College were very much higher than for other buildings. The reason for this is that the internal face of most blocks are composed of integrally coloured, plastic faced asbestos. Constructional details for the external walls are as follows:-

EXTERNAL WALLS, WINDOWS AND DOORS. ST ALBANS COLLEGE OF FURTHER EDUCATION

Aluminium curtain walling with mullion spacing at 2 ft 8 in (813 mm) and 5 ft 4 in (1625 mm) centres. Glazing in 32 oz generally with ¼ in (6 mm) polished Georgian wire at lower level. Opening lights, factory glazed and include top hung and projected top hung ventilators. High level ventilators 5 ft 4 in (1625 mm) by 2 ft 8 in (813 mm).
Main ventilators, 5 ft 4 in (1625 mm) by 2 ft 8 in (813 mm) with satin chromed furniture. Infilled panels, integrally coloured, plastic faced asbestos wall lining internally with mastic bed and pointing.

RE NO. 9.32

AGE VALUES OF EXPENDITURE FOR FINISHES AND FITTINGS

	Cost/Sq m of floor area at 1968 prices					
	Wall finishes	Floor finishes	Ceiling finishes	Decoration	Fittings	Total
ERSITIES						
idential buildings	1.722	2.688	1.306	1.489	3.739	10.307
llary buildings	2.423	3.861	2.057	1.098	5.129	14.567
ratories	2.231	4.057	2.920	1.912	12.912	24.031
srooms and lecture tres	2.916	4.530	2.754	2.293	10.946	23.438
HER EDUCATION AND NICAL COLLEGES	1.400	3.374	2.057	1.403	3.232	11.152
lbans College of her Education	-	3.200	2.676	1.048	7.375	14.299
is College, Preston	1.947	3.219	2.673	1.638	1.882	10.791
	Percentage of Total Cost					
ERSITIES						
idential buildings	2	4	2	2	5	16
llary buildings	2	5	2	2	7	19
ratories	2	4	3	2	12	22
srooms and lecture atres	3	5	3	2	10	24
HER EDUCATION AND NICAL COLLEGES	3	5	3	2	4	16
lbans College of her Education	0	5	4	1	11	20
is College, Preston	3	4	3	2	3	16

Aluminium snap on beads; 4284 sq yd (3582 sq m) at 210s 0d per sq yd (£12.558/sq m). Ship-lap boarding in 1 in (25 mm) western red cedar, left untreated on an impregnated softwood studding and glass wool insulation, including gaboon faced plywood lining; 999 sq yd (835 sq m) at 78s 9d per sq yd (£4.709/sq m).

11 in (280 mm) cavity brickwork, white gault facings with coloured cement pointing. Fair faced sandlime brickwork internally; 971 sq yd (812 sq m) at 82s 6d per squ ud (£4.934/sq m).

13½ in (342 mm) brickwork-facing bricks, fair faced both sides in gym. Assembly hall, facing bricks externally ½ in (12 mm) Parana pine boards internally with open joints on insulation board backing, fixed to softwood battens;

103 sq yd (86.2 sq m) at 92s 3d per sq yd (£5.517/sq m).
28 No. double doors fully glazed with ¼ in (6 mm) armour plate
4 No. double doors filled with hardwood louvres.
13 No. double doors filled with hardwood panels.
Size 6 ft 6 in (1981 mm) by 5 ft (1524 mm);
2925 sq ft (272 sq m) at 30s per sq ft (£16.146/sq m).

ELEMENTS NOS. 21 to 30 SERVICES

From the details of costs and the graphical presentation shown in figures 9.1 to 9.27 it will be seen that the main items of expenditure in this section are, heating, ventilating and electrical services.

Figure 9.33 shows the average expenditure on the above items and the total expenditure on services for each building group.

As is expected the expenditure on heating and ventilating is greater for laboratories, lecture theatres and classrooms than for other classes of building.

URE NO. 9.33

RAGE VALUES OF HEATING, VENTILATING, ELECTRICAL

TOTAL EXPENDITURE ON SERVICES

	Cost/sq m of floor area at 1968 prices			Percentage of Total Cost		
	Heating and Ventila-ting	Electri-cal Services	Total for Services	Heating and Ventila-ting	Electri-cal Services	Total for Services
	£	£	£	%	%	%
ERSITIES						
dential buildings	5.136	4.424	15.463	9	7	23
lary buildings	9.088	6.653	21.702	13	8	27
ratories	16.132	9.410	36.147	17	8	33
srooms and ure theatres	12.764	5.696	27.070	13	5	28
IER EDUCATION ECHNICAL GES	6.222	6.847	18.969	8	10	27
bans College of er Education	7.934	4.934	16.427	11	7	23
s College, ton	6.749	7.286	33.091	9	11	27

ANNUAL EQUIVALENT COSTS

In order to carry out cost comparisons on expenditure, all cost information must be based upon a common denominator.

A suitable unit seems to be 1000 student hours which represents one full-time student studying for one year.

The initial cost of the building must therefore be converted and the first step is to reduce the construction costs to an annual equivalent.

The allocation of areas for the various space classifications were given in Chapter VII, however, an additional area has to be added to allow for circulation, administration and the only partial utilisation of laboratories, lecture theatres and classrooms.

A study of the limited information available for actual student loading, suggests a total space allocation of 10 square metres per technical college student and 15 square metres for each university student. Each residential student occupies an additional area of 45 square metres.

Using an average cost per square metre of floor area of £65 for technical colleges and £100 for universities and the conversion factors for annual equivalent cost given in Chapter VIII, results in a total annual equivalent cost of about £3.25/sq m of floor area for technical colleges and £5.00/sq m of floor area for universities.

The expenditure on salaries for teaching staff given in Chapter VIII is based upon weighted student hours in which 300 hours at advanced level is considered to be equivalent to 600 hours at intermediate level and 1000 hours at school level, whereas the space allocation is based upon actual student hours.

If we consider four colleges included in the survey carried out by Mr W R Tuson, Chief Education Officer for Preston, we get the following results:-

College	Actual student hours	Weighted student hours	Ratio of weighted to actual student hours	Average expenditure per 1000 weighted student hours Teachers Salaries £
dford	2,618,772	3,397,854	1.30	157.58
ckburn	1,564,736	2,089,863	1.34	144.24
t Ham	1,988,677	2,758,103	1.39	152.62
isbury and South Wilts Lege	1,112,822	1,391,405	1.25	149.56

The overall average for the 28 colleges was £149.88/1000 weighted student hours. The average expenditure on National Insurance and Superannuation was equal to £18.52/1000 weighted student hours.

To allow for student weighting, divide the annual equivalent cost of £32.5 per 10 sq m by 1.3 = £25.8/1000 weighted student hours/annum, which is equal to 15 per cent of the expenditure on teachers' salaries and 9 per cent of the total expenditure.

UNIVERSITIES

Figures published by the University Grants Committee suggest an overall staff/student ratio in universities of 1:10.

Working on the basis of one full-time student producing 1000 student hours per annum and an average staff salary of £4000, results in a figure of £400/1000 actual student hours. Therefore, the annual equivalent of the initial cost of university buildings is equal to 19 per cent of the expenditure on salaries for academic staff. Figures are not available which would allow the annual equivalent cost to be expressed as a proportion of the total annual expenditure.

CONCLUSIONS

Although the difficulties encountered when making cost comparisons of building elements have been discussed, guide lines in the form of tabular and graphical cost analysis and the relative cost of various structural frameworks have been provided which will enable feasibility studies to be carried out.

It has been shown that when comparisons are based upon cost per unit of total floor area, the cost of each element is affected by the shape of the building, the quantity factor, the year and place of construction, market forces, the number of storeys and incompatibility.

Equally important is the variable affect on the different elements, for example variations in the number of storeys would have a marked affect on the cost of the roof, expressed on the basis of unit floor area, but would not have the same affect on the cost of the frame and external walls.

Bearing in mind the number of variables the size and uniformity of the sample will control to a large degree the dependance which can be placed upon cost comparisons. It is accepted that the 55 buildings for which a detailed cost analysis has been obtained represent a very small sample particularly when the variety and types of construction are taken into account, nevertheless an indication of the order of costs can be obtained from the analysis, which will enable an annual equivalent to be determined within an acceptable margin of accuracy.

If industrialised systems are to be adopted for educational building, it would seem that the component approach would have the best future, however, industrialised systems are at least as expensive as traditional methods and the available evidence suggests that as long as the supply of traditional labour and materials are adequate the non-traditional systems will not be universally adopted.

Although the development of educational thought and practices requires a high degree of flexibility in our buildings, short life buildings are not the answer.

Roof top boiler rooms have a number of advantages, but additional study is required in order that the efficiency of the teaching process remains unaffected by the operation of theboilers and plant.

It has been shown that the annual equivalent of the initial cost for buildings is equal to approximately 15 per cent of the expenditure on salaries for academic staff and 9 per cent of the total annual expenditure.

CONVERSION TABLE - (SHILLINGS/FT^2 TO £/M^2)

Shillings / Pence	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	0.538	1.076	1.615	2.153	2.691	3.229	3.767	4.306	4.844	5.382	5.920	6.458	6.997	7.535	8.073	8.611	9.149	9.688	10.226	10.764
0.25	0.011	0.549	1.087	1,626	2,164	2.702	3.240	3.778	4.317	4.855	5.393	5.931	6.469	7.008	7.546	8.084	8.622	9.160	9.699	10.237	10.775
0.5	0.022	0.560	1.098	1.637	2.175	2.713	3.251	3.789	4.328	4.866	5.404	5.942	6.480	7.019	7.557	8.095	8.633	9.171	9.710	10.248	10.786
0.75	0.034	0.572	1.110	1.649	2.187	2.725	3.263	3.801	4.340	4.878	5.416	5.954	6.492	7.031	7.569	8.107	8.645	9.183	9.722	10.260	10.798
1.00	0.045	0.583	1.121	1.660	2.198	2.736	3.274	3.812	4.351	4.889	5.427	5.965	6.503	7.042	7.580	8.118	8.656	9.194	9.733	10.271	10.809
1.25	0.056	0.594	1.132	1.671	2.209	2.747	3.285	3.823	4.362	4.900	5.438	5.976	6.514	7.053	7.591	8.129	8.667	9.205	9.744	10.282	10.820
1.50	0.067	0.605	1.143	1.682	2.220	2.758	3.396	3.834	4.373	4.911	5.449	5.987	6.525	7.064	7.602	8.140	8.678	9.216	9.755	10.293	10.831
1.75	0.078	0.616	1.154	1.693	2.231	2.760	3.307	3.845	4.384	4.922	5.460	5.998	6.536	7.075	7.613	8.151	8.689	9.227	9.766	10.304	10.842
2.00	0.090	0.628	1.166	1.705	2.243	2.781	3.319	3.857	4.396	4.934	5.472	6.010	6.548	7.087	7.625	8.163	8.701	9.239	9.778	10.316	10.854
2.25	0.101	0.639	1.177	1.716	2.254	2.792	3.330	3.868	4.407	4.945	5.483	6.021	6.559	7.098	7.636	8.174	8.712	9.250	9.789	10.327	10.865
2.50	0.112	0.650	1.188	1.727	2.265	2.803	3.341	3.879	4.418	4.956	5.494	6.032	6.570	7.109	7.647	8.185	8.723	9.261	9.800	10.338	10.876
2.75	0.123	0.661	1.199	1.738	2.276	2.814	3.352	3.890	4.429	4.967	5.505	6.043	6.581	7.120	7.658	8.196	8.734	9.272	9.811	10.349	10.887
3.00	0.135	0.673	1.211	1.750	2.288	2.826	3.364	3.902	4.441	4.979	5.517	6.055	6.593	7.132	7.670	8.208	8.746	9.284	9.823	10.361	10.899
3.25	0.146	0.684	1.222	1.761	2.299	2.837	3.375	3.913	4.452	4.990	5.528	6.066	6.604	7.143	7.681	8.219	8.757	9.295	9.834	10.372	10.910
3.50	0.157	0.695	1.233	1.772	2.310	2.848	3.386	3.924	4.463	5.001	5.539	6.077	6.615	7.154	7.692	8.230	8.768	9.306	9.845	10.383	10.921
3.75	0.168	0.706	1.244	1.783	2.321	2.859	3.397	3.935	4.474	5.012	5.550	6.088	6.626	7.165	7.703	8.241	8.779	9.317	9.856	10.394	10.932
4.00	0.179	0.717	1.255	1.794	2.332	2.870	3.408	3.946	4.485	5.023	5.561	6.099	6.637	7.176	7.714	8.252	8.790	9.328	9.867	10.405	10.943
4.25	0.191	0.729	1.267	1.806	2.344	2.882	3.420	3.958	4.497	5.035	5.573	6.111	6.649	7.188	7.726	8.264	8.802	9.340	9.879	10.417	10.955
4.50	0.202	0.740	1.278	1.817	2.355	2.893	3.431	3.969	4.508	5.046	5.584	6.122	6.660	7.199	7.737	8.275	8.813	9.351	9.890	10.428	10.966
4.75	0.213	0.751	1.289	1.828	2.366	2.904	3.442	3.980	4.519	5.057	5.595	6.133	6.671	7.210	7.748	8.286	8.824	9.362	9.901	10.439	10.977
5.00	0.224	0.762	1.300	1.839	2.377	2.915	3.453	3.991	4.530	5.068	5.606	6.144	6.682	7.221	7.759	8.297	8.835	9.373	9.912	10.450	10.988
5.25	0.235	0.773	1.311	1.850	2.388	2.926	3.464	4.002	4.541	5.079	5.617	6.155	6.693	7.232	7.770	8.308	8.846	9.384	9.923	10.461	10.999
5.50	0.247	0.785	1.323	1.862	2.400	2.938	3.476	4.014	4.553	5.091	5.629	6.167	6.705	7.244	7.782	8.320	8.858	9.396	9.935	10.473	11.011
5.75	0.258	0.796	1.334	1.873	2.411	2.949	3.487	4.025	4.564	5.102	5.640	6.178	6.716	7.255	7.793	8.331	8.869	9.407	9.946	10.484	11.022
6.00	0.269	0.807	1.345	1.884	2.422	2.960	3.498	4.036	4.575	5.113	5.651	6.189	6.727	7.266	7.804	8.342	8.880	9.418	9.957	10.495	11.033
6.25	0.280	0.818	1.356	1.895	2.433	2.971	3.509	4.047	4.586	5.124	5.662	6.200	6.738	7.277	7.815	8.353	8.891	9.429	9.968	10.506	11.044
6.50	0.292	0.830	1.368	1.907	2.445	2.983	3.521	4.059	4.598	5.136	5.674	6.212	6.750	7.289	7.827	8.365	8.903	9.441	9.980	10.518	11.056
6.75	0.303	0.841	1.379	1.918	2.456	2.994	3.532	4.070	4.609	5.147	5.685	6.223	6.761	7.300	7.838	8.376	8.914	9.452	9.991	10.529	11.067
7.00	0.314	0.852	1.391	1.929	2.467	3.005	3.543	4.081	4.620	5.158	5.696	6.234	6.772	7.311	7.849	8.387	8.925	9.463	10.002	10.540	11.078
7.25	0.325	0.863	1.402	1.940	2.478	3.016	3.554	4.092	4.631	5.169	5.707	6.245	6.783	7.322	7.860	8.398	8.936	9.474	10.013	10.551	11.089
7.50	0.336	0.874	1.413	1.951	2.489	3.027	3.565	4.103	4.642	5.180	5.718	6.256	6.794	7.333	7.871	8.409	8.947	9.485	10.024	10.562	11.100
7.75	0.348	0.886	1.425	1.963	2.501	3.039	3.577	4.115	4.654	5.192	5.730	6.268	6.806	7.345	7.883	8.421	8.959	9.497	10.036	10.574	11.112
8.00	0.359	0.897	1.436	1.974	2.512	3.050	3.588	4.126	4.665	5.203	5.741	6.279	6.817	7.356	7.894	8.432	8.970	9.508	10.047	10.585	11.123
8.25	0.370	0.908	1.447	1.985	2.523	3.061	3.599	4.137	4.676	5.214	5.752	6.290	6.828	7.367	7.905	8.443	8.981	9.519	10.058	10.596	11.134
8.50	0.381	0.919	1.458	1.996	2.534	3.072	3.610	4.148	4.687	5.225	5.763	6.301	6.839	7.378	7.916	8.454	8.992	9.530	10.069	10.607	11.145
8.75	0.392	0.930	1.469	2.007	2.545	3.083	3.621	4.159	4.698	5.236	5.774	6.312	6.850	7.389	7.927	8.465	9.003	9.541	10.080	10.618	11.156
9.00	0.403	0.941	1.480	2.018	2.556	3.094	3.632	4.170	4.709	5.247	5.785	6.323	6.861	7.400	7.938	8.476	9.014	9.552	10.091	10.629	11.167
9.25	0.415	0.953	1.492	2.030	2,568	3.106	3.644	4.182	4.721	5.259	5.797	6.335	6.873	7.412	7.950	8.488	9.026	9.564	10.103	10.641	11.179
9.50	0.426	0.964	1.503	2.041	2.579	3.117	3.655	4.193	4.732	5.270	5.808	6.346	6.884	7.423	7.961	8.499	9.037	9.575	10.114	10.652	11.190
9.75	0.437	0.975	1,514	2.052	2.590	3.128	3.666	4.204	4.743	5.281	5.819	6.357	6.895	7.434	7.972	8.510	9.048	9.586	10.125	10.663	11.201
10.00	0.449	0.987	1.526	2.064	2.602	3.140	3.678	4.216	4.755	5.293	5.831	6.369	6.907	7.446	7.984	8.522	9.060	9.598	10.137	10.675	11.213
10.25	0.460	0.998	1.537	2.075	2.613	3.151	3.689	4.227	4.766	5.304	5.842	6.380	6.918	7.457	7.995	8.533	9.071	9.609	10.148	10.686	11.224
10.50	0.471	1.009	1.548	2.086	2.624	3.162	3.700	4.238	4.777	5.315	5.853	6.391	6.929	7.468	8.006	8.544	9.082	9.620	10.159	10.697	11.235
10.75	0.482	1.020	1.559	2.097	2.635	3.173	3.711	4.249	4.788	5.326	5.864	6.402	6.940	7.479	8.017	8.555	9.093	9.631	10.170	10.708	11.246
11.00	0.493	1.031	1.570	2.108	2.646	3.184	3.722	4.260	4.799	5.337	5.875	6.413	6.951	7.490	8.028	8.566	9.104	9.642	10.181	10.719	11.257
11.25	0.505	1.043	1,582	2.120	2.658	3.196	3.734	4.272	4.811	5.349	5.887	6.425	6.963	7.502	8.040	8.578	9.116	9.654	10.193	10.731	11.269
11.50	0.516	1.054	1.593	2.131	2.669	3.207	3.745	4.283	4.822	5.360	5.898	6.436	6.974	7.513	8.051	8.589	9.127	9.665	10.204	10.742	11.280
11.75	0.527	1.065	1.604	2.142	2.680	3.218	3.756	4.294	4.833	5.371	5.909	6.447	6.985	7.524	8.062	8.600	9.138	9.676	10.215	10.753	11.291
12.00	0.538	1.076	1.615	2.153	2.691	3.229	3.767	4.306	4.844	5.382	5.920	6.458	6.997	7.535	8.073	8.611	9.149	9.687	10.226	10.764	11.302

CHAPTER X

CHAPTER X

THE LOCATION OF COURSES FOR THE CONSTRUCTION INDUSTRY

In the previous chapters I have examined the factors which influence the efficiency of the teaching and learning process.

The one remaining factor which has not been discussed is the location of courses.

Attempts are being made at the present time to rationalise courses, particularly in the further education field and comments made in this chapter are likely to be outstripped by events, however, it is necessary to examine the location of courses in order to determine how economies can be made.

Figure 10.2 shows the location of craft and higher technician courses in Construction for England and Wales in January 1969.

At a large number of these colleges the staff and facilities are not being fully utilised and even when upholding the interests of rural communities there is still a wide scope for the rationalisation of courses. Economic studies in this sphere should include the cost for the provision of subsidised transport against the savings made by operating courses at a smaller number of colleges.

— ENGLAND AND WALES —

— FIG No 10.1 —

THE LOCATION OF DEGREE COURSES IN BUILDING ENGLAND & WALES

JANUARY 1969

KEY TO SYMBOLS

⊟	UNIVERSITY SANDWICH COURSES
■	UNIVERSITY FULLTIME COURSES
△	C.N.A.A. DEGREE COURSES

COURSES AVAILABLE

TOWN	DURATION IN YEARS	TYPE OF DEGREE	NAME OF ESTABLISHMENT
BATH	4	H	UNIVERSITY
BIRMINGHAM	4	H	ASTON UNIVERSITY
BRIGHTON	4	O & H	COLLEGE OF TECHNOLOGY
COVENTRY	4	O & H	LANCHESTER COLL. OF TECH.
CARDIFF	4	O & H	UNIVERSITY OF WALES INST. OF SCIENCE & TECH.
EDINBURGH	4	H	HERIOT-WATT UNIVERSITY
LONDON	3	H	BARTLETT SCHOOL OF ARCHITECTURE
	4	H	BRIXTON SCHOOL OF BUILDING
LIVERPOOL	3 4	B TECH. F.T. B TECH. S.W.	UNIVERSITY
MANCHESTER	3	O & H	UNIVERSITY

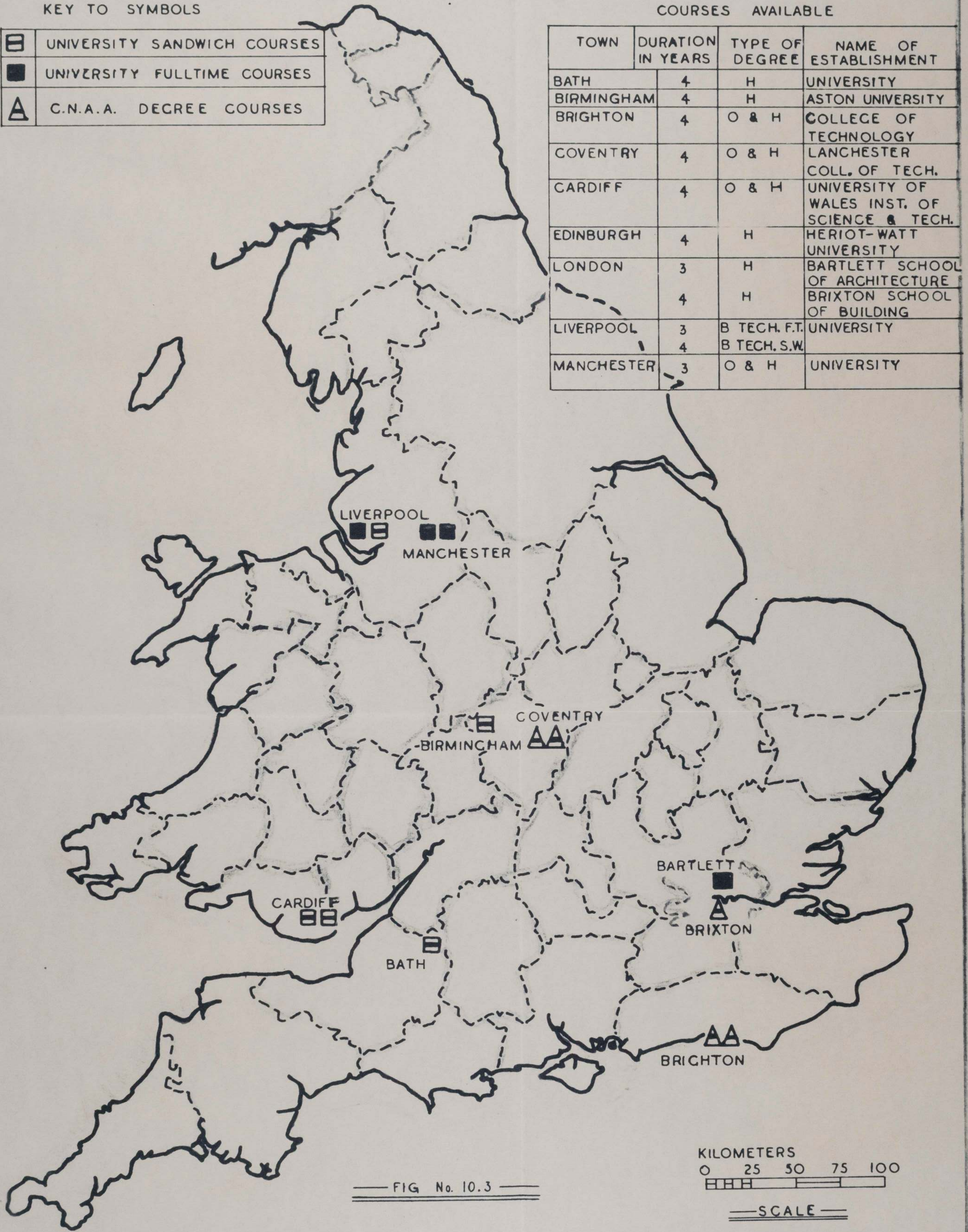


FIG No. 10.3

THE LOCATION OF COURSES IN CONSTRUCTION UP TO H.N.C. LEVEL

ENGLAND & WALES

JANUARY 1969

NOTES

● INDICATES COLLEGES OFFERING CRAFT COURSES ONLY OR TECHNICIAN COURSES BELOW O.N.C. LEVEL.

+ INDICATES COLLEGES OFFERING O.N.C. AND/OR HNC COURSES.

COLLEGES OF ART OFFERING PAINTING AND DECORATING; AND ENGINEERING DEPARTMENTS OFFERING COURSES IN GASFITTING, WELDING AND ELECTRICAL INSTALLATIONS ARE NOT SHOWN.

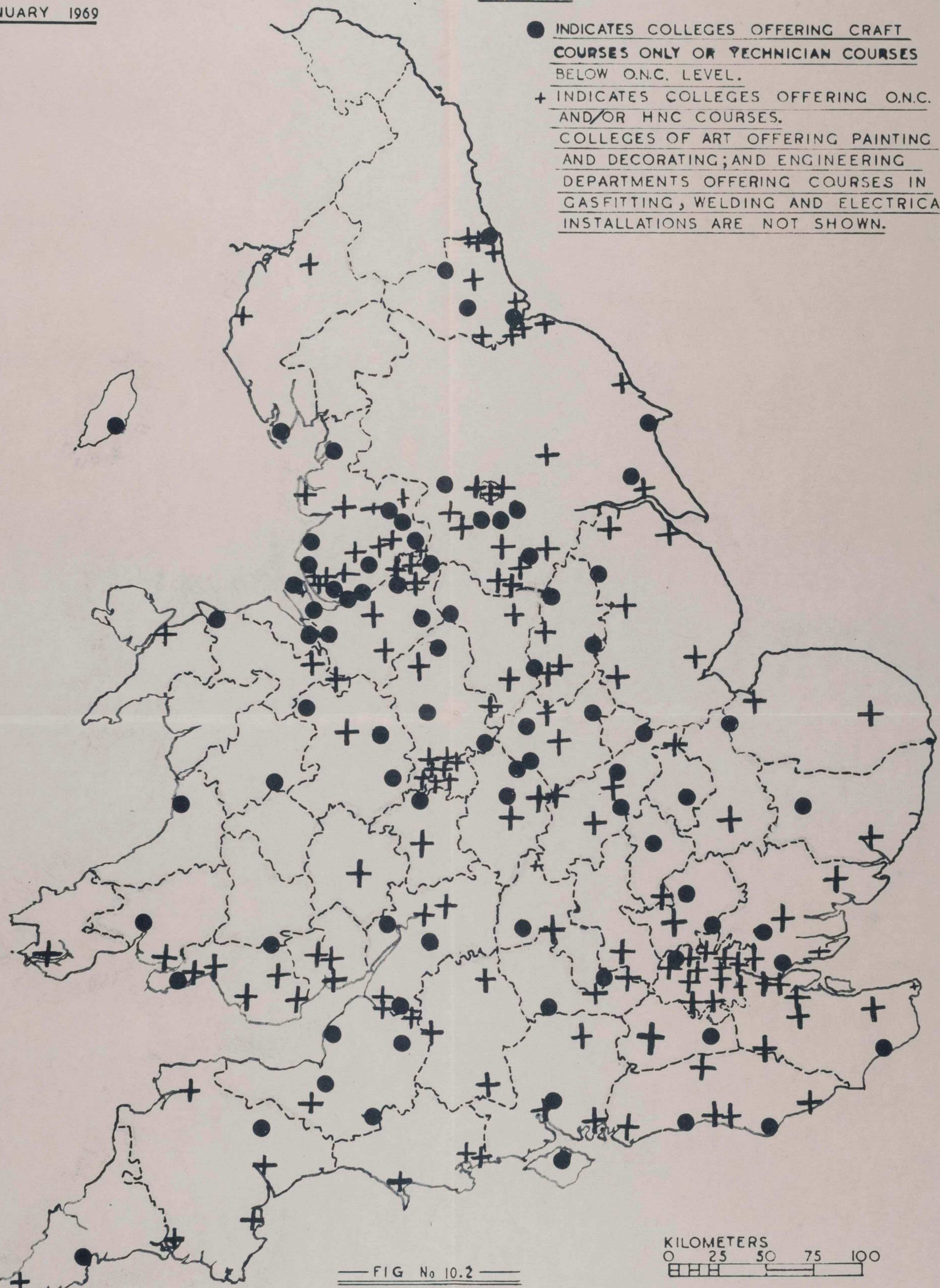


FIG No 10.2

THE LOCATION OF DEGREE COURSES IN CIVIL ENGINEERING
ENGLAND & WALES

JANUARY 1969

KEY TO SYMBOLS

SYMBOL	COURSE
⊟	UNIVERSITY SANDWICH
■	UNIVERSITY FULLTIME
△	C.N.A.A. SANDWICH
▲	C.N.A.A. FULLTIME

COURSES IN THE LONDON AREA

NAME OF ESTABLISHMENT	DURATION	TYPE
UNIVERSITY COLLEGE ■■	3	O & H
IMPERIAL COLLEGE ■■	3	O & H
KING'S COLLEGE ■■	3	O & H
QUEEN MARY COLLEGE ■■	3	O & H
ENFIELD COLL. OF TECH. △△	4	O & H
REGENT ST. POLYTECHNIC △▲	4	O & H
WOOLWICH POLYTECHNIC △	4	H
KINGSTON COLL. OF TECH. △△	4	O & H

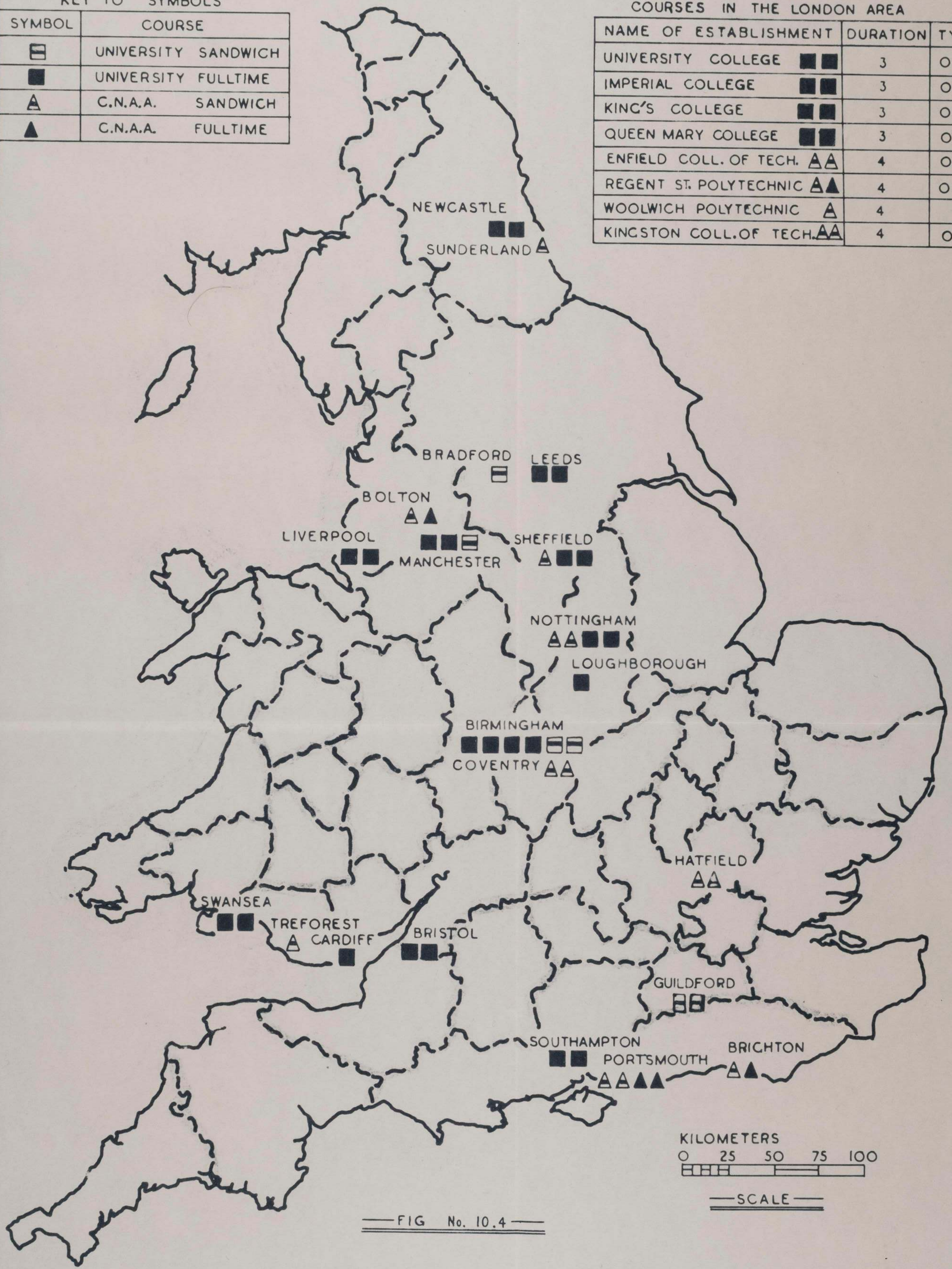


FIG No. 10.4

THE LOCATION OF DEGREE COURSES IN ELECTRICAL ENGINEERING

— ENGLAND & WALES —

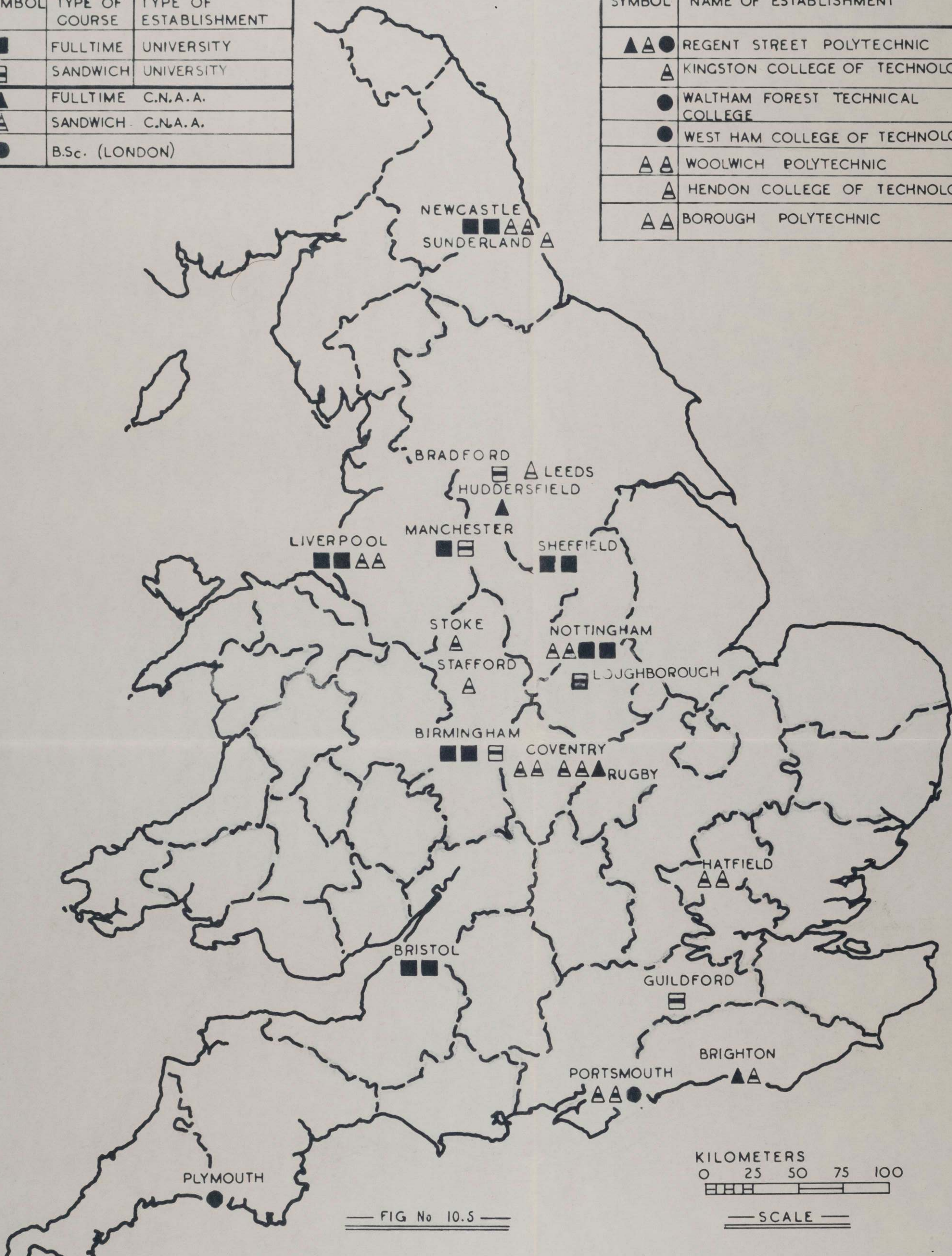
JANUARY 1969

KEY TO SYMBOLS

SYMBOL	TYPE OF COURSE	TYPE OF ESTABLISHMENT
■	FULLTIME	UNIVERSITY
⊟	SANDWICH	UNIVERSITY
▲	FULLTIME	C.N.A.A.
△	SANDWICH	C.N.A.A.
●	B.Sc. (LONDON)	

COURSES IN THE LONDON AREA

SYMBOL	NAME OF ESTABLISHMENT
▲△●	REGENT STREET POLYTECHNIC
△	KINGSTON COLLEGE OF TECHNOLOGY
●	WALTHAM FOREST TECHNICAL COLLEGE
●	WEST HAM COLLEGE OF TECHNOLOGY
△△	WOOLWICH POLYTECHNIC
△	HENDON COLLEGE OF TECHNOLOGY
△△	BOROUGH POLYTECHNIC



— FIG No 10.5 —

THE LOCATION OF COURSES IN ARCHITECTURE — ENGLAND & WALES

JANUARY 1969

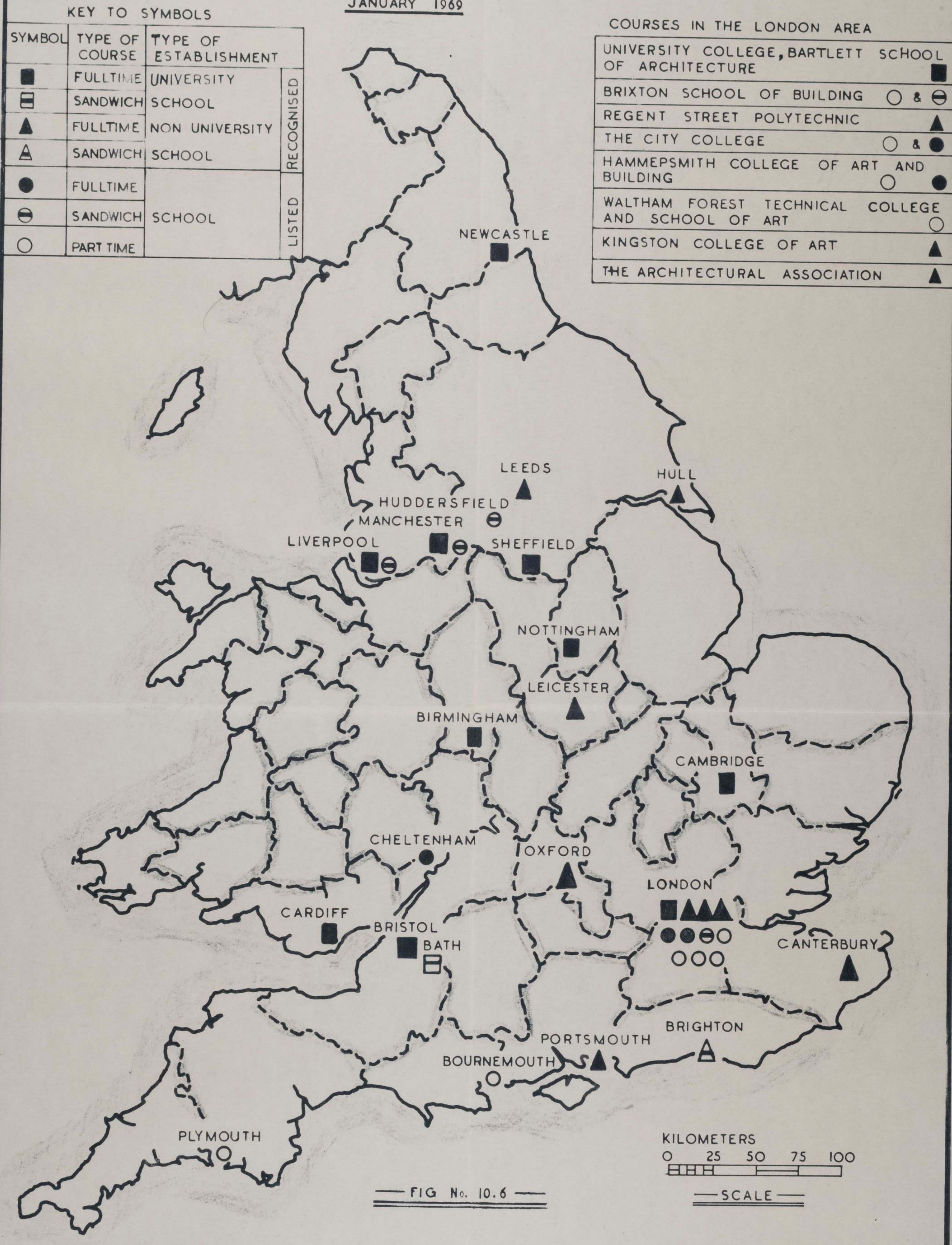


FIG No. 10.6

THE LOCATION OF C.N.A.A. DEGREE COURSES — ENGLAND & WALES

JANUARY 1969

KEY TO SYMBOLS

SYMBOL	COURSE
A	ARCHITECTURE
B	BUILDING
C	CIVIL ENGINEERING
E	ELECTRICAL ENGINEERING
M	MECHANICAL ENGINEERING
Q	QUANTITY SURVEYING
S	STRUCTURAL ENGINEERING

COURSES IN THE LONDON AREA

NUMBER	NAME OF ESTABLISHMENT	
16	THE CITY UNIVERSITY	A
17	HENDON C.O.T.	E.M
18	REGENT STREET POLYTECHNIC	C.E
19	BOROUGH POLYTECHNIC	E
20	BRIXTON SCHOOL OF BUILDING	B.Q.S
21	WOOLWICH POLYTECHNIC	C.E.M.
22	ENFIELD C.O.T.	C

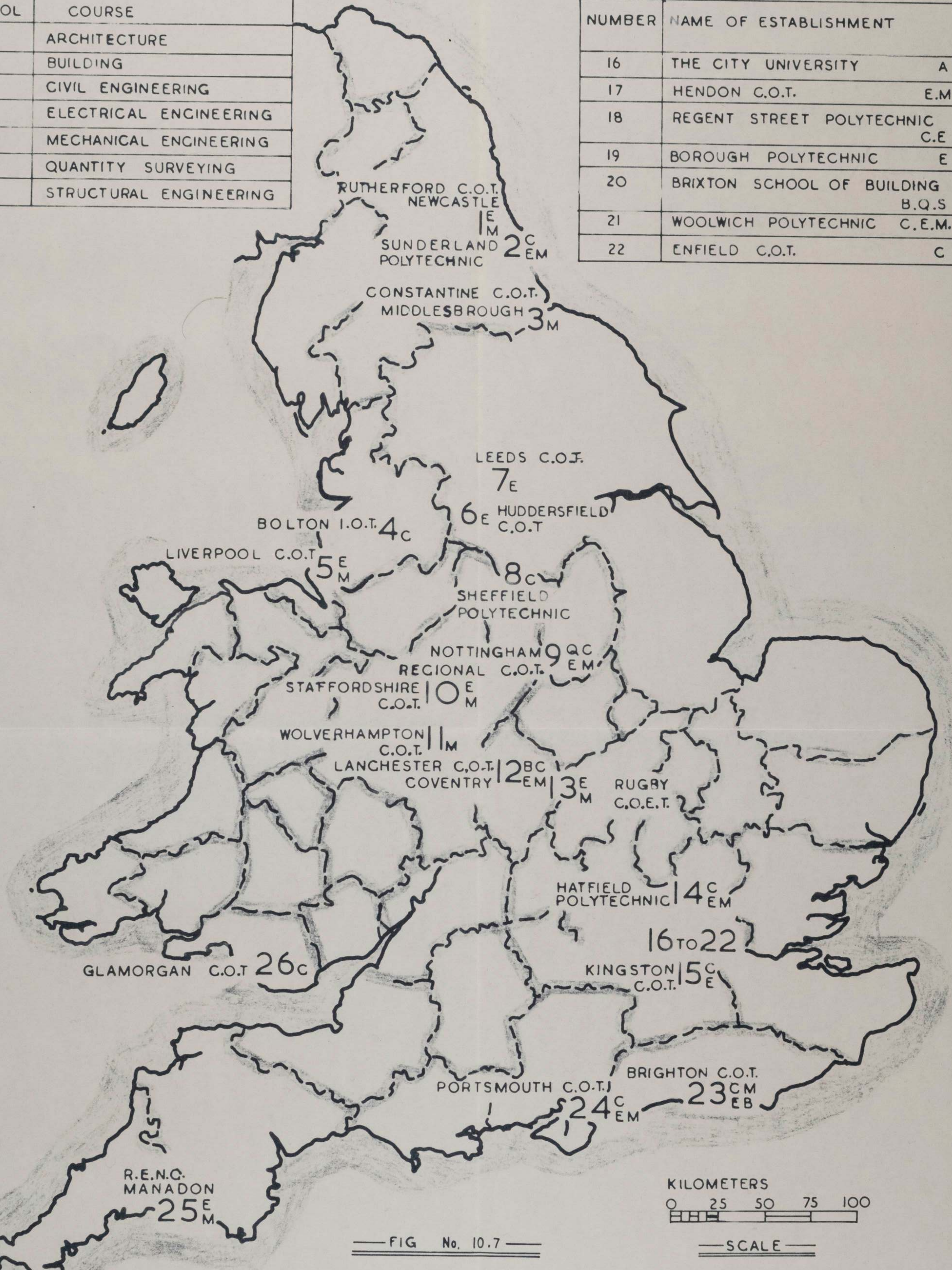


FIG No. 10.7

Figures 10.3; 10.4; 10.5 and 10.6 show the location of degree courses in Building, Civil Engineering, Electrical Engineering and Architectural courses.

It would seem that with a realistic policy for the provision of student accommodation, economies could be made, although local politics and civic pride are two very important factors which have to be considered when discussing the location of university courses. Of course it is always possible to determine the cost to the Community of these two factors. There is, however, one real advantage which can be obtained by the rationalisation of University Courses in addition to economic considerations and that is the opportunity to introduce effective multi-disciplinary education, the introduction of which would have far reaching effects throughout the Construction Industry and which will only become a reality when the various disciplines are located on the same campus.

COUNCIL FOR NATIONAL ACADEMIC AWARDS (CNAA)

This is the sphere of education which has experienced the most rapid expansion in recent years. Figure 10.7 shows the location of CNAA Degree courses for the Professions normally associated with the Construction Industry and the following extracts from the Council's 1968-69 report show the extent to which this expansion has occurred.

WORK OF THE SUBJECT BOARDS 1968/69

Subject Board	No of Meetings	No of Visits	No of Courses Considered	Approved	Rejected
Agricultural Engineering	-	1	1	1	-
Architecture	2	3	4	1	3
Biological Sciences	3	4	10	6	3
Business Studies	5	6	16	6	9
Ceramics	1	1	1	1	-
Chemistry	3	8	22	12	8
Civil Engineering	3	5	9	3	4
Combined Studies	3	3	5	2	3
Economics	4	7	10	3	6
Electrical Engineering	5	10	22	11	5
English Studies	1	-	2	-	2
Estate Management Building Economics and Land Use	2	3	4	3	-
General Science	1	4	4	3	1
Geography	2	2	2	1	1
Instrumentation and Control Engineering	2	1	3	2	-
Languages	4	5	9	3	5
Legal Studies	3	3	4	3	-
Librarianship	3	3	3	2	1
Management Studies	4	1	2	-	2
Manufacturing Technology	-	1	1	-	1
Materials Science	1	1	3	1	1
Maths/Computer Science	3	6	19	8	3
Mech/Prod Engineering	5	9	24	10	10
Carried Forward	60	87	180	82	68

Subject Board	No of Meetings	No of Visits	No of Courses Considered	Approved	Rejected
Brought Forward	60	87	180	82	68
Metallurgy	1	-	1	1	-
Music	2	1	1	-	-
Nautical Studies	1	1	2	1	-
Pharmacy	2	1	2	-	1
Physics	3	6	13	11	-
Psychology	3	1	2	1	1
Public Administration	1	-	1	-	1
Sociological Studies	4	3	5	4	1
Special (Land Use)	-	1	1	-	1
Town Planning	1	-	1	-	1
Totals	78(80)	101(71)	209(145)	100(62)	74(67)

The 35 courses not classified under the last two columns were still under consideration on the 30 September 1969.

The totals shown in brackets are for the year 1967/68.

Although the proportion of courses approved was higher than for the previous year the Council expressed concern for the number of courses which they had not been able to approve and were examining the reasons for the rejections.

COURSES IN PROGRESS LEADING TO FIRST DEGREES AND THE NUMBER OF STUDENTS ENROLLED, BY SUBJECTS, 1969/70

The average number of first year enrolments in Arts and Social Studies is 47 per course entry while in Science and Technology it is 27. This situation reflects the great demand for degree places in Arts and Social Studies and a number of colleges would have admitted many more well qualified students if they had had the resources to cope with them. It is encouraging that with few exceptions, for example, Chemistry and Civil Engineering, the first year enrolments for courses in Science and Technology were larger last September (1969) than in September 1968. In Electrical Engineering the number of first year enrolments has risen even though the number of courses has remained the same. Growth points in terms of increased provision of courses and larger numbers of students include Biology, Business Studies, Computers and Modern Languages.

FIRST DEGREE IN OPERATION 1969/1970

Subject	Number of Courses	First Year Enrolments	Total Enrolments
Accounting	1(-)	26(-)	26(-)
Aeronautical Engineering	2(4)	27(22)	68(123)
Agricultural Engineering	1(1)	51(55)	126(116)
Architecture	1(-)	27(-)	62(-)
Arts, Humanities	3(2)	192(183)	456(316)
Biology, Applied Biology, Biological Science	9(5)	282(143)	609(372)
Building Technology and Management: Building	3(3)	62(75)	218(196)
Business Studies	20(16)	1142(822)	2730(1876)
Ceramics	1(1)	7(10)	47(52)
Chemical Engineering	3(3)	44(53)	121(105)
Chemistry, Applied Chemistry, Chemical Technology	21(17)	321(304)	946(847)
Civil Engineering	21(20)	648(714)	1961(1748)
Commerce with Engineering	1(1)	-(-)	7(11)
Communication Engineering	1(-)	20(-)	20(-)
Computer Science, Applied Computing	8(6)	389(300)	983(744)
Computer Systems Engineering	1(-)	20(-)	20(-)
Economics	4(2)	153(88)	298(200)
Electrical Engineering	24(24)	738(657)	2264(1906)
Electronic Engineering	3(2)	71(40)	137(78)
Engineering	4(4)	201(175)	381(310)
" Geology	1(1)	34(31)	60(41)
" Systems and Control	1(-)	24(-)	24(-)
Environmental Engineering	1(1)	23(18)	40(18)
Carried Forward	135(113)	4502(3690)	11604(9059)

Subject	Number of Courses	First Year Enrolments	Total Enrolments
Brought Forward	135(113)	4502(3690)	11604(9059)
Estate Management	1(1)	45(52)	102(79)
Food Science	1(1)	28(24)	58(38)
Geography	1(-)	30(-)	30(-)
Industrial Engineering	1(1)	18(24)	61(37)
Instrumentation and Control Engineering	1(1)	23(19)	39(19)
Information Science	1(2)	17(22)	28(22)
International Marketing	1(1)	30(35)	61(35)
Land Surveying Sciences	1(-)	19(-)	19(-)
Law	5(4)	200(194)	489(390)
Librarianship	3(2)	83(48)	123(48)
Materials Science	1(1)	14(11)	23(11)
Maths	15(13)	294(242)	698(542)
Mechanical Engineering	21(21)	652(671)	2050(1885)
Metallurgy: Metallurgy and Materials	3(3)	45(56)	178(130)
Modern Languages	8(4)	275(165)	517(289)
" Studies	1(1)	61(60)	163(110)
Nautical Studies	2(2)	67(52)	141(87)
Operation Research with Computing	1(-)	24(-)	24(-)
Pharmacology	1(-)	12(-)	12(-)
Pharmacy	6(6)	310(315)	728(681)
Photographic Technology	1(1)	12(12)	26(25)
Physics, Applied Physics, Physical Electronics	13(13)	178(178)	591(611)
Polymer Science and Technology	1(1)	26(26)	85(75)
Carried Forward	225(192)	6965(5896)	17850(14173)

D.

Subject	Number of Courses	First Year Enrolments	Total Enrolments
Brought Forward	225(192)	6965(5896)	17850(14173)
Printing Technology	1(1)	11(16)	44(44)
Production Engineering	2(2)	20(31)	115(130)
Psychology	1(-)	22(-)	22(-)
Public Administration	1(1)	37(20)	52(20)
Quantity Surveying, Building Economics	4(3)	85(57)	169(115)
Science, Applied Science, Physical Science, Combined Studies in Science	8(5)	317(259)	495(394)
Social Science, Sociology	5(2)	315(233)	514(233)
Sociology of Education	1(1)	110(101)	291(205)
Statistics and Computing	1(1)	40(38)	66(38)
Structural Engineering	1(1)	36(26)	74(46)
Textile Marketing	1(1)	31(32)	54(32)
Textile Technology	1(1)	-(3)	8(13)
Urban Estate Surveying	1(-)	31(-)	31(-)
Urban Land Economics	1(1)	56(43)	93(43)
Urban and Regional Planning	1(1)	23(24)	82(61)
Totals	255(213)	8099(6779)	19960(15547)

DETAILS OF COURSES IN OPERATION FOR THE SESSION 1969/70

First Degree Courses

1. Science and Technology

Sandwich	134(123)
Full-Time	56(48)
Part-Time	7(4)
Total	197(175)

2. Arts and Social Sciences

Sandwich	28(23)
Full-Time	28(14)
Part-Time	2(1)
Total	58(38)

3. All Fields of Study

Sandwich	162(146)
Full-Time	84(62)
Part-Time	9(5)
Total	255(213)

Figures in brackets are for 1968/69

The Number of Students Following First Degree Courses

Session 1969/70

		Science and Technology	Arts and Social Studies
First Year	Sandwich	3781(3577)	1369(1151)
	Full-Time	1446(1120)	1123(753)
	Part-Time	148(77)	232(101)
	Total	5375(4774)	2724(2005)
Second Year	Sandwich	2968(2483)	953(574)
	Full-Time	925(772)	613(468)
	Part-Time	62(50)	185(104)
	Total	3955(3305)	1751(1146)
Third Year	Sandwich	2422(1733)	517(389)
	Full-Time	578(650)	421(125)
	Part-Time	26(9)	15(-)
	Total	3026(2392)	953(514)
Fourth Year	Sandwich	1643(1196)	381(150)
	Full-Time	91(65)	52(-)
	Part-Time	9(-)	-(-)
	Total	1743(1261)	433(150)

Fifth Year enrolments, which are few, are included among the Fourth Year

Total	Sandwich	10814(8989)	3220(2264)
	Full-Time	3040(2607)	2209(1346)
	Part-Time	245(136)	432(205)
	Grand Totals	14099(11732)	5861(3815)

Summary

Total (Science and Technology)	14099(11732)
" (Arts and Social Studies)	5861(3815)
Grand Total of all Students	19960(15547)
Total Sandwich (all fields of study)	14034(11253)
" Full-Time " "	5249(3953)
" Part-Time " "	677(341)
Grand Total of all Students	19960(15547)

The total of 19960 students represents an increase of 28 per cent over the previous session. Another point of interest is that 2724 students, over one third of all students admitted to the first year of courses in September 1969, enrolled for courses in Arts and Social Studies, while only 3 years before, the proportion of students starting courses in these areas was less than one fifth. Another trend is the reduced proportion of students following sandwich courses which is now 64 per cent of all students in the first year as against 70 per cent in all years. Part of this was due to the approval of 14 new full-time courses in Arts and Social Studies. In Science and Technology the increase in the number of full-time students occurred mainly because of the approval of courses in fields such as General Science and Quantity Surveying for which there may be insufficient opportunities for practical training at the present time.

Candidates Registered for the Council's Research Degrees of M Phil and Ph D as at 31 December 1969

Field of Work	Location of Candidates		Total
	Number of Colleges	Research and Industrial Establishments	
Aeronautical Engineering	2	-	2
Architecture	1	-	1
Biological Sciences	38	44	82
Chemistry	180	15	195
Civil Engineering	17	1	18
Economic History	1	-	1
Electrical Engineering	39	8	47
English	1	-	1
Geography	2	-	2
Geology	4	-	4
Instrumentation and Civil Engineering	5	-	5
Languages	4	-	4
Legal Studies	4	-	4
Materials Science	2	1	3
Mathematics/Computer Science	19	-	19
Mechanical Engineering	56	2	58
Metallurgy	52	5	57
Nautical Studies	1	-	1
Naval Architecture	1	-	1
Pharmacy	38	5	43
Photography	1	-	1
Photographic Technology	2	-	2
Physics	66	15	81
Printing	1	1	2
Psychology	3	-	3
Town Planning	2	-	7
Totals	542	97	639

Although the above table, which shows the number of registrations for the Council's research degrees on 31 December 1969, does not include a comparison with the position at the end of the 1967/68 period, the figures do in fact

12.

represent a very substantial increase. For example on 30 September 1968 there were 412 registrations at 68 establishments. This compares with 639 registrations at 91 establishments on 31 December 1969. A particular feature of this development has been the increase in registrations sponsored by research and industrial establishments which has risen from 38 to 97.

A less encouraging aspect is the relatively small number of applications received from engineering establishments and departments.

Entry Qualifications of First Year Students

Science and Technology	Percentage
General Certificate of Education	75
Ordinary National Certificate or Diploma	21
Higher National Certificate or Diploma	3
Other Qualifications	1
Arts and Social Studies	
General Certificate of Education	96
Ordinary National Certificate or Diploma	1
Higher National Certificate or Diploma	less than 1
Other Qualifications	3

CHAPTER XI

CHAPTER XI

TEACHING METHODS

A study of this nature would not be complete without the inclusion of a section devoted to the relative merits of the various teaching techniques.

Quite a large amount of research has been carried out by a number of authorities aiming to establish the efficiency of the various visual aids and lecture methods.

An interesting study has been carried out by I MacFarline Smith of Garnet College entitled "An Experimental Study of the Effect of Television Broadcasts on the "G" Courses in Engineering Science" from which the general conclusion was drawn that Television broadcasts were having a positive effect both on the attainments of students and their attitudes, despite the difficulties due to the disruption of classes and problems associated with the integration of the Television programme into the teaching syllabus.

However, it is my opinion that one of the best research programmes carried out into teaching methods was by John McLeish and published in his book "The Lecture Method".

It is my hope that the precis of his book which follows will be taken as a stimulant rather than a substitute for the actual book.

"THE LECTURE METHOD" BY JOHN McLEISH

(CAMBRIDGE INSTITUTE OF EDUCATION 1968)

SUMMARY

The book is an account of research carried out to study the effectiveness of lecturing. The author was very conscious of the amount of time spent by educationists and others discussing teaching techniques without seeking to substantiate their opinions by carrying out controlled experiements. He sets down the results of experimental work he carried out at four centres of education and supports it by reference to similar work carried out by other educational research workers.

The experiments indicated that in general participatory methods were most effective, especially with the more mature and academically able students. There was no marked difference in attitude between male and female students, although female students tended to show a greater preference for participatory methods.

There are four main chapters:-

Student retention of lecture materials;

Experimental work of students attitudes;

Improving the lecture;

and Conclusions.

They are preceded by an introduction, and introductory note by Robert H Thouless, Reader Emeritus in Education and Psychology at Cambridge University.

INTRODUCTORY NOTE

Robert H Thouless, reader emeritus in educational psychology at the University of Cambridge suggests that the university of the future may not include the activity of lecturing at all but that at the present time, because of the shortage of staff, many universities had increased their lecture periods. He also states that many university lecturers regard their function, not to convey information but rather to promote understanding of information that students have gained from other sources.

INTRODUCTION

The author introduces the work by stating that he was only concerned with lecturing techniques adopted by higher education and that the objectives of his study were as follows:-

(a) To determine the efficiency of the lecture.

(b) What effectdoes the lapse of time have on the students recall of material presented during the lecture?

(c) How great is the equalising effect of private study by the student if different teaching methods are adopted.

(d) To find out what the students attitudes are to different methods of instruction.

The author states that educationists are aware of the great variety of ways in which students assimilate information and that the lecture, which is defined as an uninterrupted discourse, is not always the most efficient way in which to provide that information. He states that the lecture dates from the earliest times when books were in very short supply and that since books have become more freely available, the value of the lecture has been in doubt.

STUDENT RETENTION OF LECTURE MATERIAL

THE NORWICH EXPERIMENT

The author first discusses experiments carried out by educational psychologists and assesses the value of their work. An earlier research worker had discovered that the "spoken word" generally failed to communicate anything after the first 15 minutes.

In one series of experiments carried out by this research worker broadcast talks having a total duration of 45 minutes were played over to groups of adult and grammar school students. Some listeners heard only the first 15 minutes of the talk, others heard 30 minutes whilst a third group heard the whole 45 minutes. A test carried out immediately after the listeners had heard the talk showed that the retention of material by the listeners deteriorated from 41% of the 15 minute lecture down to 20% of a 45 minute lecture and that very few had grasped the essential features of the last 15 minutes despite a very graphic description and final summary.

The Norwich experiment was designed to determine what proportion of a lecture, students carried away with them, either in their heads or in their notebooks.

The students were divided into three groups;

Group 1 heard the complete lecture, whilst

Groups 2 and 3 were asked to leave the lecture theatre after 40 minutes and 25 minutes respectively. All three Groups were tested immediately after they had left the lecture theatre and were allowed to use aides-memoires they had prepared under the threat of an immediate examination. It was found that they had an immediate recall of approximately 42% of the material given during the lecture but this recall reduced by approximately half after one week. It was stated that the test immediately following the lecture would have a reinforcing effect and would, therefore, aid recall for the later test.

NORTHERN POLYTECHNIC (SCHOOL OF ARCHITECTURE) EXPERIMENT

This was an attempt to test the conclusions arrived at in the Norwich experiments.

The students were divided into three groups as follows:-

Group 1. A motivated reading group.

Group 2. A motivated lecture group.

Group 3. An unmotivated lecture group.

GROUP 1 were informed that they were to be allowed an hour to study the verbatim text of the lecture on synectics and they would then be involved in an exercise using the information studied.

GROUP 2 were told how important the lecture was that they were about to hear and that they would be taking part in an exercise in which they would be asked to use the information given during the lecture. They were also advised to take notes.

GROUP 3 were directed into the lecture theatre without any information.

The students were tested following a ten minute coffee break. By "coincidence" the amount retained by the 44 students who participated was exactly the same as the Norwich students - namely 42%.

TABLE NO.1 shows the results of the tests and indicates that motivation had no effect on the retention and, that reading the text was more effective than hearing the lecture provided that the same amount of time was allocated to each activity.

TABLE NO.1

GROUPS SCORES: NORTHERN POLYTECHNIC

Type of Group	Group 1	Group 2	Group 3
Recall expressed as a percentage	48.53	39.31	39.56

TABLE NO.2 shows the results of tests carried out to determine the interest level of the three groups.

TABLE NO.2

	Group 1	Group 2	Group 3
Interest level expressed as a percentage	44	41	35

Further tests provided so little difference between Groups 2 and 3 that they were combined as listeners.

TABLE NO.3 shows the results of tests carried out to determine the effectiveness of reading versus listening, and TABLE NO.4 shows the results of tests on immediate recall, and recall after a period of one month.

TABLE NO.3

READING VERSUS LISTENING TO A LECTURE

	"Recall"	"Application
Readers	48%	36%
Listeners	39%	38%

TABLE NO.4

	Immediate Recall	Delayed Recall
Readers	48%	36%
Listeners	39%	36%

The results of the delayed recall tests were better than the Norwich results but students had been given a complete text of the lecture and had also participated in a number of synectics exercises following the lecture.

EXPERIMENTAL WORK ON STUDENTS ATTITUDES

This survey was carried out amongst lecturers and final year students of Cambridge College of Education, but also included teachers from secondary modern schools, primary schools, schools for educationally sub-normal children and also teachers from Commonwealth countries.

All groups showed a majority in favour of participatory methods with the older more mature and students of higher academic status preferring the participatory methods more than students of lower academic ability.

An additional survey carried out amongst the participants of the above experiment in an attempt to correlate attitudes towards teaching with personality traits and attitudes, gave the following results:-

TABLE NO.5

This Table gives the results of an attempt to correlate attitudes towards teaching with personality traits and attitudes.

Attitudes Towards Teaching	Personality Traits and Attitudes
Strongly in favour of formal methods	Favour corporal punishment; relatively speaking they are stable, tough minded conser-vatives with a philistine conformist outlook.
Unfavourable to formal teaching methods	Strongly value scholastic activities and standards of workmanship, and are generally tender minded radical introverts.
Favour individual methods of teaching	Most uncertain, most in need of recognition, least radical and also least interested in helping others.
Favour class participation	Naturalist in their thinking but strongly favour scholastic values. Extremely radical and least favourable to corporal punishment.

READING UNIVERSITY GRADUATES

A more detailed survey carried out by sociology students amongst first and second year undergraduates, confirmed the work done at the Cambridge Institute of Education.

IMPROVING THE LECTURE: SURVEY OF PREVIOUS STUDIES

In this section the author summarises the arguments which has continued since the Middle Ages on the effectiveness of traditional university methods of teaching.

One factor in favour of the lecture is that the professor learns, or is kept up-to-date by having to prepare and deliver lectures year after year.

The Hale Committee on University Teaching Methods 1964 provides a great deal of factual information and also defends the lecture system. Arguments in favour of the lecture made by University lecturers were as follows:-

(a) Students are too immature to learn effectively from reading.

(b) The lecture opens up the subjects for them.

(c) The lecturer can go back over different material using different words, whereas books are restricted to one form of explanation.

(d) Visual aids - even in three dimensions can be built up gradually.

(e) New materials can be introduced.

(f) It is a halfway house to publication.

(g) It can reach large numbers and bring students into contact with many minds and points of view.

(h) Finally it is the most economical way to use professorial time.

The Robins Committee on Higher Education (1962) could see no virtue in formal lectures delivered to small audiences nor in highly-specialised lectures delivered to small universities.

SYSTEMATIC EXPERIMENTS ON THE LECTURE METHOD

An experiment involving 782 students into the effectiveness of note taking indicated that taking notes did not help retention. A five minute test at the end of the lecture did help retention as did forcefulness, dramatic appeal and quality of the lecture.

The superiority of the discussion method over the lecture method was demonstrated both for the very bright student and the more ordinary ones.

The least effective method for students to obtain information is unsupervised reading.

CONCLUSION

The lecture method is open to criticism if it is used as an all-purpose teaching method as it pays little regard to differences amongst students.

The lecture has its own specific virtues, for example, the scholar can inspire his audience with his own enthusiasm, or, he can communicate the latest results of work carried out by his fellow scholars. However, to achieve the required standard of lecturing performance, both training and practice are essential.

Where students prepare for a lecture by assigned reading and private study, the way is paved for the transformation of the lecture into a dialogue between the student and the subject under discussion.

Feedback from students suggests that the lecture system is not acceptable in modern times. In spite of the national and cultural differences between students in Britain, America, the Soviet Union, India and other countries the inadequateness of the lecture system is one of the subjects about which there is general agreement.

CONCLUSIONS

CONCLUSIONS

The corner stone upon which this work has been built is the requirement for educational building to be constructed in such a form that it will be suffieicntly flexible so as not to restrict educational development. This flexibility may result in higher initial costs, but as these costs represent about 15 percent of the expenditure on the salaries for academic staff, it is relatively easy to justify an increase in initial costs, in order to obtain an economy in the use of academic staff.

The present method of cost control based upon the application of expenditure limits tends to restrict the adoption of real economic solutions and these restrictions will not be overcome until a system of cost-in-use is applied which takes into account all items of expenditure.

One way in which such a scheme could be employed would be to appoint a central authority made up of economists, educationists, sociologists and professional members of the Building Team who would be given mandatory powers. The Terms of reference for this central authority would be to:-

(a) Study educational development.

(b) Examine the efficiency and effectiveness of the various teaching techniques, including the study of teaching aids and machines.

(c) Promote schemes in order to obtain the most effective and economic use of staff and facilities.

(d) Collect and publish cost information.

(e) Provide specifications and guide lines for design.

The existence of the type of central authority outlined above would reduce the importance attached to expenditure limits which exists at the present time and would attach greater importance to cost-in-use studies.

The provision of specifications and design guide lines, together with the implementation of the results of cost-in-use studies, need not necessarily lead to drab uniformity, the aim would be to provide the right environment within a flexible structure so that the teaching and learning process would not be impeded by constructional limitations.

Strong links would obviously be forged between the proposed central authority and organisations such as the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom.

Implementation of the results of cost-in-use studies in order to provide an effieient and effective national education system, would probably mean a reduction in the degree of autonomy exercised by universities and to a lesser extent colleges of further education, however, if as I believe, the real function of our educational system is to provide the expertise upon which our national survival depends then the luxury of self-government should not be allowed to restrict the introduction of the necessary overall surveillance.

Some rationalisation of courses is taking place at the present time in the further education sector and can be easily justified provided the interests of rural communities are protected.

It would seem that this rationalisation could be extended to courses at university level, which in addition to savings in expenditure would allow advantage to be taken of the educational opportunities provided by multi-disciplinary groupings.

One of the major obstacles to rationalisation at university level is civic pride, however, the community have the right to know what civic pride is costing.

Research workers such as John McLeish have demonstrated that the lecture method of imparting knowledge is of doubtful value and that the best method is probably a combination of assigned reading, private study and participatory methods of teaching. Note taking does not seem to help retention and unsupervised reading appears to be the least effective method for students to obtain information. However the true picture cannot be obtained by considering education techniques or items of expenditure in isolation to each other.

The efficiency of educationists and students is affected by the constraints placed upon them by the type of building in which they work.

Although economic studies can indicate areas where substantial rewards are possible comparisons which affect the environment should take account of quality in addition to the normal items of cost and quantity.

International comparisons of building costs are complicated by both indirect and direct influences, updating building costs by the use of construction indices must be carried out with caution.

Comparisons of building costs can be affected by a great number of influences ranging from market forces, to the shape of the building and therefore elemental costs should be used with caution. Even the comparison of various structural forms is difficult due to the impracticability of restricting one form of construction in order to make it comply with the limitations of another. Although the Department of Education and Science exerts a greater degree of control upon school and college building than the University Grants Committee exerts upon university buildings, it comes as some surprise that the Department do not normally get a detailed breakdown of construction costs and although there is a continual exchange of information the Department is unable to provide a systematic feedback of cost details.

Short life buildings or industrialised systems do not seem to provide the answer to the requirement for flexibility in our educational buildings at the present time or in the foreseeable future.

It has been shown that the salaries of academic staff represent a high proportion of the annual expenditure, but equally important is the fact that whilst the annual equivalent cost of the building remains fairly static (ignoring the value of the land, which remains at the end of the useful life of the building) salaries are continually increasing.

An increase in the student/staff ratio would have a much greater effect than economies in construction, for example a variation of 15 percent of the expenditure on academic staff salaries is equivalent to 100 percent variation in construction costs. Therefore if a system for the allocation of expenditure could be organised which embraced the whole field of higher education administration and spending, it would be possible to achieve not only considerable economies but also provide a more effective education.

I wish to express my thanks and appreciation to the following firms who provided details of their training schemes and allowed me to discuss education and training with members of their staff.

1 Architects Co Partnership
2 Arup Associates
3 Austin, Smith, Salmon, Lord, Partnership
4 R A Axtell & Partners
5 British Rail
6 Budyen and Partners
7 Building Design Partnership
8 Clifford Culpin and Partners
9 Davis, Bellfield and Everest
10 Gray Associates
11 Greater London Council, Inner London Education Authority
12 John Laing and Sons Ltd
13 London Transport
14 Lee and Partners
15 Llewelyn Davies, Weeks, Forestier-Walker & Bar
16 Monk and Dunston
17 Ove Arup and Partners
18 Edward A Pearce and Partners
19 Steensen, Varming, Mulcahy and Partners
20 Waterman and Partners
21 George Wimpey & Co Ltd
22 Yorke, Rosenberge and Mardall

Although the views expressed in this thesis are my own, I would like to acknowledge the assistance and information given to be by the following:-

Roy P Harding Esq
Chief Education Officer
County of Buckingham

W R Tuson Esq
Chief Education Officer
Preston Education Committee

P G Cooper Esq
Officer of Works
The University of Aston in Birmingham

C P Thompson Esq
Bursar
University of Birmingham

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SUMMARY

The foregoing sections of the Thesis describe in detail the many factors "educational, physical and financial" that determine the rational design of buildings for higher education.

In this final section these many factors are assembled in the form of a feasibility study, which aims to show the interplay and the relative importance of these many factors in the design of the particular building considered.

This building is the St Albans College of Further Education.

An alternative design for the St Albans College of Further Education has been produced and the order of cost for the various elements which make up the building has been determined. The total cost of the building, thus obtained has been converted to an annual equivalent cost and included with the other items of college expenditure so that the relationship between the various items of expenditure can be studied.

The alternative design, herewith considered, is composed of a four storey reinforced concrete frame building with a single storey workshop and laboratory block attached, has flat slab floors, the absence of beams allowing maximum flexibility of room sizes.

The need for educational buildings to be designed for diversification of use is now recognised by the general public and educationists alike, however, this need can only be satisfied if sufficient support facilities such as adequate car parking are provided and the minimum of restrictions are placed upon the hours of use.

This requirement for greater utilisation of educational facilities has been brought about by the increasing demand for mid-career training, up-dating courses, specialist lectures and other extramural activities.

In order to cater for the forementioned requirements and to reduce the administrative problems and isolationism which occurs when departments are housed in separate buildings, the accommodation provided in eight blocks at the St Albans College of education has been located in a single multi-storey building.

Examination of the total annual expenditure indicates that even for a building with a relatively high specification and an increased study area per student of 26.5 percent, the annual equivalent of the initial cost of the building represents only 18.3 percent of the total annual expenditure.

The expenditure on staff, running costs and college expenses represents 65 percent, 8 percent and 9 percent respectively of the total annual expenditure.

Variations in the initial cost of the building must therefore be viewed in the context of the total annual expenditure. For example it can be shown that an increase in the bay size of the flat slab floor of 50 percent results in an increased cost for the structural frame of approximately 20 percent. This percentage seems high until it is realised that the structural frame accounts for 25 percent of the total building cost which in turn represents only 18.3 percent of the total annual college expenditure.

INTRODUCTION

Chapters I to XI of the thesis attempted to evaluate the many variables in there effect upon the total annual expenditure of establishments providing further and higher education.

It was shown that a study restricted to a consideration of building technology and economics of construction did not produce the most satisfactory or even the most economic solution.

The relatively high expenditure on academic staff, approximately equal to seven times the annual equivalent of the initial cost of the building illustrates the need to plan the building so as not to inpare the efficiency of the academic staff.

Continual development of teaching techniques also makes flexibility an essential requirement, however, because the majority of further education colleges and universities have specialist characteristics, the need for flexibility of the structure is further emphasised.

An illustration of how requirements for specialist educational facilities change can be seen in colleges and universities providing courses in mining and textiles, which are no longer required to the same extent as they were twenty years ago.

Recent changes in the training and recruitment programme of the Gas Board, although not having the same impact as the reduction in the training demand of the coal and extiles industries is another example of industrial development affecting training and educational requirements.

This section has been written at the request of the assessors to further illustrate how the various design decisions affect the overall economic solution.

THE PROBLEM

To discuss the planning of an educational establishment without reference to a particular location is difficult, as specialist facilities, the area of land available, site access, future extensions, car parking facilities, cycle storage and the position of the site in relation to external noise sources, such as road and rail traffic will all influence the site layout.

An economical layout of services, such as gas, high voltage electricity and waste disposal is an important planning consideration. However, educational requirements and other planning considerations will often justify an arrangement which results in a slightly less economic layout of the services.

The overall site plan will generally be so arranged that administrative buildings and other facilities occupy a central or prominant position. This arrangement should be designed to serve the needs of the staff, students and the general public.

The arrangement of rooms within a building will require a knowledge of student circulation, particular function of rooms, building technology, economics of construction and maintenance costs.

For example mathematics is an important subject for students studying engineering, chemistry and physics, in addition, chemistry laboratories require special ventilation facilities to cater for fume dispersal, whereas, engineering and physics students normally make use of relatively heavy equipment, which should ideally have a ground floor location. Combining these requirements suggests a multi-storey construction with the physics and engineering laboratories on the ground floor, chemistry laboratories on the top floor and classrooms for subjects such as technical drawing, mathematics, etc, on intermediate floors.

It was as a result of the reasoning outlined above that the need was stressed in the conclusion of the first submission of the thesis, for a multi-disiplinary design group. The group should be composed of educationists, economists and members of the building professions so as to combine the various specialisms required to produce buildings which place the minimum constraint upon educational development and at the same time allow staff and students to operate efficiently in a pleasant environment.

If such a group were to be formed, they should not be restricted to research and development work. Greater efficiency would be obtained if they were made accountable for the actual design and construction of educational establishments.

DESIGN EXAMPLE

To illustrate the order of signifiance of the factors discussed in the thesis, an alternative design has been developed for the St Albans College of Further Education (see figures 9.5; 9.8; 9.9 and plates 9.1 to 9.7 in section IX of the thesis) which provides the same number of administrative and teaching spaces, although with an increased floor area, in order to obtain greater flexibility and room utilisation.

Figures A.1 to A.3 show the general arrangement of the rooms and figure A.4 provides a detailed breakdown of the floor areas for both the St Albans College of Further Education and the feasibility study block.

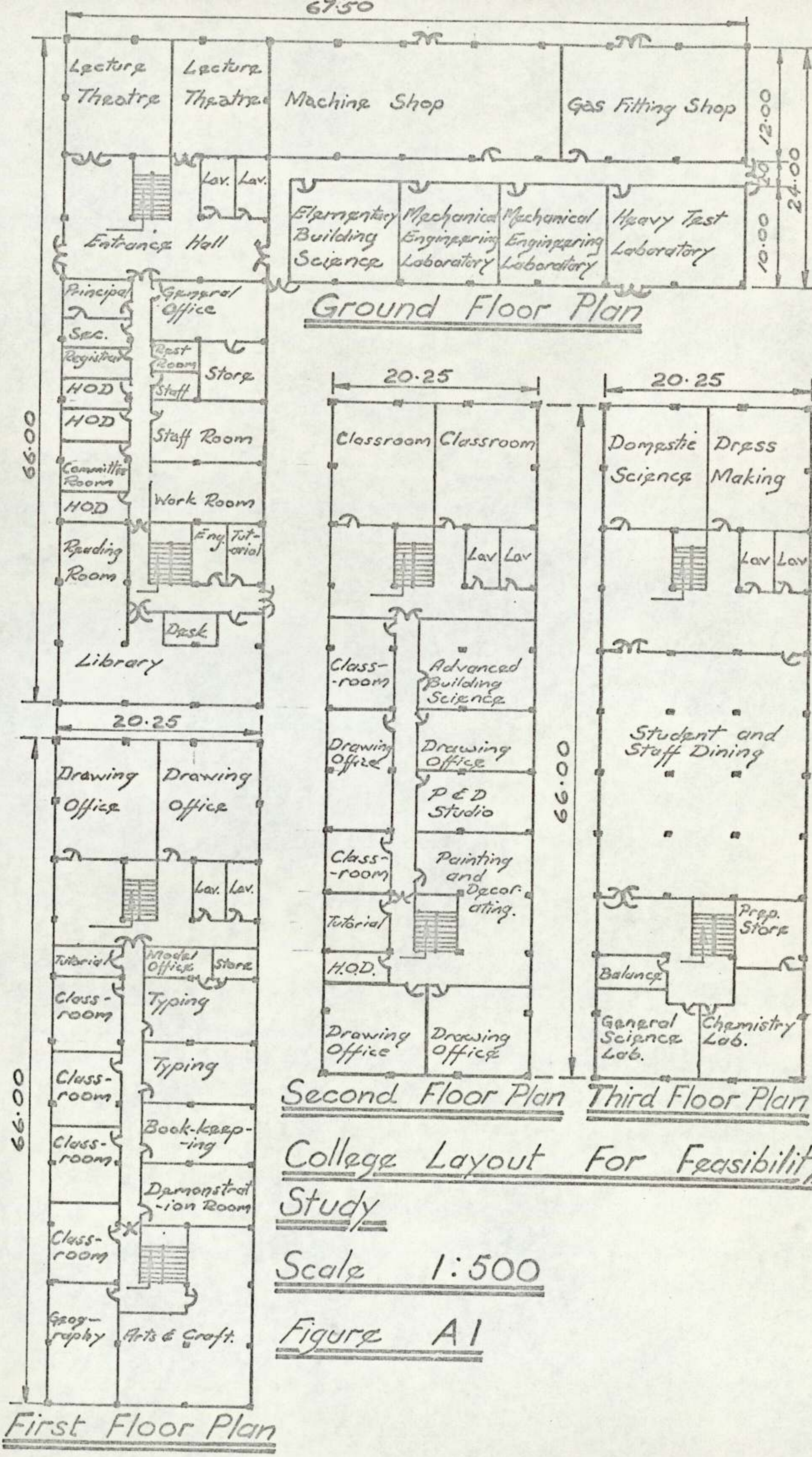
The feasibility study block is a multi-storey building, composed of reinforced concrete columns supporting hollow flat slab floors. The column grid is 6.00 metres by 6.75 metres and the floor loading is in accordance with CP3, Chapter V, ie $2.87kN/m^2$ (60lbf/sq ft). An additional loading of $0.96kN/m^2$ (20lbf/sq ft) has been allowed to enable the position of partitions to be altered.

The philosophy behind the design is that by having all of the College housed in one building a greater co-operative spirit is engendered, administration is easier and problems associated with room utilisation are reduced. Individual blocks housing separate departments encourage isolationism and generally act against the efficient administration of the College.

A heavy test laboratory has been provided on the ground floor to house equipment used by engineering and building students.

A single storey craft and laboratory block has been attached to the main four storey block to allow staff and students to travel between the various specialist rooms within a controlled environment and to reduce the tendency of departmentalisation discussed earlier.

Two large lecture rooms are situated near the main entrance, which, in addition to their normal college function, are ideally situated for use by the general public when attending specialist lectures or talks. The



College Layout For Feasibility Study

Scale 1:500

Figure A1

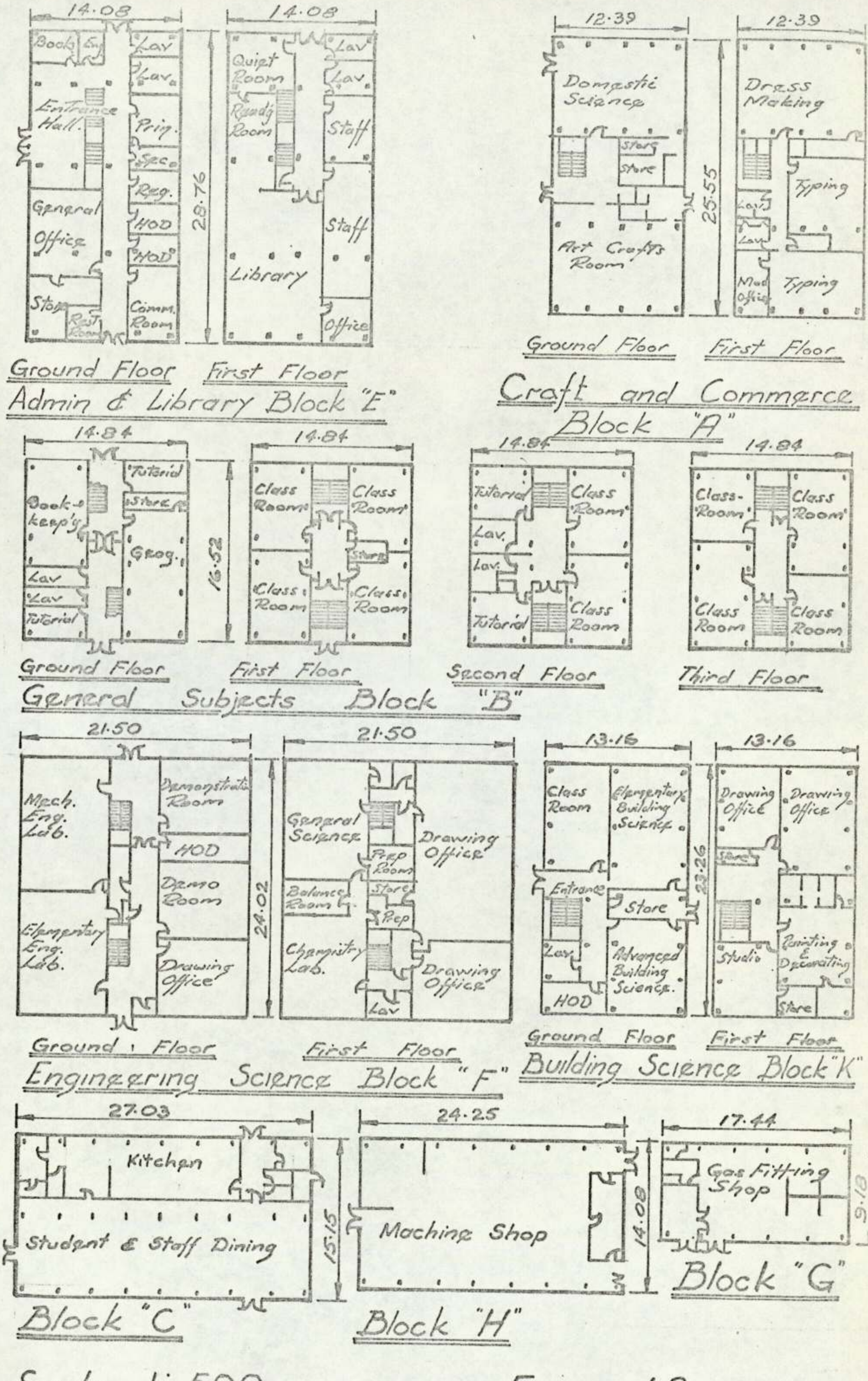


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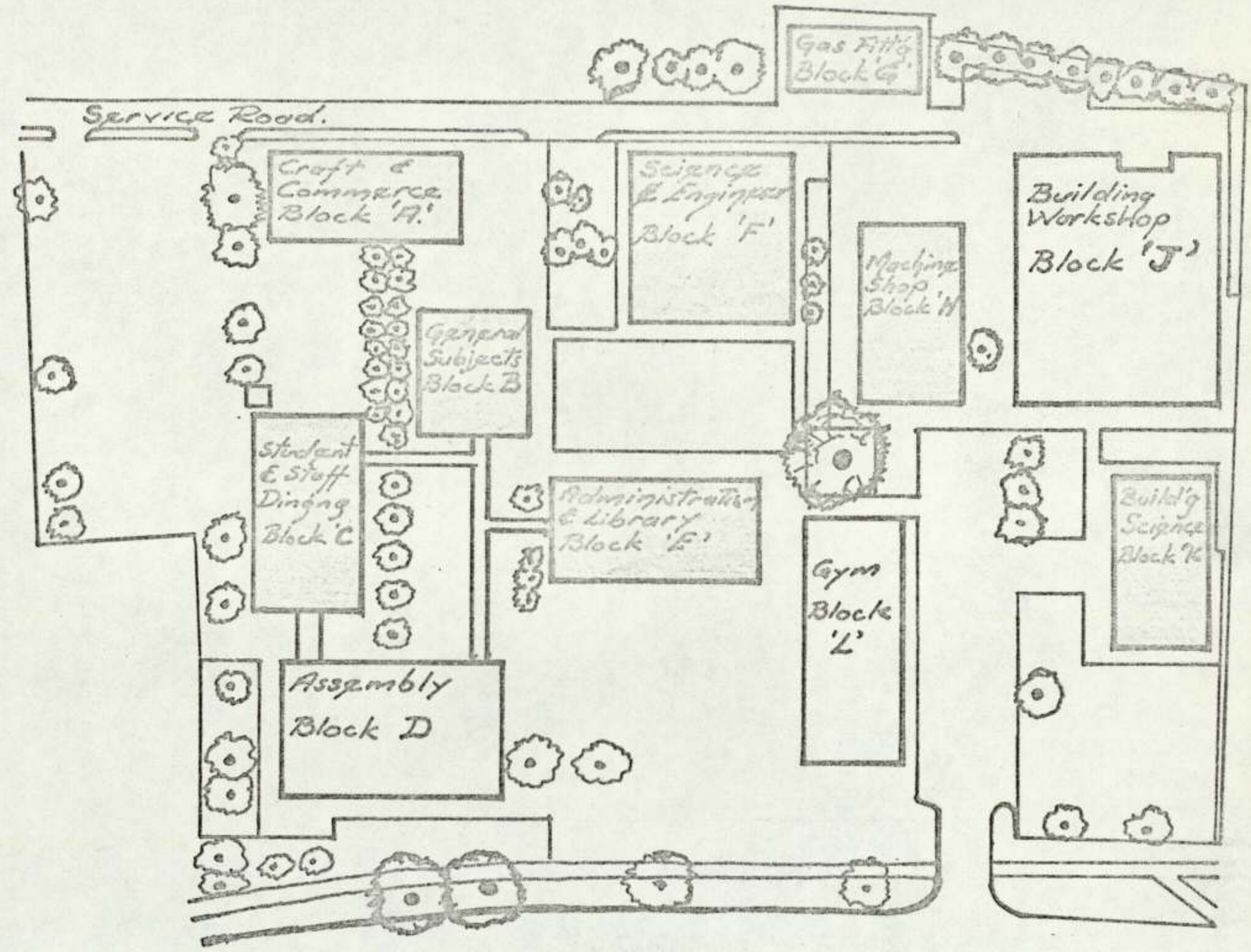
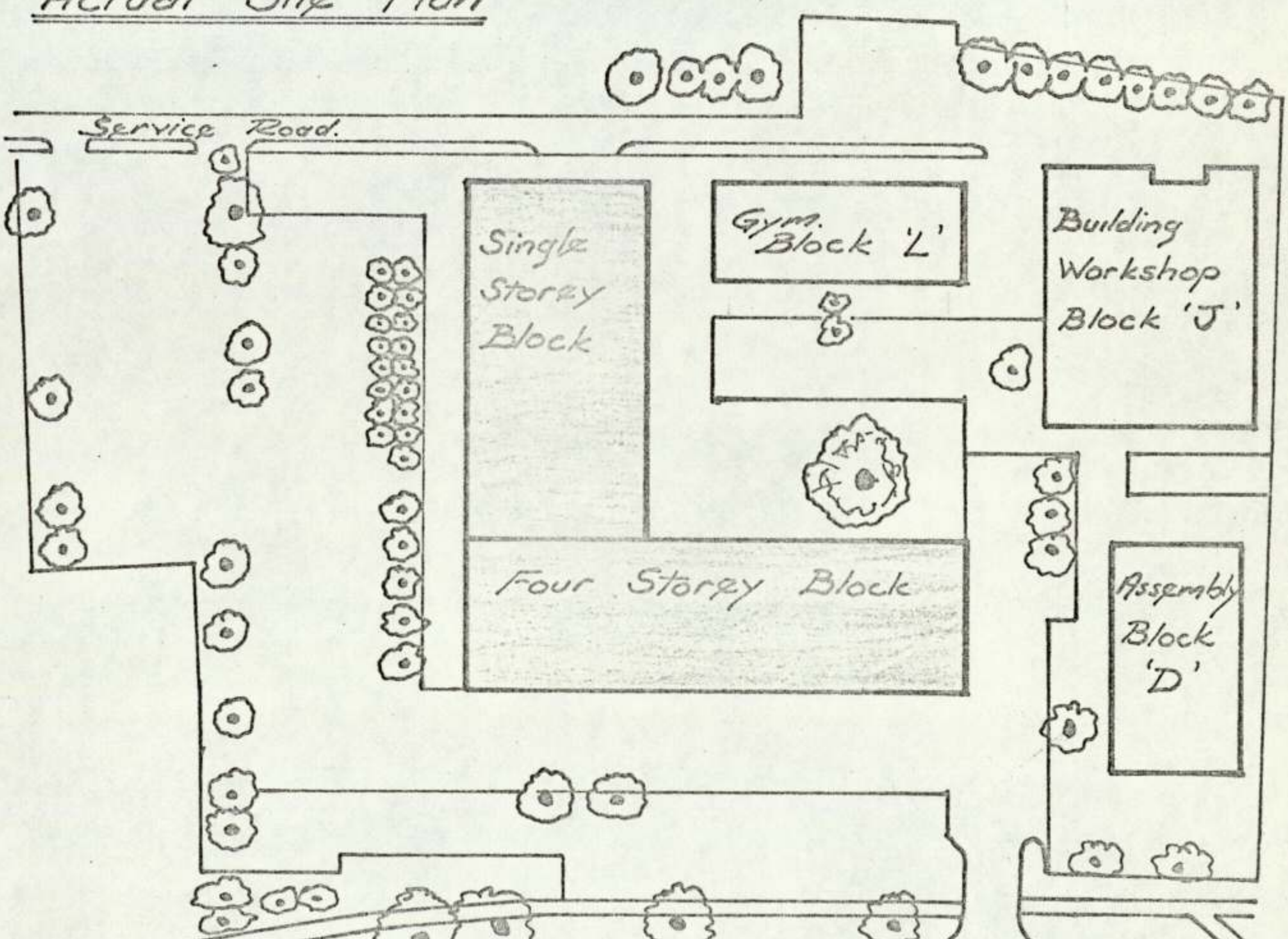
Figure A.2

Floor Plans For St. Albans College of F.E.



Actual Site Plan



Possible Site Plan For Feasibility Study

Scale 1:1000

Figure A.3.

Figure A4

Comparison of Floor Areas

Function	Number of Rooms	Floor Area in square metres	
		St Albans	Feasibility Study
<u>Study Area</u>			
Mechanical Eng Labs	2	196.90	202.5
Building Science Labs	2	169.45	218.5
Test Laboratory		-	135.0
Chemistry Lab	1	78.50	108.625
Conservatory, Prep Store and Vivarium	1	47.56	45.50
General Science Lab	1	84.54	91.125
Domestic Science	1	112.87	121.5
Arts and Crafts (including stores)	1	154.90	184.5
Machine Shop	1	338.70	348.0
Gasfitting	1	158.87	219.00
Painting and Decorating	1	98.10	132.00
P&D Studio	1	32.36	69.00
Geography	1	74.13	81.00
Book-keeping	1	56.48	69.00
Typing	2	129.60	138.00
Model Office	1	18.03	19.50
Classrooms, Lecture Rooms, Drawing Office and Demonstration Room (including stores)	18	1,069.24	1,494.00
Dress Making	1	112.87	121.5
Balance Room	1	20.44	20.25
Tutorial Rooms	4	95.32	103.75
Library (including Office)	1	241.18	243.00
Total carried forward		3,299.41	4,174.875

Figure A4 Continued

Comparison of Floor Areas

Function	Number of Rooms	Floor Area in square metres	
		St Albans	Feasibility Study
Administrative Areas			
Principal	1	23.78	27.00
Principal's Secretary	1	11.89	20.25
Registrar	1	16.35	20.25
Committee Room	1	32.70	33.75
General Office and Bookshop	1	69.49	69.00
General Office Store	1	32.87	40.50
Rest Room	1	5.95	14.25
Staff Common Room	1	63.92	69.00
Staff Work Room	1	31.22	69.00
Resident Engineer	1	8.16	22.75
Heads of Departments	4	67.70	75.75
Small Staff Room	1	-	14.25
Total Administrative Area		364.03	475.75
Circulation Area		760.93	1,223.375
Cloakrooms and Toilets		146.07	120.00
Student and Staff Dining		409.30	486.00
Study area BF		3,299.41	4,174.875
Grand Total		4,979.74	6,547.625

administrative accommodation, library and committee room have all been situated on the ground floor to allow easy access.

The first and second floors house the study areas only, the flexibility of which was a major consideration when deciding upon the provision of a heavy test laboratory in the single storey craft and laboratory block.

The kitchen, dining area, domestic science and chemistry rooms are all situated on the third floor to faciliate the important need for ventilation.

One row of internal columns have been omitted from each end of the building and the floors supported by reinforced concrete beams in order to further improve the flexibility of the accommodation provided.

CONSTRUCTION AND COST DETAILS

PRELIMINARIES AND CONTINGENCIES

The many variables which are included in these two items were discussed in Chapter IX of the thesis where it was shown, that the type of structure to be erected, the nature and location of the site, can affect the expenditure on preliminaries and that the sum of money included in the tender, under contingencies, cover the unforeseen work.

It was shown in Chapter IX that the average cost for further education and technical colleges, was £5.00/m^2 of gross floor area. This figure has been adopted for the feasibility study block.

WORK BELOW GROUND FLOOR FINISH

It will be obvious from the discussion in Chapter IX of the thesis that the expenditure on this item is more closely related to the ground floor area of the building than to the gross floor area. However, in order for this cost to be included with the other elements it must be converted to a cost per square metre of gross floor area.

The expenditure on work below ground floor finish level for the multi-storey technical colleges and classroom blocks of universities studied was as follows:

College	Number of Storeys	Cost/m^2 of floor area	
		Gross Area £	Ground Floor Area £
Oswestry College of F E	2	7.093	14.186
Slough College of F E	6	1.697	10.182
Derby College of Technology	8	2.689	21.512
Bedford Technical College	8	1.673	13.384
Redcar Technical College	3	4.846	14.538
N E Essex Technical College	5	5.221	26.105
C&CA Lecture Theatre Block	2	3.229	6.458
St Albans College of F E	4	1.554	6.216

The load bearing structure of the feasibility study block is considerably heavier than the CLASP framework of the St Albans College of Further Education. A figure therfore of £16.00/m^2 of ground floor area has been adopted for the four storey block which in turn gives a figure of £4.00/m^2 of gross floor area.

Work below ground floor finish for the single storey section has been assessed at £5.00/m^2 of floor area and an average figure therefore for the total college of £4.50/m^2 of gross floor area has been adopted.

An estimate of cost for this item based upon approximate quantities gave a total cost of £27,500 which is equal to £4.35/m^2 of gross floor area.

STRUCTURAL ELEMENTS

The affect of building shape, quantity factor, height and the inter-relationship between the various structural elements were discussed in Chapter IX and illustrated in figures 9.28 to 9.31 of the thesis.

Becuase of the higher relative cost of the structural frame, upper floors and roof and because of the difficulty in obtaining comparable costs based on gross floor area for a similar structure, an estimate was prepared based upon approximate quantities.

Quantity and cost details are as follows:-

Description	Cost	
	Total £	Per sq m of gross floor area £
300mm flat slab floor, spanning in two directions (without drops) including reinforcement and shutters 5.346m^2 at £4.1/m^2	21,919	3.47

Description	Cost	
	Total £	Per sq m of gross floor area £
Perimeter beams and beams over end bays, including reinforcement and shutters. 326 cubic metres at £14/cubic metre	4,564	0.72
400mm square rc columns forming a grid in the four storey building of 6 metres by 6.75 metres including reinforcement and shutters. 3,730 cubic metres at £16/cubic metre	59,680	9.44
250mm rc roof, including roof lights over single storey workshop block, reinforcement and shutters. 2,308 square metres @ £5/square metre	11,542	1.83
Asphalt on screed to falls and foamed polystyrene insulation slabs 2,056 square metres at £2.25/square metre	4,626	0.73
Total	102,331	16.19

A value of £16.25/m^2 of gross floor area has been adopted, which compares very closely with the average for all of the buildings of the St Albans College of Further Education of £15/m^2 of gross floor area.

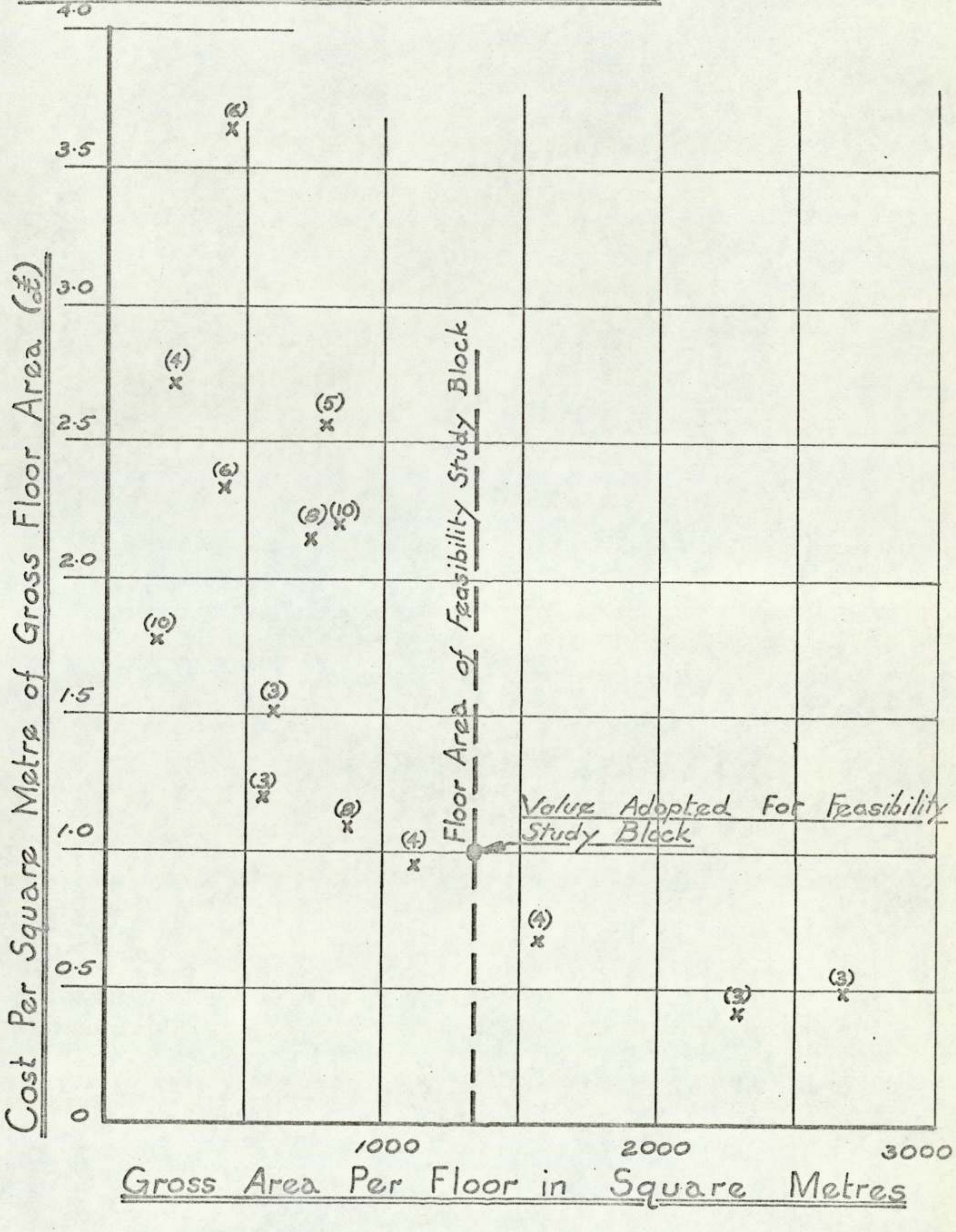
STAIRS

The following table provides cost details for the stairs in the educational buildings of three storeys or more, taken from the cost survey, details of which were given in Chapter IX of my thesis.

Cost Comparison of Stairs in Buildings of 3 Storeys or More				
Educational Building	Number of Storeys	Total floor area m^2	Average area/floor m^2	Cost in £/m^2 of total floor area
Slough, classroom and lab block	6	2,584	431	3.658
Derby, classroom and lab block	8	6,962	870	1.093
Bedford, classroom block	8	5,862	733	2.162
St Albans, classroom block	4	976	244	2.729
Harris College, class-room block	4	4,509	1,127	0.960
Harris College, class-room block	3	1,682	561	1.233
Redcar College of F E	3	6,880	2,293	0.415
NE Essex Technical College	5	3,916	783	2.553
Edinburgh University Lecture Theatre	10	1,672	167	1.775
Edinburgh University, Agricultural College	3	8,020	2,673	0.493
Leicester University, Teaching Block	4	6,262	1.566	0.683
Jews Theological College, London	6	2,462	410	2.344
Leicester University, Research Block	3	1,775	592	1.511
Edinburgh University, Teaching Labs	10	8,360	836	2.223

Figure A5 shows the cost of stairs expressed as a cost per square metre of floor, plotted against the plan area of the floor being served. It will be seen that the cost of the stairs per unit of floor area reduces as the area

Cost Comparison Showing the Relationship Between Expenditure on Stairs and the Floor Area Served at Each Level



—Figure A5—

of floor being served increases. Some scatter is caused by variations in the stair specifications.

The gross area of an individual floor in the multi-storey feasibility study block is 1336.5 square metres and has been included in figure A.5 indicating a cost of £1.00 per square metre of gross floor area.

EXTERNAL WALLS, WINDOWS AND DOORS

The factors affecting the apparent cost of the external envelope were discussed on pages 199 to 202 of the thesis, where it was shown that when making cost comparisons on the basis of unit floor area the quantity factor alone made it appear that the external walls of Edinburgh University were 3.81 times the cost of those for Leicester University, whereas, an examination of the actual costs of walling (see figure 9.30) showed the walls of Leicester University to be the most expensive.

It was also shown that the quantity factor for external walls is related to the shape of the building, the storey height and the area occupied by other items such as windows. The external envelope quantity factors for the 55 educational buildings analysed in my study ranged from 0.333 to 1.107.

The actual cost of the external envelope is affected by:

a. the market forces at the time of tendering

b. the total height of the building

c. the year and place of construction

d. the affects of other elements, such as the load bearing structure and finishes

e. the quantity used.

The quantity factor for the external envelope of the St Albans College of Further Education and the feasibility study are as follows:-

College	Area of external envelope in square metres	Gross floor area in square metres	Quantity Factor
St Albans College of F E	3627.07	4979.74	0.728
Feasibility Study	2900.60	6547.625	0.443

If the cost per square metre of the external envelope were the same for both the St Albans College of F E and the feasibility study block, the variation in quantity factor alone would be responsible for indicating a cost ratio (based on unit floor area) of 1 to 1.64.

The unit cost details shown in figure A.6 have been developed for comparative purposes and are based upon 1968 material and labour costs.

A unit cost of £6.25 per square metre of external wall has been adopted which corresponds to a 280mm cavity wall having an external leaf of facing bricks and an internal plastered surface finished with emulsion paint.

The cost of windows, composed of 6mm plate glass is approximately the same as the brickwork and therefore with the exception of a slight variation in the cost of the load bearing frame, the effect of altering the ratio of window to wall area can be ignored.

FIGURE A6

Unit Costs of Walls and Windows

Description	Cost per square metre £
EXTERNAL WALLS	
228mm thick brick walls (pc £10.00/1000) including fair face one side, plastered internally and finished with emulsion paint	5.50
280mm cavity brick walls (pc £10.00/1000) including fair face one side, plastered internally and finished with emulsion paint	5.75
280mm cavity brick walls (pc £10.00/1000 for commons and £20.00/1000 for facings) including fair face one side, plastered internally and finished with emulsion paint	6.20
25mm T and G softwood boarding including battens, glass wool insulation, inner half fletton brick wall, plastered and finished with emulsion paint	4.60
As above but machine made sand-faced tiles instead of 25mm T and G softwood boarding	5.10
57mm portland cement facing slabs, fixing, including cramps, insulation, inner leaf, plastered inner surface and emulsion paint	10.70

Figure A.6 Continued.

Description	Cost per square metre £
CURTAIN WALLING	
Galvanised steel standard grid curtain walling, containing opening lights, 6mm polished plate glass, insulation and infill panels	22.60 (average)
As above but in anodize aluminium	25.70
WINDOWS	
6mm polished plate glass including fixing in position	6.00
Double glazing unit in hardwood and 2 skins of 6mm polished plate glass	13.50
INNER WALLS	
76mm hollow clay, thermalite, clinker concrete blocks, plastered and emulsion paint both sides	2.80
As above but 102mm thickness	2.90
Half brick fletton, plastered and emulsion paint both sides	3.60
As above but one brick thickness	5.50

Figure A.6 Continued

Description	Cost per square metre £
57mm Paramount dry portion and emulsion paint	2.60
51mm single skin demountable steel partition, self finish	6.95
51mm double skin insulated but single glazed steel partition, self finish	8.00
51mm double skin insulated, double glazed steel partition, self finish	9.35

A useful check on the cost developed for the feasibility study can be made, by comparing them with the construction and cost details of Leicester University given in figure 9.30 of the thesis.

It will be seen that the external walls have a very similar specification to those of the feasibility study block and were priced at £5.46 per square metre. To this figure a cost of approximately £1.00 per square metre must be added to allow for plaster and painting.

The cost therefore of the external walls is £6.20 x 0.443 which equals £2.75 per square metre of gross floor area. The figure 0.443 is of course, the quantity factor for external walls.

PARTITIONS, INTERNAL DOORS AND IRONMONGERY

A tabular and graphical presentation of these costs was given in figures 9.5; 9.6; 9.7; 9.9; 9.12; 9.18 and 9.25 of the thesis. However for ease of reference, the summation of the costs for partitions, internal doors and ironmongery have been abstracted and are presented in the following table.

The cost of Partitions, Internal Doors and Ironmongery Expressed as a Cost Per Square Metre of Floor Area For Multi-Storey Classroom Block.

College	Number of storeys	Cost per square metre of floor area £
St Albans College of F E Block A	2	3.380
St Albans College of F E Block B	4	4.862
St Albans College of F E Block K	2	3.453
Harris College, Preston	3	4.728

College	Number of storeys	Cost per square metre of floor area £
Harris College, Preston	4	5.155
Slough College of F E	6	2.772
Derby Technical College	8	4.229
Bedford College	8	3.142
Redcar Technical College	3	2.915
NE Essex Technical College	5	4.402
Edinburgh University	10	2.525
Agricultural College, Edinburgh	3	3.615
Glasgow University	4	4.157
Leicester University	4	3.616
Jew's College, London	6	3.644
Total for 15 buildings		£56.595
Arthmetic mean = £3.775		

A figure of £4.00/square metre of floor area has been adopted for the feasibility study block.

FINISHES AND FITTINGS

Figure 9.32 of the thesis shows that the greatest variation in cost is due to the quality and quantity of the fittings provided. I have therefore adopted the St Albans figure of £14.50 per square metre of gross floor area to allow for the same relatively high standard.

SERVICES

The average costs of services is shown in figure 9.33 of the thesis and a more detailed breakdown is given in figures 9.5; 9.6; 9.7; 9.9; 9.14; 9.22 and 9.27.

It will be seen that the main items of expenditure are heating, ventilating and electrical services.

In order that the two buildings shall be comparable and because the shape and construction of the building does not alter the cost significantly, the average cost of £16.00 per square metre of floor area for the St Albans College of F E has been adopted.

The Total Cost of the Feasibility Study Block is as follows:-.

Item	Cost per square metre of gross floor area £
Preliminaries and contingencies	5.00
Work below ground floor finish	4.50
Structural frame, upper floors and roof	16.25
Staircases	1.00
External envelope	6.25
Partitions, internal doors and ironmongery	4.00
Finishes and fittings	14.50
Services	16.00
Total cost of building per square metre of gross floor area	67.50

In Chapter IX of the thesis I showed that the average amount of floor area provided for each technical college student was ten square metres. After discussing the statistics of college expenditure which I obtained from W R Tuson, Chief Education Officer for Preston, and which were presented in graphical form in figures 8.1 to 8.5 of the thesis I established a factor of 1.3 for converting the cost of ten square metres of gross floor area to the equivalent cost per one thousand weighted student hours.

The main theme running through the thesis, is that because of the relatively high expenditure on slaries for academic staff compared with the annual equivalent cost of the building, it is uneconomic as well as educationally undesirable, to impair the efficiency of academic staff by economising on the building.

In order to further illustrate the example already given earlier in the thesis, the feasibility study block has now been developed which gives an increase of 31.5% over the gross area and 26.5% over the study area provided for the St Albans College of Further Education.

Therefore when converting the annual equivalent cost to a cost per 1,000 weighted student hours a gross floor area of thirteen square metres per student must be used in place of the ten square metres established in my thesis. The factor of 1.3 remains constant.

The cost of the structure expressed as a cost per 1,000 weighted student hours is determined by multiplying the annual equivalent cost per square metre of gross floor area by the average floor area per student and dividing by a constant of 1.3.

It follows that the cost of the structure expressed as a cost per 1,000 weighted student hours is:

$$5.57 \times 13 \times \frac{1.}{1.3} = £55.7/1000 \text{ student hours.}$$

The average annual expenditure for twenty eight colleges of further education (from the statistics provided by W R Tuson) expressed as a cost per 1,000 weighted student hours, for the year 1966-1967 was as follows:-

STAFF COSTS	£	£
Salaries for teaching staff	149.88	
Laboratory assistants and maintenance staff	13.17	
Caretakers and cleaners	8.76	
Administration, clerical and library staff	8.48	
National insurance and superannuation	17.17	
Total for staff costs		197.46
BUILDING RUNNING COSTS		
Upkeep of buildings	4.93	
Fuel, light and cleaning	7.91	
Rent and rates	12.27	
Total for building running costs		25.11

COLLEGE EXPENSES		
Furniture, fittings, educational equipment, stationary, text books and library books	21.66	
Advertising, printing and postage	4.41	
Total for college expenses		26.07
Annual equivalent of initial cost expressed as a cost per 1,000 weighted student hours		55.70
Grand Total	£	304.34

It will be seen from the above figures that the:

staff cost represents 64.88% of the total annual expenditure
building running cost represents 8.25% of the total annual expenditure
college expenses represents 8.57% of the total annual expenditure
annual equivalent represents 18.30% of the total annual expenditure.

Inflation will cause the expenditure to increase in all of the above items with the exception of the annual equivalent cost of the building, which will only be affected by variations in the interest rate.

An increase of two percent, from eight to ten percent would cause an increase in the annual equivalent cost of approximately twenty five percent on a sixty year building life.

It will be seen that the annual equivalent for the feasibility study block expressed as a cost per one thousand student hours is £55.70 compared with

£25.80 used in the thesis. The reasons for this difference are as follows:-

1. An average figure for the initial cost, based upon my cost survey, of £65 per square metre of gross floor area was used, whereas the estimated cost for the feasibility study block is £67.50 per square metre of gross floor area.

2. The gross and the "study" floor area provided in the feasibility study block allowed each student an increase in floor area of 31.5 percent and 26.5 percent respectively.

3. The interest rate adopted was 5 percent in the thesis, which was the current rate at that time, whereas the rate used three years later for determining the annual equivalent of the feasibility study block is 8 percent, this higher rate has the effect of increasing the annual equivalent by approximately 60 percent.

THE EFFECT OF VARYING FLOOR LOADING AND COLUMN SPACING

Approximate estimates indicate that to increase the superimposed load on the suspended floors of the feasibility study block from 2.87kN to 5.00kN would result in an increase in the cost of the structural frame of ten percent.

Increasing the bay size of the flat slab floor from 6.00 metres by 6.75 metres to 6.75 metres by 9.00 metres results in an increased initial cost of twenty percent for the structural frame.

It will be seen that the cost of the structural frame, including foundations, for the feasibility study block accounted for approximately twenty five percent of the total cost of the structure and that the additional cost for increasing the superimposed floor load and bay size as discussed in the previous paragraphs therefore represented an increased expenditure, expressed as a total cost of the building of approximately 2½ percent and 5 percent respectively. Not a very large price to pay for the increased flexibility which would ensue.

THE INTERNAL ENVIRONMENT

In Chapter VI pages 120 to 129 of the thesis, the general principles of good lighting were discussed.

Having discussed the difference between sky factor and daylight factor, it was shown that both were dependant upon the size and shape of the window, the position of the reference point, obstructions, loss of light due to glazing and that, in addition, the daylight factor, which can be determined in an actual building by a meter or my the use of a model placed under an artifical sky, takes account of reflected light from floor, walls and ceiling.

The need for quality combined with quantity was discussed in relation to the problems of glare, as was the need to provide the right amount of light for the particular function to be performed within the room.

With these principles in mind, the feasibility study block was designed so that the deepest rooms (11.50 metres) were on the north face of the building, thus reducing the problems associated with glare and solar radiation.

Figures A7 and A8 show the difference in daylight factor distribution within one of these rooms for 1.95 and 2.60 metre high windows. The calculation of the daylight factor was discussed and illustrated in Chapter VI of my thesis.

It will be seen from figures A7 and A8 that the daylight factor falls below two percent at a distance of 5.00 metres from the external wall for a 1.95 metre high window and the distance is increased to 6.50 metres for a 2.60 metre high window.

A two percent daylight factor is generally accepted as the minimum and when natural ullumination falls below that level, it is now customary to provide permanent supplementary artificial lighting (PSAL) which was discussed in Chapter VI of my thesis.

Windowless lecture theatres are becoming more common and there seems no reason why the trend should not continue into the design of classrooms and laboratories. Advantages such as the efficient control of heating and lighting are obvious, solar radiation, glare, variations in illuminations levels throughout the room, problems of sound and heat insulation are immediately iliminated.

Compensation for loss of natural lighting can be provided by large areas of fenestration, suitably orientated in recreational areas and the refectory.

Factors affecting the internal environment cannot be discussed without reference to the economics of alternative forms of construction necessary to obtain that environment and therefore figure A9 has been developed to enable cost comparisons to be made in association with properties such as

Diagram Showing Daylight Factor Distribution For a Classroom 11·50 m Deep by 6·00 m Wide Having a Full Width Window Along the Short Side Only

Scale 1:50

Figure A.7

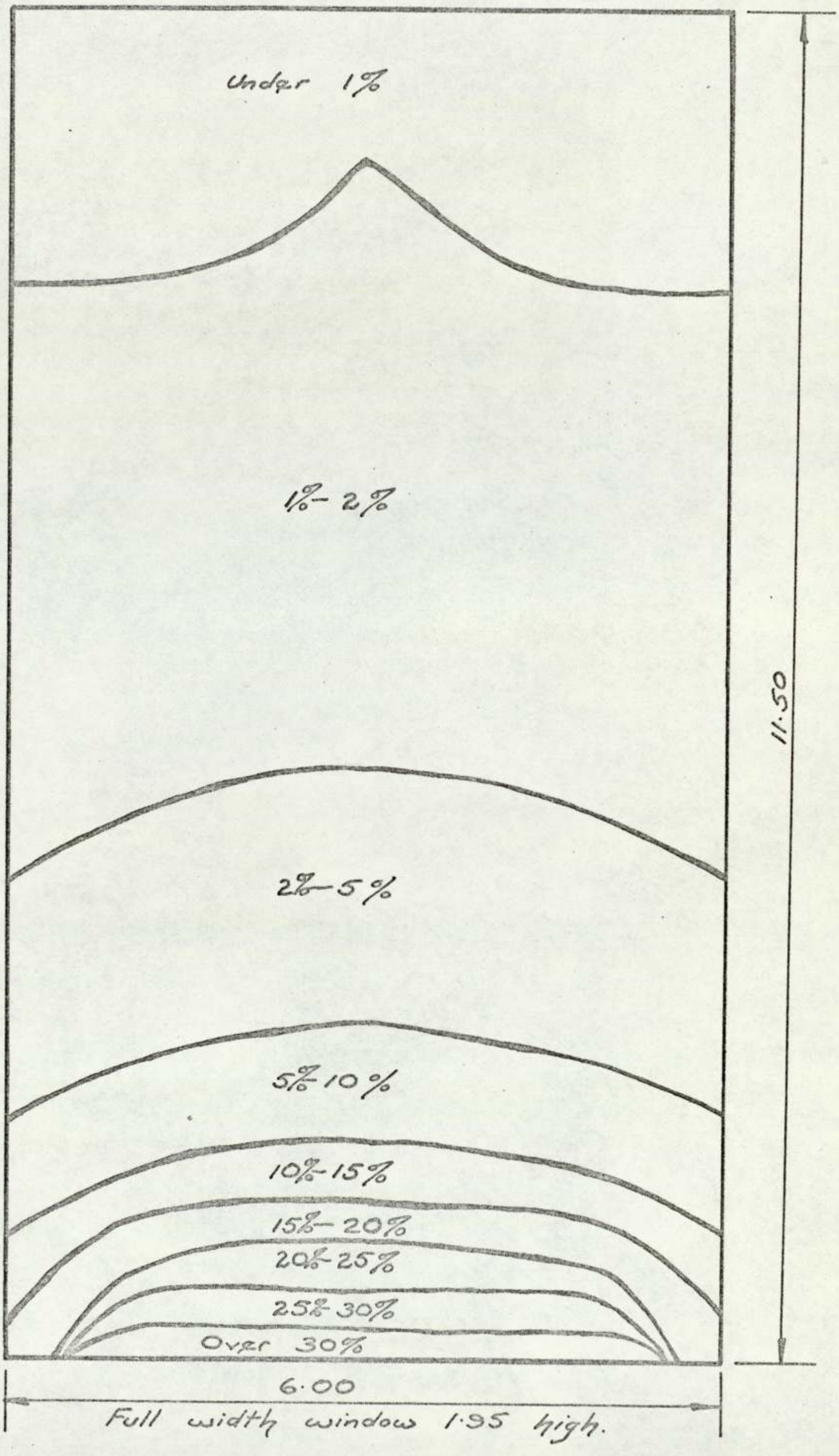


Diagram Showing Daylight Factor Distribution For a Classroom 11·50 m Deep by 6·00 m wide Having a Full Width Window Along The Short Side Only.

Scale 1:50

Figure A8

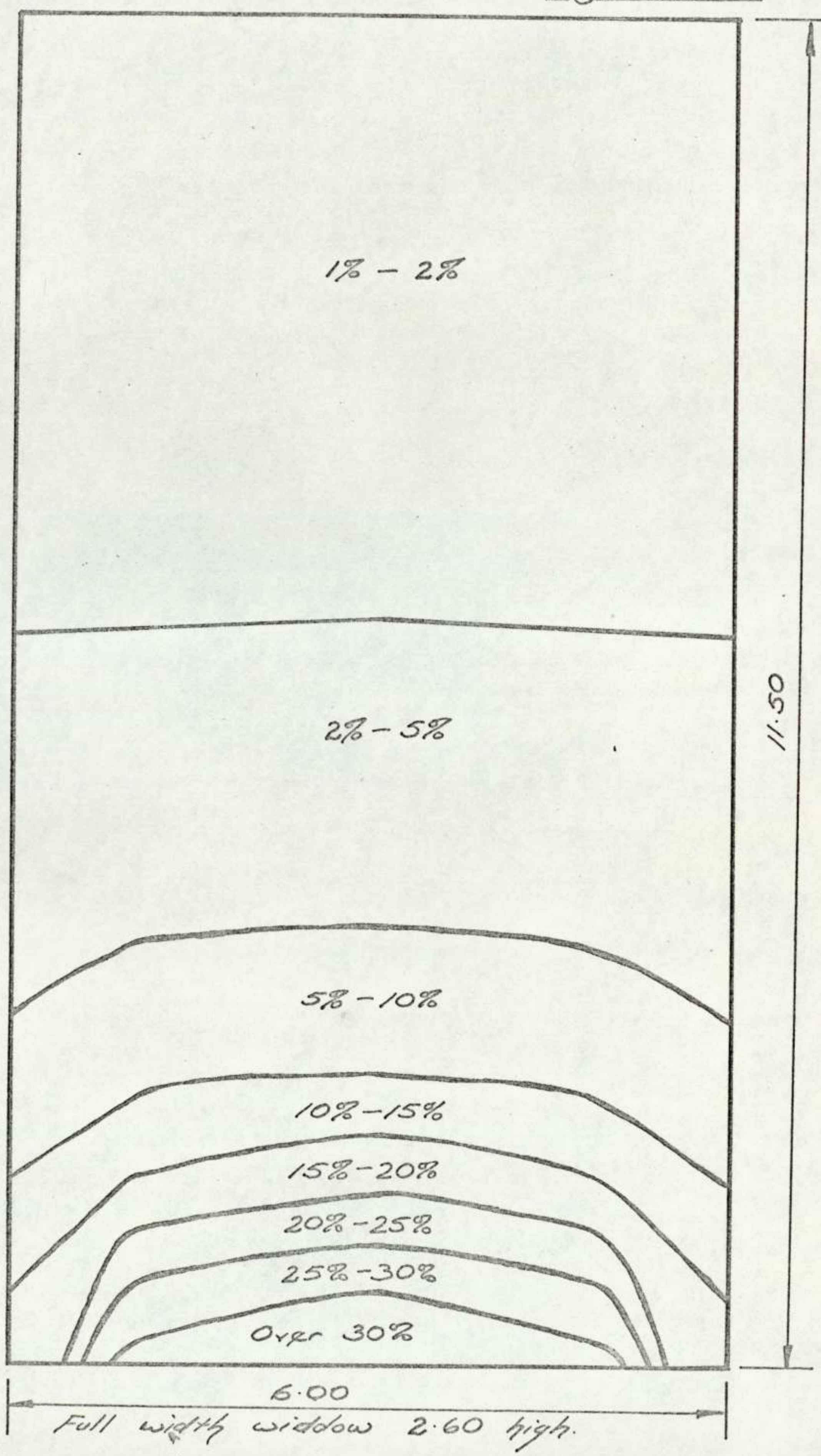


FIGURE A9

Item	Light Transmission % (1)	Thermal Transmittance W/M^2 ^oC (2)	Sound Insulation dB	Cost £/M^2 ^oC
Sheet and polished plate glass	85	5.00	Slight improvement for increase in weight 20	6.00
Double Windows	72 (3)	Maximum efficiency obtained with 20mm cavity 2.67 a 6mm cavity gives a value 1.87	Varies from 22 for 100mm cavity with openable lights to 44 for a 200mm cavity and sealed lights. (4)	10.50 for thermal insulation 13.50 for sound insulation
Glass Blocks	60	2.20	40	48.00
229mm thick brick walls plastered internally	Nil	2.32	50 (5)	5.75
280mm thick brick cavity walls plastered internally	Nil	1.54	50 (5)	6.20

FIGURE A9 (continued)

(1) Assumes clean glass.

(2) See figure 6.15. Values taken for normal exposure and W, SW, SE orientation.

(3) Width of cavity has a neglible affect providing walls of cavity are painted white.

(4) 50mm cavity best for high frequency sounds and 100m cavity best for low and medium frequency sounds.

(5) Dependent partly on flanking transmission, see page number 147 chapter VI.

light transmission, sound and thermal insulation.

Using figure A.9 we can examine the relative expenditure for providing adequate lighting to one of the classrooms of the feasibility study block.

Consider for example a 11.50 metre deep classroom, a heating season duration of 210 days (see page 138 Chapter VI) and a mean temperature difference of 12 degrees celcuis (see page 137 Chapter VI).

A cost of one penny per kwh has been assumed for heat and light energy.

Item	Annual Equivalent of Initial Cost at 8% interest £	Expenditure on heating from figure 6.14 £ (1)	Expenditure on lighting		Total Annual Expenditure £
			Annual Equivalent £ (2)	Electricity Consumption £ (4)	
280mm thick brick cavity wall, plastered internally.	9.9	12	29 (3)	17	67.90
As above, but including single plate glass windows 1.95 x 6.00 metres	9.65	28.35	27	10	75.00
As above, but with double glazing, 20mm cavity	14.11	17.25	27	10	68.36

(1) The better insulation values of the 280mm cavity wall and the double glazing would have the effect of reducting the capital expenditure on the heating installation. This saving could only be considered in relation to the total requirement.

(2) The annual equivalent of the electrical installation is based upon an interest charge of 8 percent and a replacement life of 20 years.

(3) A higher level of illumination has been allowed in the windowless classroom.

(4) The electricity consumption for lighting is dependent upon classroom utilisation. These figures are based upon an annual use of 1700 hours.

COST OF LAND

The one major item of expenditure which has not been considered is the cost of land.

Figure 6.8 reproduced the results of a survey carried out by the National Building Agency (4) into land prices and showed the average cost per acre to vary from £42,685 to £2,296 depending upon geographical location and whether the site was situated in an urban or rural area.

However, I have considered the expenditure on land to be capital investment on behalf of the community, rather than a capital expenditure, as the land will remain, at least equal to its initial price after the useful life of the building has ended.

The present tendency is for the land to continually increase in value and there seems no reason to believe that this trend should not continue.

In the case of St Albans College of Further Education the area of the site was 3½ acres and assuming a cost of £10,000 per acre, the initial expenditure on land is equal to £5.35/m^2 of gross floor area.

AN ECONOMIC ENVIRONMENTAL AND FUNCTIONAL STUDY
OF BUILDINGS ERECTED FOR EDUCATIONAL PURPOSES

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This chapter is based upon information obtained from the following references

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Chapter III. Professional Institutions Associated with the Construction Industry.

This chapter has been based upon information obtained from the following references and professional institutions

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9. "The Chapters, Bye-Laws, Regulations and Rules," supplemented by information received from the Secretaries of the following institutions:-

   a. The Institution of Civil Engineers

   b. The Institution of Mechanical Engineers

   c. The Institution of Electrical Engineers

d. The Institution of Heating and Ventilating Engineers

e. The Institution of Structural Engineers

f. The Royal Institute of British Architects

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