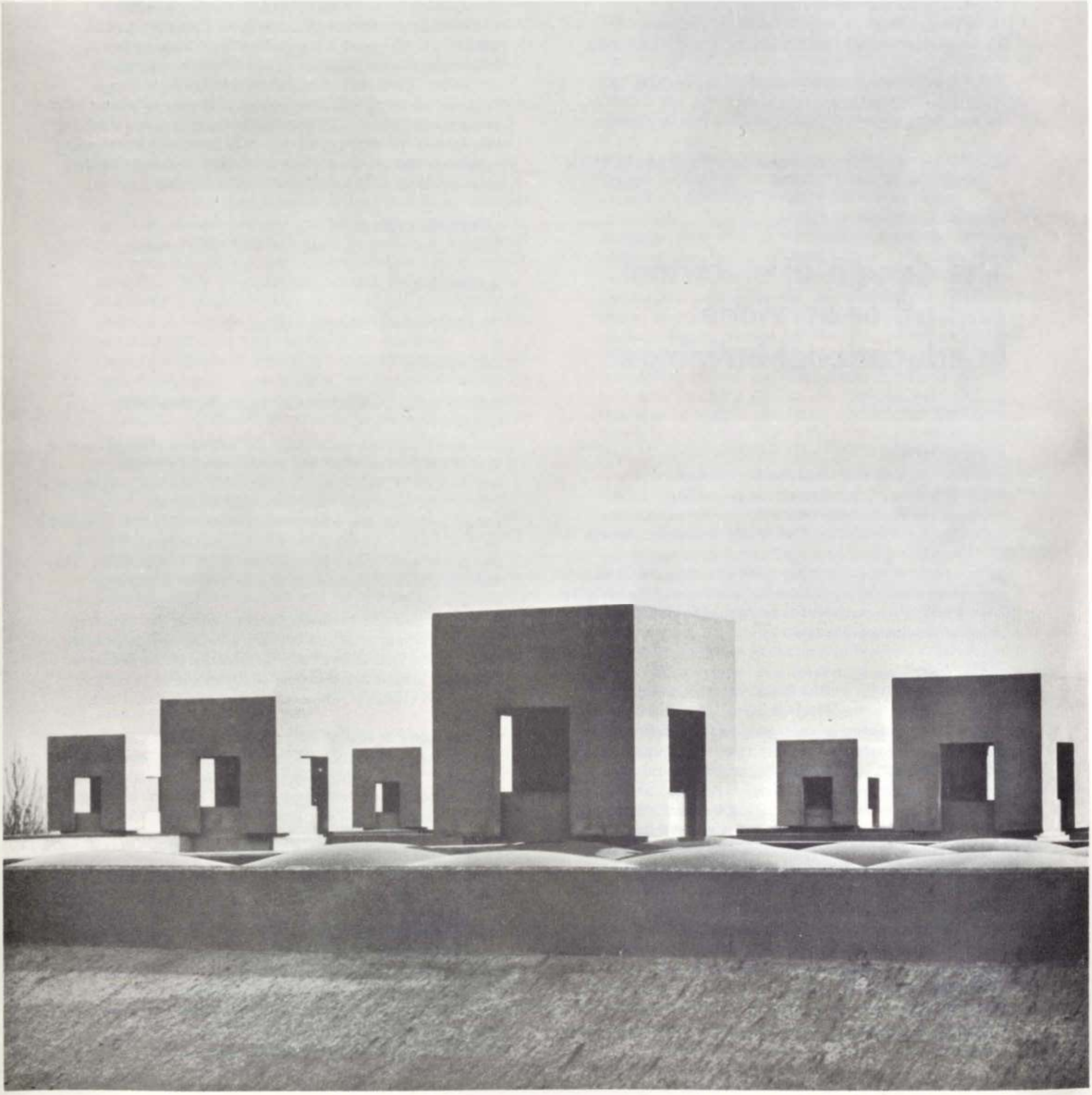
THE ARUP JOURNAL

MAY 1966



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Contents

The front cover shows the roofscape of Birmingham University Mining and Metallurgy Building.
On the back: Point Royal, Bracknell. The deck showing relationship with ground. (Photos: H. Sowden)

The design of electrical and other services in educational buildings*

F. A. Abbott

INTRODUCTION

The building industry is currently involved in an expansion programme and a substantial part of this programme is concerned with the provision of new buildings for universities, technical colleges, schools and the like. This paper sets out to discuss some of the problems of effectively integrating the required electrical and mechanical services into the building and to describe a design process evolved to overcome them. It also shows some of the designs themselves.

AIMS

We should begin by setting down our aims which are for better building in the broadest sense. We are all part of a design team planning an environment for people to work or live in. The architect obviously makes the biggest contribution to this planning but we, as services engineers, must try to appreciate the overall conception and by suggestion and practical application we must contribute towards the successful completion of the building. It has to be realised that the type, finish and position of many of the simple objects with which we are concerned - switches, socket outlets, clocks, etc., all play their part in the overall design. Unfortunately one is only too well aware that in many buildings this aspect has been overlooked when a switch or a fuseboard stands out like a sore thumb or when a lighting scheme does not appear quite right.

DESIGN TEAM

It has been my experience that the traditional methods of building design, in which all the various professions involved work in different firms, can no longer cope satisfactorily with the complexities of the industry today. The advent of many new materials and processes and the wide range of facilities required, has necessitated the employment of more and more specialist consultants and has also shown up the need for more and closer collaboration between the professions. There are now a number of group practices which include members of some or all the professions concerned. There are many advantages to be gained from this type of practice but also a number of disadvantages such as division of responsibility and recording of design decisions. Rome was not built in a day, however, and changes in procedure resulting from any new method take time to mature. One particular point which has become apparent, however, is the need for the training of all the members of the team to be modified. The architectural profession is aware of the shortcomings of the present arrangements and is studying methods of improving the situation. The services engineers are in a more difficult situation in that the training courses sponsored by the engineering institutions are not appropriate to this field of design. There is a real need for a new form of training for the building services engineer of the future to embrace a grounding in all services, i. e. electrical, plumbing, drainage, heating and ventilating, with specialization later in the programme. The institutions have a group studying this matter but changes of this sort inevitably come about slowly so that the immediate need is to provide a design team made up of the engineers now available.

SERVICES DESIGN

Educational buildings fall into four broad classes:

1
Residential

2
Teaching space, common rooms, etc.

3
Laboratories

4
Special areas such as lecture theatres, museums, computer rooms, etc.

The most complex class from the services point of view is that of the laboratories and I will therefore tend to concentrate on this type. Modern buildings and particularly educational buildings, are becoming more and more complicated and the traditional methods of design whereby an architect carries out the overall planning calling on advice from the other professions from time to time, has become too cumbersome to result in truly integrated designs.

The most common problem experienced by the services engineer is that he is not brought into the design process until far too late and yet it is the quality of the services that most affects the eventual occupier. If he is cold or cannot see properly, other merits of the building are forgotten.

The difficulty is one of administration in that the contribution to be made by, for example, the electrical engineer, is not very great in the initial stages of the job and he is only required intermittently and then usually at short notice. This is often impossible if he is in a different office, sometimes in a different town.

Some of the information that he has to contribute, however, such as substation or intake details, and vertical or horizontal service runs, is very important. The architect, as overall planner, is understandably put out when asked to accommodate switchrooms and the like when he has spent hours making the various bits of his jigsaw fit together without them.

The other services engineers are in a similar situation. The basic principles of the plumbing and heating systems have to be discussed, together with space requirements for the boilers, chimney and main service runs. The

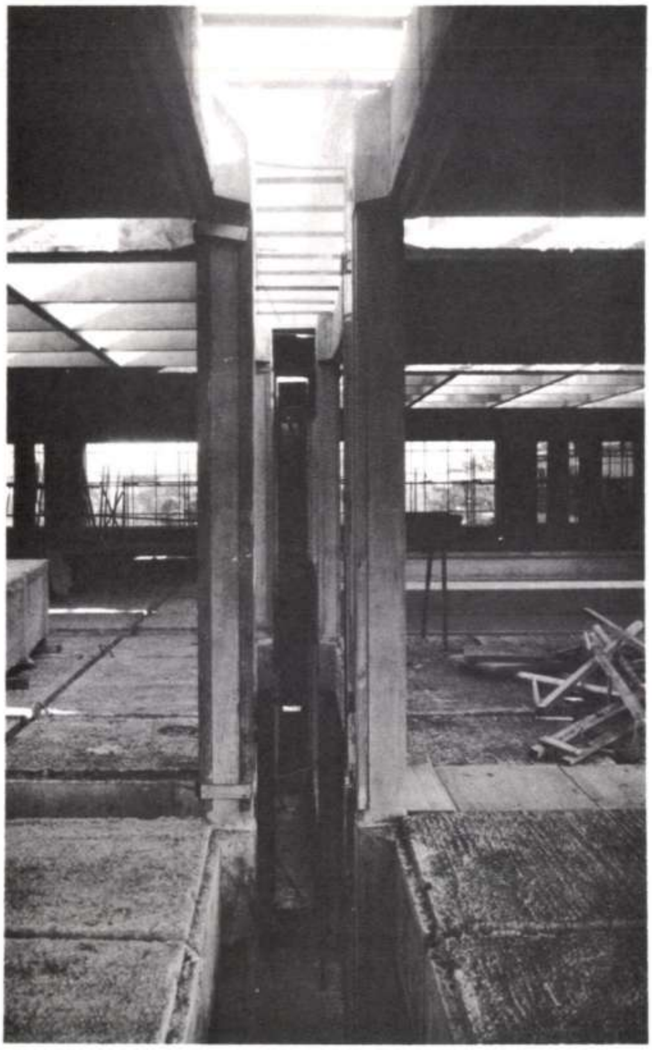
* Read before the Institution of Electrical and Electronics Technician Engineers on 15 November, 1965.

heating designer has perhaps the biggest part to play in this initial design since choice of building materials, size and aspect of windows, etc., can seriously affect the size of boiler installation, the method of distribution and the type of control system to be used.
This need for early information on what we can call plant spaces and duct positions is therefore vital to a truly integrated design. This, however, immediately poses another problem because accurate details of the spaces required are dependent on accurate brief information from the client and this is seldom forthcoming in the very early stages. After all, how can one be precise without a layout of the building? Here there is a chicken and egg situation which shows up the need for a services system, a basic philosophy that once determined will ensure that services connections can be made to anywhere in the building.

SERVICES PHILOSOPHY
It is in the development of this philosophy that joint discussions between architects, structural engineers, and services engineers are important so that each member of the team knows the basis upon which the shape of the building is founded.
Thus far my remarks apply to all building design, but this development of a services system has further implications when related to educational buildings. There is a need for flexibility in the design or perhaps a more descriptive word would be 'convertability'. The point is that many educational buildings, particularly those in universities, are subjected to several changes of use over the years, and can be taken over by totally different departments of study, each of which will have its own requirements for services.
In addition, teaching methods change and more advanced forms of educational aids can make big demands on the versatility of the services already installed. Education and research are not static and cannot be tied to a rigid structure. It is necessary to provide the convertability which the services philosophy can supply to enable these changes to be made in the future with a minimum of cost and distribution to other parts of the building.
Various methods of providing versatility of services have been developed. False ceilings and floors can be used but in many cases these are too expensive. An alternative approach is to design the structural elements in such a way that service ways are created naturally by the form of the various floor beams, columns, slabs, etc., without the need for false floors. This, once again, calls for close co-operation between the members of the design team in the early stages.
This services philosophy can also be helpful in another aspect of building design. The electrical installation is the subject of a sub-contract and the requirements have to be detailed in a specification and its accompanying drawings. These documents have to be prepared in time for a tender to be received for incorporation in the main contract for the building. The drawings are based on the architect's plans, and as these are not finalized until very late in the design process, the time allowed for preparation of the scheme is often inadequate.
If, however, it is known that routes are available throughout the building, the scheme can be developed earlier, leaving only the finalized layout drawings to be completed at the last moment.
The same applies where changes in design are made while building is in progress. Too many cases occur today where a pipe or cable has to be run on the surface owing to a change in building design after the original services scheme was prepared. With built-in service ways this is avoided.
To proceed then, the services system has to be designed to cope with all the normal requirements, but it is still necessary to ensure that the brief does not include any special services, such as full air-conditioning, which requires large air ducts. These can easily fill up service ways that are otherwise quite adequate.
While I have stressed the need for convertability it is economically impossible to provide for every eventuality throughout the building, and careful thought must be given to the location of equipment requiring heavy servicing.
Specialist requirements are a feature of educational buildings, particularly university laboratories. The variety of services is very wide and on the electrical side alone can include single and three phase outlets, stabilized supplies, low voltage and D. C. services, facilities for power and high frequency cabling between laboratories, closed circuit television and other intercommunications equipment, all in addition to the normal power and lighting circuits. Provided, however, that the services system has been adequately developed, all these items together with the mechanical services can be accommodated.

DETAILING OF SERVICES
This then leads to another point. Having developed the services philosophy it is important that economic use is made of the space provided. There is a temptation to assume that the pipe that you are designing at the moment is the only one going into a particular section of duct. It is important that details of the runs of all the various services are co-ordinated and to ensure that the first pipe run in the duct does not prohibit its use by anyone else.
The traditional services drawings are all diagrammatic and while this is sometimes satisfactory, more detailing must be provided in heavily serviced areas if trouble on site is to be avoided. It becomes necessary to detail conduit and trunking runs and show elevations including structural and architectural items where these affect the services runs.
This is one of the points in which the present training system is found to be lacking. Detailing of conduit requires a far more intimate knowledge of its characteristics than is normally provided in training and to ensure true integration, various services, structural and architectural details, often have to be included on the same drawing. As I have said, present services drawings are largely schematic and the co-ordinating draughtsman has to interpret these to show precise outlines of pipe bends, flanges, valves and the like. Unless he has had suitable training, he has to check every item of suspension details, spacings, type of lagging and so on.
It is true that with a group practice the specialist designer is readily available, but it is the time factor which is important. I have found that if a drawing of this type is on the board too long, the design suffers.
The preparation of these drawings, however, is only half the battle. The next stage is to make sure that the various sub-contractors on site use them. One is up against traditional methods of building and this includes traditional methods of receiving information. The electricians or pipe fitters on site are often frightened by a whole sheaf of drawings and have to be encouraged to use them and appreciate their value. It is not only the services sub-contractors, however. I know of one case where the architect went to a great deal of trouble in detailing a tiled wall to ensure that flush-type electrical outlets and taps would be positioned centrally within a tile and accurate dimensions were given on the detail drawings. Unfortunately, on site, although the services sub-contractors did their work correctly, the tiler started in an opposite corner and all the work was of no avail!

ILLUSTRATIONS
The illustrations show the services philosophy developed for two university buildings. The first, for the Department of Mining and Metallurgy at Birmingham University has been handed over to the client and is in use. Figs. 1 and 2 show the vertical and horizontal service ways created by the structure. The building was conceived on a low cost basis coupled with speed of erection and services flexibility. It was therefore designed as a precast floor slab unit supported on precast columns in a modular form making a series of four three-storey cubes joined at adjacent corners. The column assemblies consist of four sub-columns which form the corners of the vertical ducts

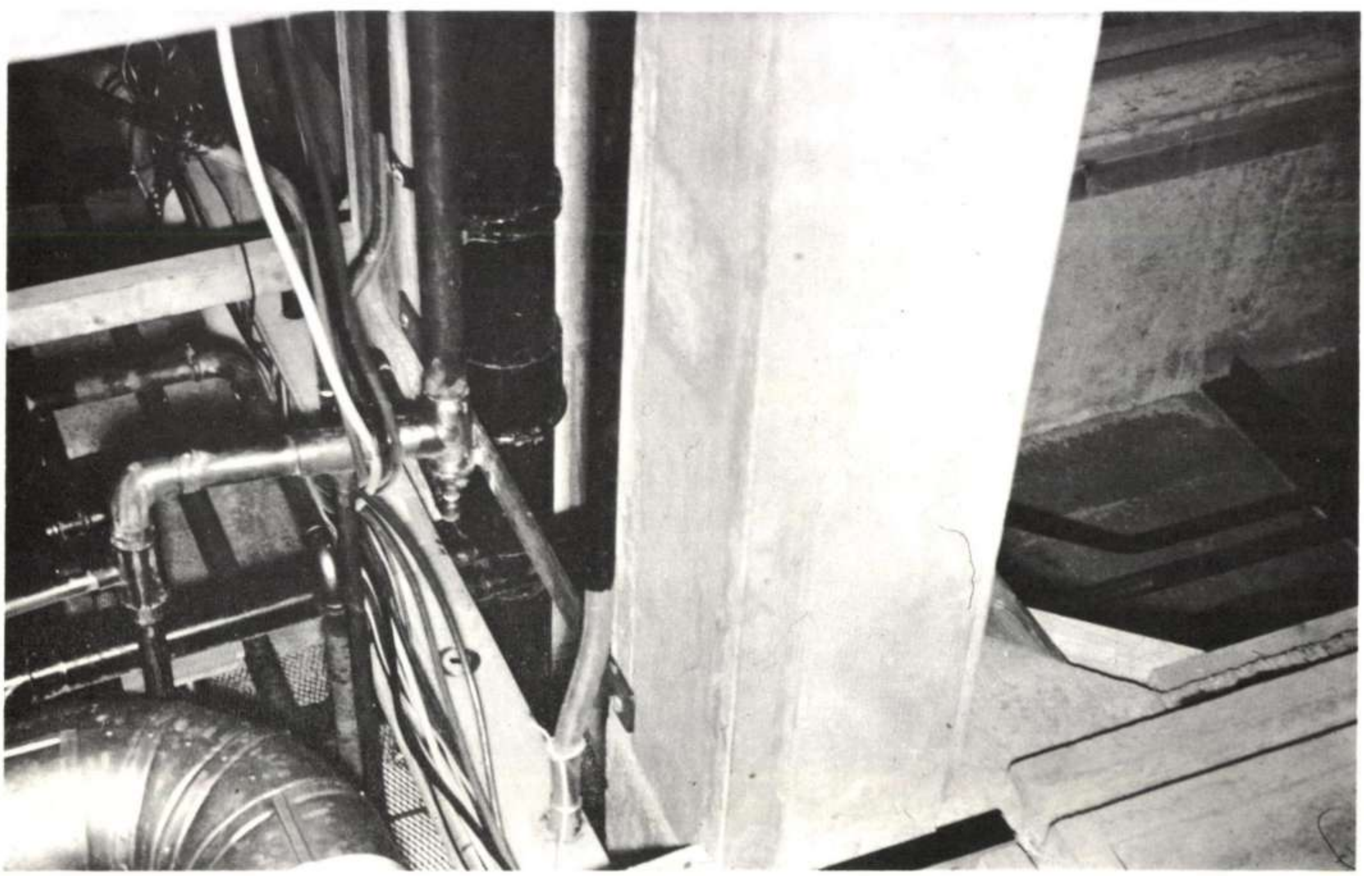


in each assembly. The floor slabs which are approximately 21 ft square and weigh 16 tons each were cast on site. They have a hole at each corner and this locates over one of the sub-columns. Adjacent floor slabs are thus one column width apart and this space forms the horizontal ducts within the 2 ft depth of the slabs.
The second building design is for the proposed University of Loughborough and is shown on fig. 3. Analysis of the brief indicated that large column-free floor areas of the order of 50 ft in each direction were desirable. This planning requirement necessitated a deep structure and this coincided with the need for complete services flexibility. The depth of each floor framework is therefore allocated for use of the various services generally as shown in fig. 4.

GENERAL REQUIREMENTS
I would now like to describe the general range of services provided and some of the more specialist items that have been, or are being, provided in various buildings. Some of the problems involved are also mentioned.
The main need for electrical services in laboratories is for a large number of single-phase outlets at close centres. For example, in one case a 13-amp outlet is provided at 3 ft spacing along the benches and walls and in others twin outlets are provided every 4 ft or even every 2 ft 6 in. The need is for quantity of outlets and not for total power. Many experiments require the connection of several instruments, heaters, etc., and the all too common practice of using several surface-type sockets mounted on a loose piece of wood and connected by a flex to the only available socket must be discouraged by the provision of adequate permanent outlet. A very large diversity factor is permissible and the average load is seldom more than 100 watts per outlet.
A three-phase supply and bulk single-phase point of 30 or perhaps 60 amperes is usually provided in each

Fig. 1 above
Birmingham University
Construction in progress showing services ducts within columns and between floor slabs

Fig. 2 below
Birmingham University
Duct intersection at head of column showing various services



laboratory as standard. Three-phase outlets should include a neutral conductor, because even though this may not be required for motors or their starters, auxiliary control circuits are frequently designed for single-phase working. The need for D. C. seems to be diminishing and with the advent of the compact solid state rectifiers the policy is to provide local units rather than a centralized system with a lot of D. C. wiring.
The use of wiring trunking wherever possible is most desirable and this is really an extension of the services philosophy mentioned earlier. The trunking with socket outlets can often be incorporated on a service rail together with compressed air, gas and water services as necessary.

An important point here, however, is in the design of the trunking itself. In many types the sockets are mounted on the covers and when modifications or additions are required, it is often necessary to remove existing sockets to enable the cover to be released or sometimes to expose the line parts at the back of sockets where these are removed with the cover. These problems are overcome by the use of a two-compartment trunking with a separate lid for the wiring duct. Provided adequate standardization of spacing is achieved, the trunking can be produced at an economic price.
As mentioned, electrical outlets often share a service rail with other services. Generally speaking, the electrical

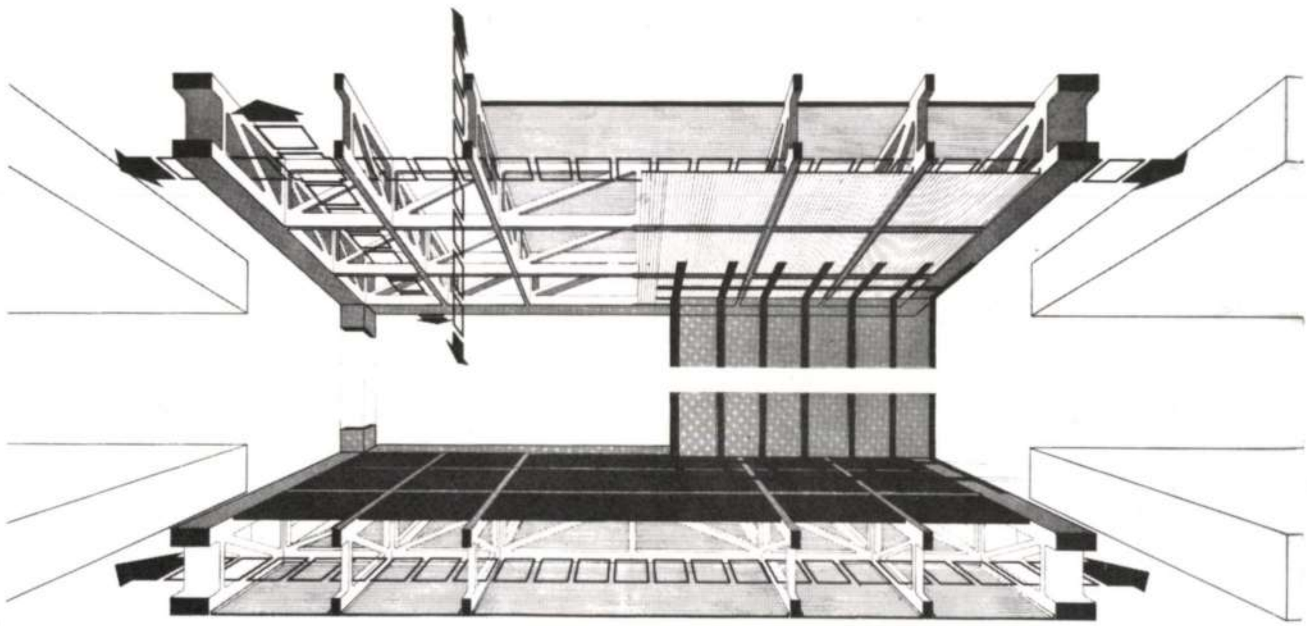
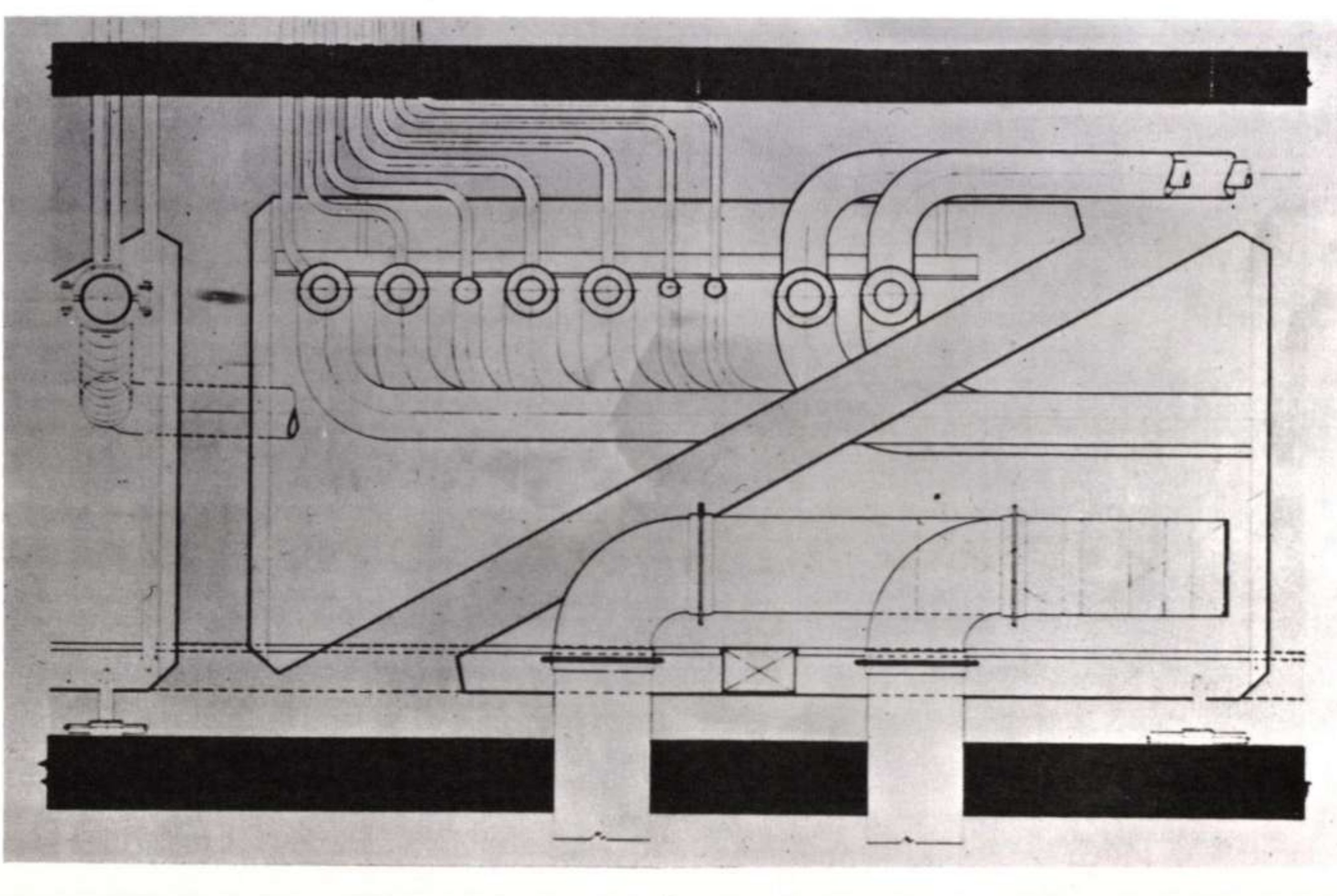


Fig. 3 above
Proposed University of Loughborough
Section through space unit showing services routes and partition grid in relation to structure

Fig. 4 below
Proposed University of Loughborough
Allocation of services space



equipment should be at the top of the rail, but where necessary compressed air and gas pipes can be run above. Water services, however, must always be below the electrical outlets to minimize danger from leaking pipes. Cooling water is sometimes required to remove heat from experimental rigs and a piped system can be run throughout the laboratory areas fed by a central cooling plant. Control circuits can become very involved, particularly if chilled water is used and full consideration of the requirements should be given in the early stages of design to ensure that adequate thermostats, control valves and interlocks are included.
The greatest advances in equipment installed in educational buildings are probably in the field of communications. At one time communications consisted solely of telephone equipment, with perhaps a few permanent type temporary power wires strung between laboratories. Modern requirements call for more sophisticated arrangements including loudspeaking intercoms, audible alarms, personal call systems, closed-circuit television and signals wiring between various parts of the building. In many of these cases it is impossible to design the actual wiring in the early stages of the development and it is necessary to provide adequate routes for the wires whether these be conduits, trunking or cable trays.

OXFORD UNIVERSITY.
DEPARTMENT OF NUCLEAR PHYSICS

Now to describe one or two installations in more detail - the new laboratories of the Department of Nuclear Physics at Oxford University are equipped to enable studies to be made of the structure of atoms and more particularly of the nucleus.
The studies are divided into two main groups, nuclear structure and high energy physics and the main item of equipment is a two-part electrostatic generator. Beams of particles with energies up to 20 MeV are required to study reactions in the heavier nuclei and these are obtained by operating the two parts of the generator in tandem. Each part, however, can be used independently for studies of the lighter atoms. The high energy physics group requires beams of far greater energy in range of tens of thousands of MeV and use is therefore made of the machines at the Rutherford Laboratory at Harwell and at CERN in Switzerland. Preparation of the experiments and analysis of the results are carried out at Oxford.
In the laboratories a large amount of electronic equipment has been installed by the Department and provision for signals cables was made throughout the basement areas where the target and control rooms are located and where also one of the parts of the generator is housed. Wiring trays are run in a system of floor trenches and in addition trunking was provided at high level round the walls. It has been found that the trays in the trenches are well used but the high level trunking is not so useful for experimental cabling although more permanent types of wiring to radiation warning signs and gate locks have been accommodated.
A loud speaking intercom system has been provided to enable the central control room to contact experimenters in other parts of the building. The system is in two parts, each comprising a master unit and up to six slaves. There are twenty-one connection points throughout the building for the slave units and those required are selected on a plug board in the control room. Wiring for closed circuit television is also installed, terminating on the same connection points as the intercom.
A system of permanent signal wiring was provided between the target rooms and the control room to enable signals from materials under test to be received in the control room and amplified, measured or counted as necessary. The system had to be flexible and allow for various experiments to be set up simultaneously in various parts of the target rooms. The design evolved uses a loom of 18 cables laced together, suspended from trolleys running in tracks on the ceiling. The cables terminate on standard suspended boxes also trolley-mounted in the target rooms.
The second phase of Nuclear Physics, now under construction, incorporates further facilities for experimental electronic cabling between the laboratories on the second and third floors and down to the existing trays in the basement. The trays on the upper floors are of timber detailed into the corridor cupboard partition units, so that wires from any laboratory can be fed on to the tray along the corridor and into another laboratory or alternatively down the vertical services duct to the basement as required.
Normal intercommunication throughout the building is provided by a General Post Office telephone exchange of the PABX 4 type. This type of equipment requires a minimum of work by the operator and is, in fact, most suitable where the majority of outgoing calls are obtained by the extensions themselves. University personnel are not tied to desk positions and it is therefore necessary to provide means to locate people throughout the building. This is achieved by means of a personal call system using a loop aerial and small receivers each tuned to a different frequency signal. The control equipment is located at the telephone operator's position. One interesting problem that has occurred in this building, which is also of wider concern, is that of voltage stability. The equipment used in modern laboratories is very varied and some is extremely sensitive. The voltage stability of the electricity mains is very often taken for granted but when intricate electronic counting equipment is installed, voltage fluctuations of 2% can be troublesome. The provision of a centralized voltage stabilizer is usually uneconomic and it is far more realistic to provide individual stabilizers on the more sensitive instruments themselves. Nevertheless, quite large and sudden voltage swings of 5% or more can occur on the mains and these are often beyond the limits of the stabilizing equipment. Swings of 1 to $1\frac{1}{2}$% are quite normal, for example, the automatic tap chargers on the high voltage system operate on steps such as these but it has been known for control engineers to operate manual tap chargers three or four steps almost instantaneously and this plays havoc with the electronic counters.
Lifts can also cause voltage dips on the system, but the effect can be minimized by providing an entirely separate feed to the lift from the main switchboard. Nevertheless, the need for special forms of lift control should be considered at the outset if delicate measuring instruments are to be used.

CAMBRIDGE UNIVERSITY.
NEW MUSEUMS SITE

This question of delicate measurements has also raised another problem, this time at the new laboratory buildings for the Department of Zoology at Cambridge University. There, research is to be carried out on the minutest parts of cellular life, involving the detection and measurement of micro-voltages. It is not perhaps realised that the magnetic field created by the normal power and lighting installations in a building is quite substantial and when related to the measurement of these small voltages can be overwhelming. Special precautions have had therefore, to be taken to minimize the magnetic field by always running lead and return wires in the same conduit and lacing pairs of wires in trunking. Rings of wiring have to be avoided, although the standard ring main scheme is permissible provided that no area is enclosed by the ring. Fluorescent lighting is particularly difficult because of the chokes and special low loss units have to be used. In one case the electrostatic field created by the installation is also to be kept to a minimum and while this is normally very low for a conduit scheme, special attention has to be given to the switch plates and socket outlet plates to ensure as complete a metal shroud as possible. Lighting fittings both tungsten and fluorescent, also have to be screened by use of wired glass or the like. The building on the New Museums Site is to house a

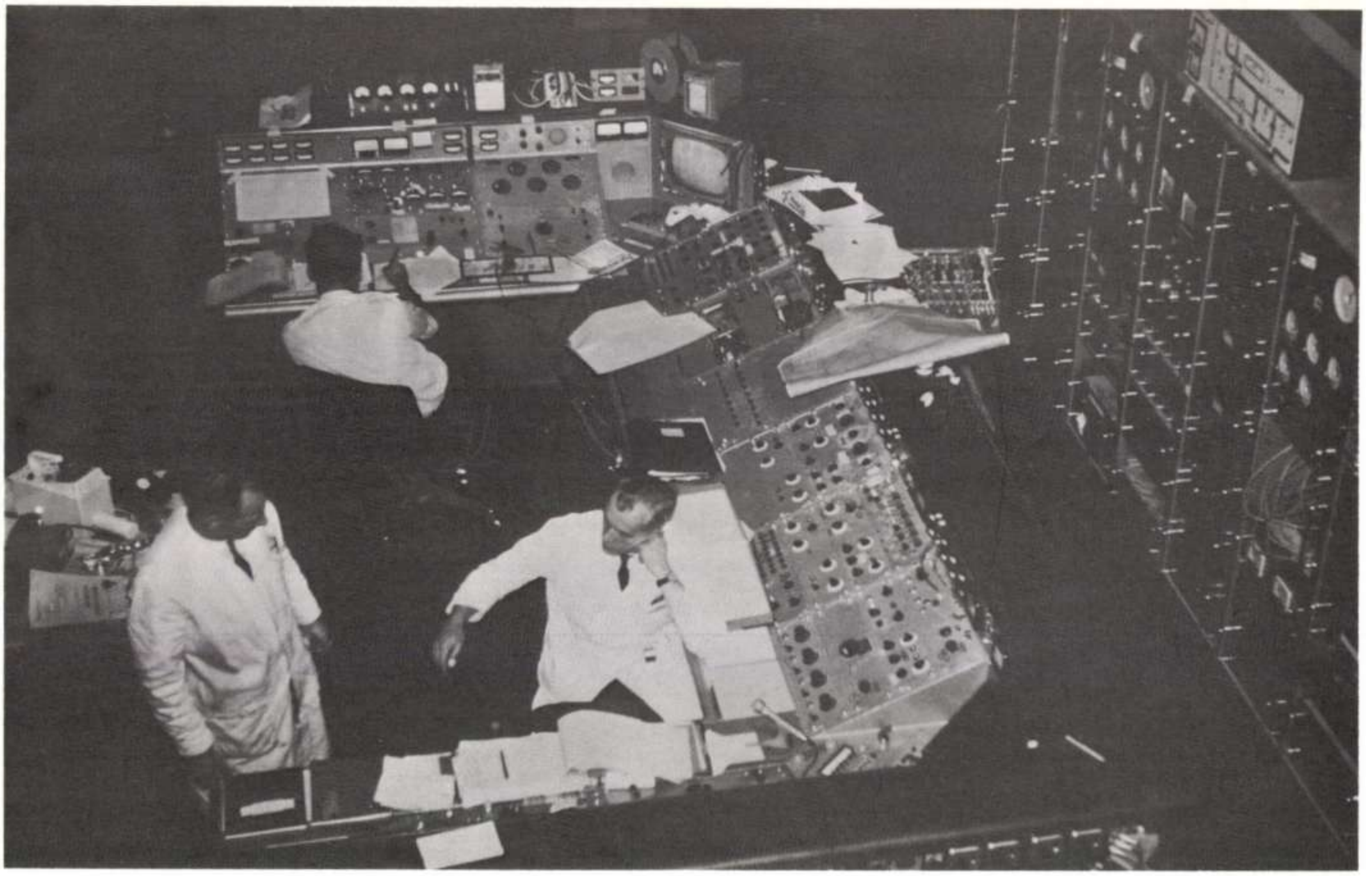
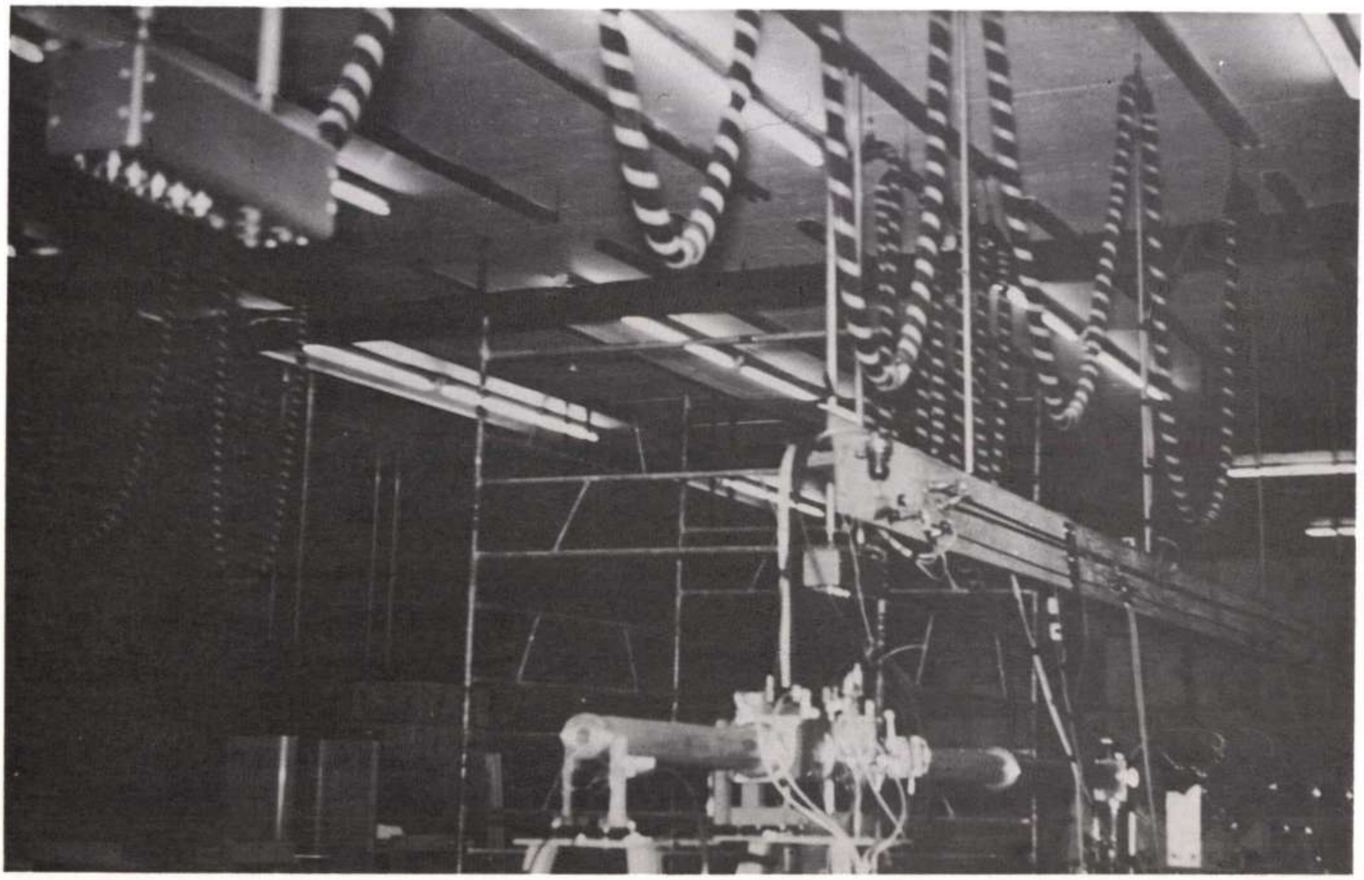


Fig. 5 above
Oxford University, Department of Nuclear Physics
General view of control room

Fig. 6 below
Oxford University, Department of Nuclear Physics
General view of target room showing signal cables



museum for the exhibition of zoological specimens ranging from animal skeletons to insects and will be shared with two other departments, Metallurgy and the Mathematical Laboratory. The usual bench services will be provided in Metallurgy together with fume cupboards. A process area will house the fatigue testing machines, furnaces and the workshop. Further special precautions against external interference are required for the electron microscope and the field ion microscopes.
The Mathematical Laboratory will accommodate a modified Atlas II computer and provision is made for another computer of similar size. Special services for the computers include full air conditioning, chilled water circulation and once again, wiring trays for inter-connecting signals wiring. The computer itself provides all the power supplies required from a standard three-phase and neutral input. The computer is very complex and every second of operating time is valuable. To avoid interruptions to the programmes caused by fluctuations on the mains, motor alternater sets are installed to supply interference-free power to the computer racks. The fly-wheel effect of the machines is sufficient to iron out voltage dips and surges on the public supply.
There will be routes from the wiring trays under the computer floor to every other room in the laboratory to enable teleprinters and the like to be set up in remote positions. Routes to the G. P. O. main distribution frame are also planned so that the computer can work direct from an external source.
The whole of the lower half of one end of this building will house a 500-seat lecture theatre. Lecture theatres create a particularly difficult design problem, mainly for the architect but also for the services engineers. The equipment now available for use in a lecture theatre is very varied and each item of equipment seems to require a different position or angle of screen, a different viewing angle and different lighting. The introduction of closed-circuit television has aggravated the problem because large-screen projection of television pictures is unsatisfactory technically, and the provision of a large number of screens suspended throughout the theatre is unsatisfactory architecturally. The use of this medium, however, will increase, and this is a problem to be solved.

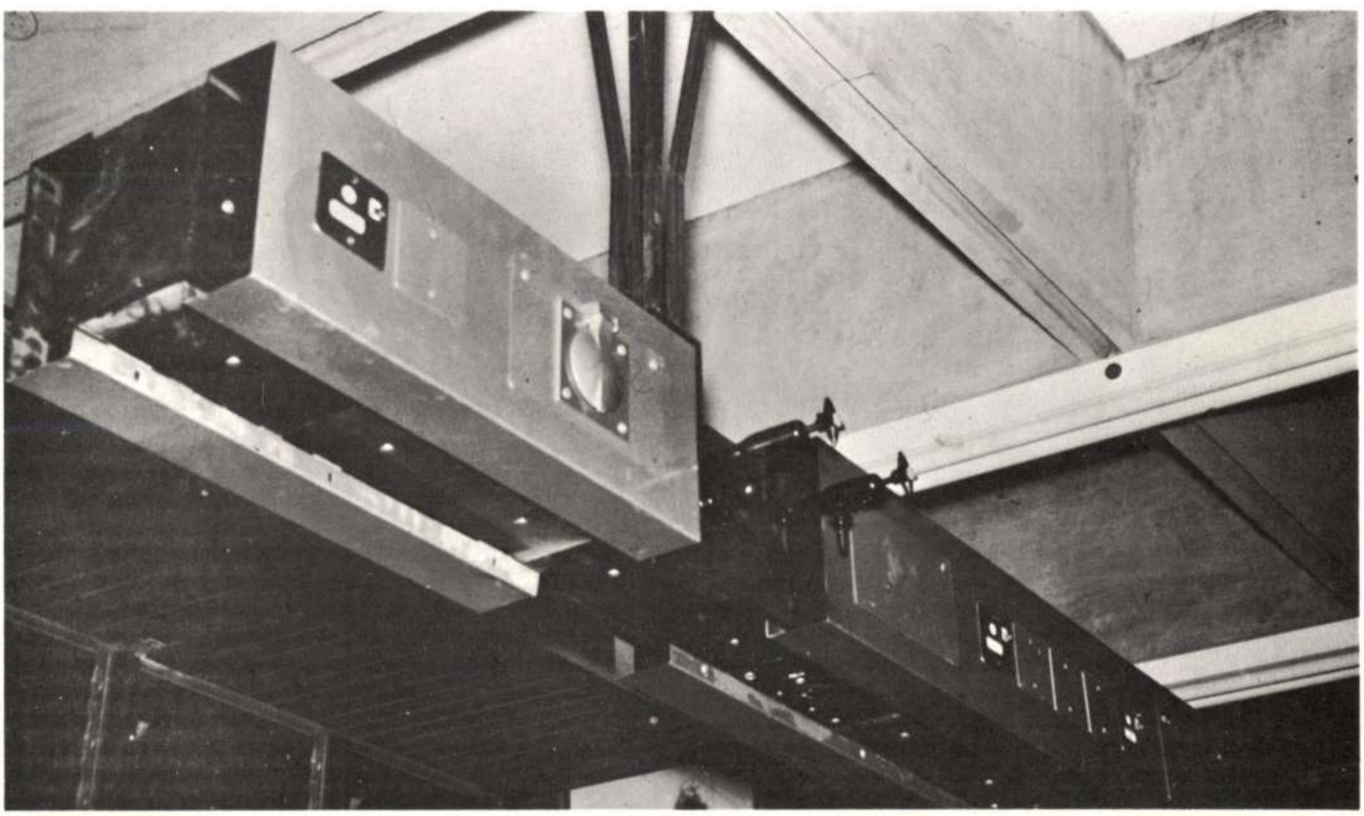
BIRMINGHAM UNIVERSITY.
DEPARTMENT OF MINING AND METALLURGY

The new building for the Departments of Mining and Metallurgy is the first of those incorporating a services philosophy. Many lessons have been learned which are being incorporated in the later designs - for example the need to provide a route to every part of the floor slab and also the careful design required at duct junctions to avoid a throttling effect.
The services provided are similar to those already described but one or two special features are worth noting.
A system of trunking runs in the ducts around each floor feeding out to service rails, bench units, booms and lighting points. Island benches are fed by services laid in the screed. The vertical ducts are used extensively for services to benches, ventilation and fume cupboard extracts and drainage. Fan heaters are also housed in some of the vertical ducts.
The fluorescent lighting fittings used in the laboratories are specially designed to fit on to the ribs of the coffers and the wiring to these is run in a small trunking fitted into a slot cast into the underside of each rib.
Services booms are provided in the large laboratories to give gas, cold water, compressed air and AC and DC supplies to the centre of the rooms.

SUMMARY

With the increasing complexity of building, it is necessary to provide a design team working in much closer collaboration than has been the practice up to now. Attempts to set up such teams have shown the need for a reappraisal of the training schemes. It is also desirable to change and augment the method of presenting information to the contractors on site but this cannot be done too quickly. Services in educational buildings are very varied and subject to alteration and extension because of changes in educational procedures. It is therefore desirable to develop a services philosophy for laboratory buildings to make services routes and requirements as independent as possible of structural and architectural planning.

Fig. 7
Birmingham University. Services boom



The architect's approach to architecture*

P. M. Dowson

We have been asked to make these talks personal so I hope you will appreciate that this is a very exposed position to find oneself in.
To express oneself clearly on one's own approach to architecture is, of course, a very difficult thing to do. One's motives are too often, I suspect, not what one might like to think they are and with the best intentions, get post-rationalized. However, talk as one may, the first slide+ of the first building will always let the cat out of the bag. So as I have framed my talk this evening largely on slides+, there will be no escape.
Hugh Morris, a fortnight ago, in his lecture was speculating on the reason he was asked to speak and suggested that it was because of his social attitude towards architecture. I have been speculating as well, and assume that it's on account of my relationship with a group practice that I have been picked, so before turning to the main subjects of the lecture I want to enlarge a little on this aspect and also fill in a certain amount of background as to how and why I find myself working as I do.
I started my architectural education late, at the end of the War but it had given to me, as to many of my generation, a time for reappraisal. It was a confused time of both idealism and disenchantment. It saw the beginnings of the LCC housing drive and the Hertfordshire schools programme and the advanced exercises in prefabrication of Bruce Martin. His Boreham Wood school I remember as a real landmark in this field.
It is often said that an architectural student spends the rest of his life trying to build his thesis - as a consequence I have been looking back at mine. It was written basically on The Problem of Permanence, with work on prefabrication systems and structure with a capital S. It all now sounds terribly pretentious and clearly was but certainly most of us, I think, at the time, felt that the really urgent question was how to reconcile the demands of industrialized methods with those of an environment worth living in - how, in fact, to provide for mass needs without these being crushed by the very measures designed to meet them.
This period and the events of this period, I think, largely cast my whole future approach to architecture. In retrospect it was an exciting moment. We felt we were being faced with unique opportunities where the basic problems of architecture were peculiarly relevant because they were so urgently matched by the need. We were being confronted by new social problems in a context which was completely changed. My generation, as J. M. Richards has pointed out, was indeed very fortunate in having more than any preceding one, the great opportunity to practise what the visionary architects of this century had preached.
Previous speakers in this series have talked of buildings that have influenced them. When I think about this myself, I find 'how' and 'why' difficult to assess and I am reminded of Gropius's remark as a child that his favourite colour was many colours. But certain buildings once seen, are with one for life and inevitably become built in to one's vision and experience of architecture.
At random, I immediately think of the extraordinary achievement of the builders of the early Christian era who, using space as an idea and light as a material, could communicate so powerfully their sense of mysticism, giving visible shape to a spiritual aspiration. Or I remember, having spent the morning being shown round la Tourette by the monk who worked as client closely with Le Corbusier - how moved I was by the feeling of weight his building lent to this community's intention.
I remember the excitement of seeing for the first time the plans and photographs of the Barcelona pavilion, or for that matter, the first time I saw the Campidoglio buildings of Michelangelo in Rome. I always feel sure that Michelangelo would have loved precast concrete and he would certainly have done the most marvellous things with it. Then of course, there is architecture as an organism - whole places, towns or villages, where a vernacular architecture evolved systems that were sufficiently flexible and humane to make it quite difficult for others to make a mess of them.
At base though, architecture remains about people. That is why a house is both so fascinating and so difficult to design - a kind of controlled experiment, a laboratory where we can be closest to our main subject - people. Ultimately - how, given a site, can we help enrich the lives of those who are going to make it their home? How can a vital relationship be established between 'the way of life' and the environment, which is at the heart of it all? Certainly we must analyse as clearly and logically as we can but we must also cultivate an acute response to the subjective human need. There is always this tension that exists between the balance and resolution of apparent opposites, beyond the reach of analysis, within the field of the intuitive. So much of what we want, we can't really define at all but can only recognise.
On leaving the AA I joined Arups and this was the beginning of a second education. To know Arup is to be powerfully influenced, as anyone who knows him well will confirm and as many now from successive architectural generations have learned.
I first worked there on the design of a prefabricated timber system for small schools and then almost immediately became involved in the design of a factory. The first job any of us does of any size, is, for the most of us, I suspect, a harrowing experience. It certainly taught me early that a building is no 'commodity' but a very complex operation, which will go flat on you if there is the least relaxation - a relentless, tenacious business to the bitter end.
Looking back on this job now, I realise that we had almost every situation in the book thrown at us. I particularly remember the very good site agent being sacked on Friday, being hired over the weekend by the client and arriving on Monday morning as clerk of works, which had, as you might expect, some interesting repercussions.
In 1958 I was asked to design some new buildings for Somerville College and so I then had to decide whether or not to go into private practice. During these years at Arups a valuable working relationship had begun to evolve between a few of us and I realised that I wanted to continue to work in this way. For some time I had also had the growing conviction that the whole question, of the nature of design and of the architect's part in this had to be reconsidered, because of the sheer complexity of modern buildings.
Those who have been members of a mixed professional group will know how exciting it can be, if a common identity of purpose exists. With the breakdown of traditional frontiers between the professions there can be a surprising release of enthusiasm, particularly among those who traditionally have the less interesting jobs and understandably, feel sometimes that their task is perhaps more that of a salvage expert than of a designer or consultant. This is no panacea however and it has plenty of its own problems. There must be a continuous intellectual hurly-burly and while the designers on the one hand must be emotionally involved, on the other they must not be possessive of their own ideas - this is a polygamous notion perhaps - which some understandably,

* Talk given at R. I. B. A., 1 February, 1966.
\+ Editorial note: slides are replaced by photographs.

find impossible. The problem of course, is to co-ordinate and intensify the efforts of people with completely different skills, trainings and backgrounds to try and achieve a fusion of ideas.

Group practice is not design by committee, nor does it absolve the architect from his unique responsibilities for providing the clothing of our society. Rather, I believe, it is one viable way of assisting him.

There are, of course, others, and I don't want this to sound too much like a plug for group practice.

It takes time to build this kind of group - ten years in our case - and like many growths it was haphazard. From a nucleus of architects and engineers we engaged our own quantity surveyors. Service engineers joined us because we had such little success in getting the type of detailed drawings we wanted and that I believe integrated services demand.

Our clients rightly expect high technical competence and this is what we, as architects, are, I believe, at present, least able to ensure. In many buildings the mechanical and electrical services already form the largest proportion of the cost and they are becoming, of course, more and more of a headache.

Finally, I must emphasize that the buildings illustrating this talk represent the efforts and contributions of many people working together in mixed professional groups. The schemes I'm going to talk about fall broadly into three main categories - industrial, residential and general university work. I am discussing them in general terms under these main headings to illustrate the approach behind their design. I am starting with industrial buildings. They were the first I was involved with.

INDUSTRIAL

Industrial buildings are, by and large, 'serviced envelopes' and to follow this generalization with another, the ideal in England from a technical point of view, is a single-storey steel shed serviced and lit from the roof and of infinite span. Working back from there, there are of course a host of problems that we all know about - problems of expansion, economy, flexibility, construction, servicing, maintenance and the rest of it.

In the buildings that I am illustrating, the structure has been thought of mainly as support for the services, providing for the maximum economic flexibility and ease of maintenance and finally considered as a support for a lightweight roof membrane. Walls are brick or glass screens, depending on their function.

Fig.1
CIBA (ARL) Ltd., Duxford. Maintenance Block

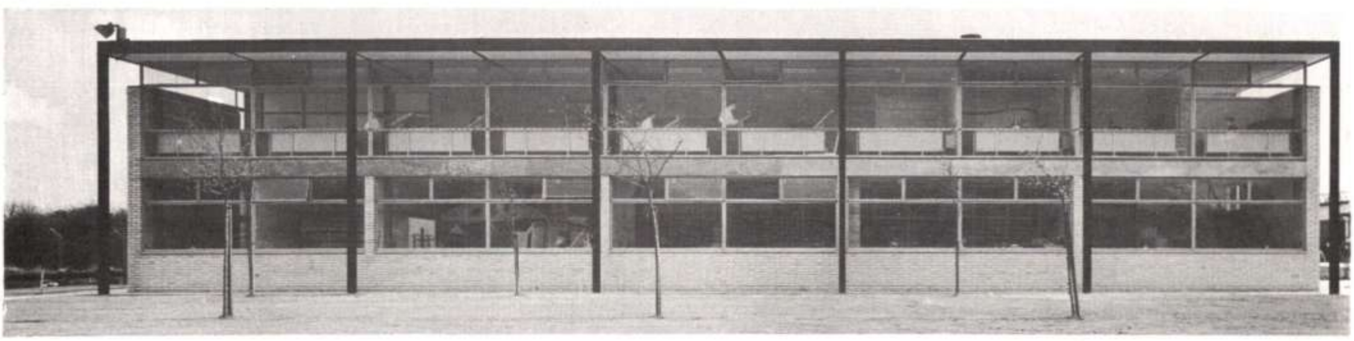
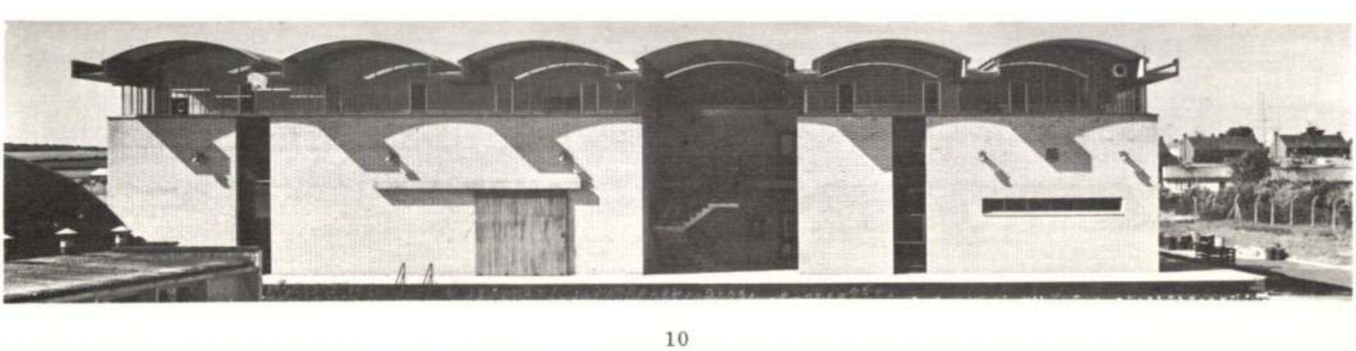


Fig.2
VIK Supplies Ltd. Photo: C.Westwood

Fig.3
CIBA (ARL) Ltd., Duxford Multi-purpose building. Photo: C.Westwood



RESIDENTIAL

I am turning now to the residential examples - first, a block of flats at Bracknell, then a graduate building for Corpus, Leckhampton, and finally a small house in Suffolk. Although varying from a large building on the one hand to a small house on the other, they have much in common in their use of space and in the way they establish a relationship between the small and the large scale - between the man-made and the natural - and it is this aspect particularly that I want to discuss in relation to these examples.

Bracknell is a point block with 17 storeys and 102 flats with all services, cars, etc. below the entrance level, leaving the building standing cleanly on its green.

Leckhampton houses a graduate community in two pavilions related to each other and to their garden. When moving about this building one is constantly made aware of this dual relationship and the repetition of identical elements creates a discipline around which many other threads are woven - but I will come back to that later.

In both buildings we wanted to create at once a sense of enclosure and release, a sense of location and generosity and to avoid the feeling of isolation which a room in a high building will often produce in people. One can lie in bed in the Bracknell tower and look straight down on the Berkshire countryside without any sense of exposure.

LECKHAMPTON

Turning now to the graduate building for Corpus, Leckhampton in Cambridge - here we developed some of the same ideas used at Bracknell. We again tried to create in the rooms at once a sense of location and generosity, a sense of enclosure and release. At Leckhampton on sunny days the sliding windows can be opened and the whole room can become a balcony - a small space but a part of a larger one that nevertheless still is itself defined. People living both in Bracknell and in Corpus have, quite unprompted, made comments on this aspect as something which gives them real pleasure. The origins of Bracknell and Corpus are Somerville, designed eight years ago and which will be finished last. The second stage is to be completed this summer.

SMALL HOUSE IN SUFFOLK

The other day Hugh Morris talked most eloquently about the design of a whole new town and a new university - but I believe I detected a special warmth that crept into his voice when he described a little house of his. Architects will talk

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Fig.4
The block (Point Royal, Bracknell) stands cleanly on its green with a ha-ha between the deck and landscape
Photo: C.Westwood

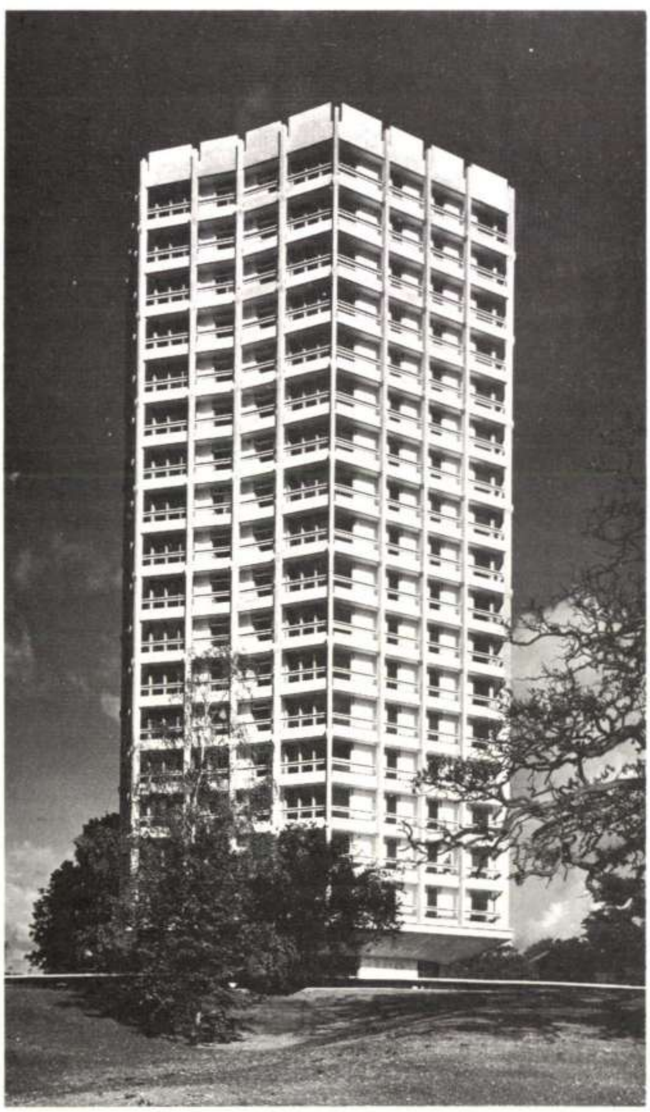
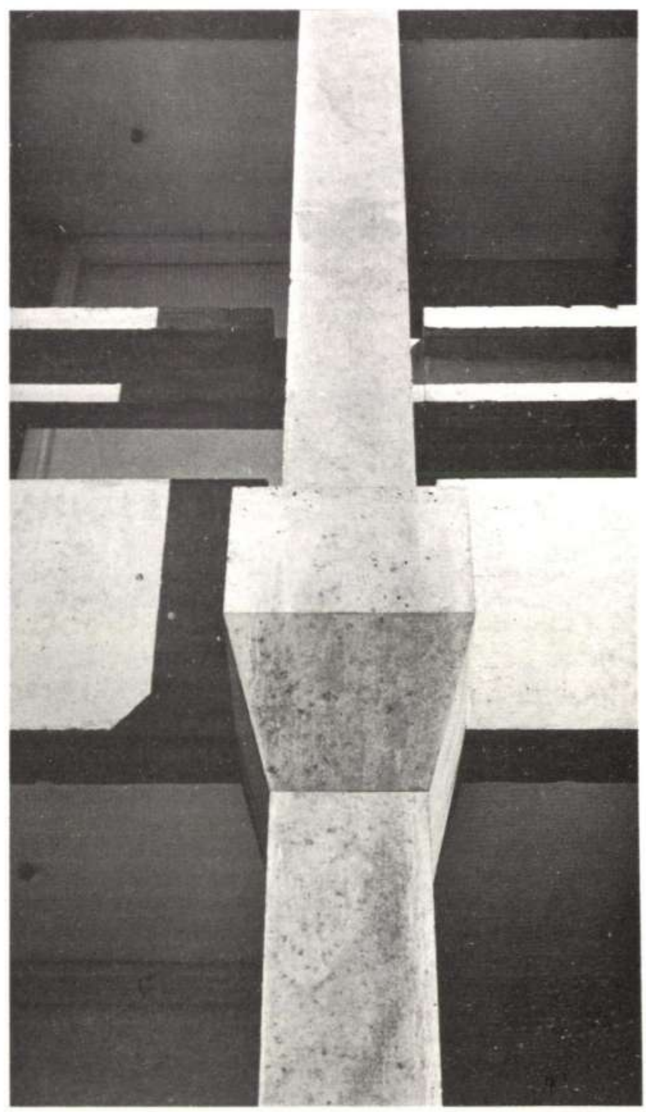


Fig.5 displayed on back cover
Point Royal, Bracknell. The deck showing relationship with ground
Photo: H.Sowden

Fig.6
Point Royal, Bracknell.
Precast column detail of frame designed for weathering
Photo: C.Westwood



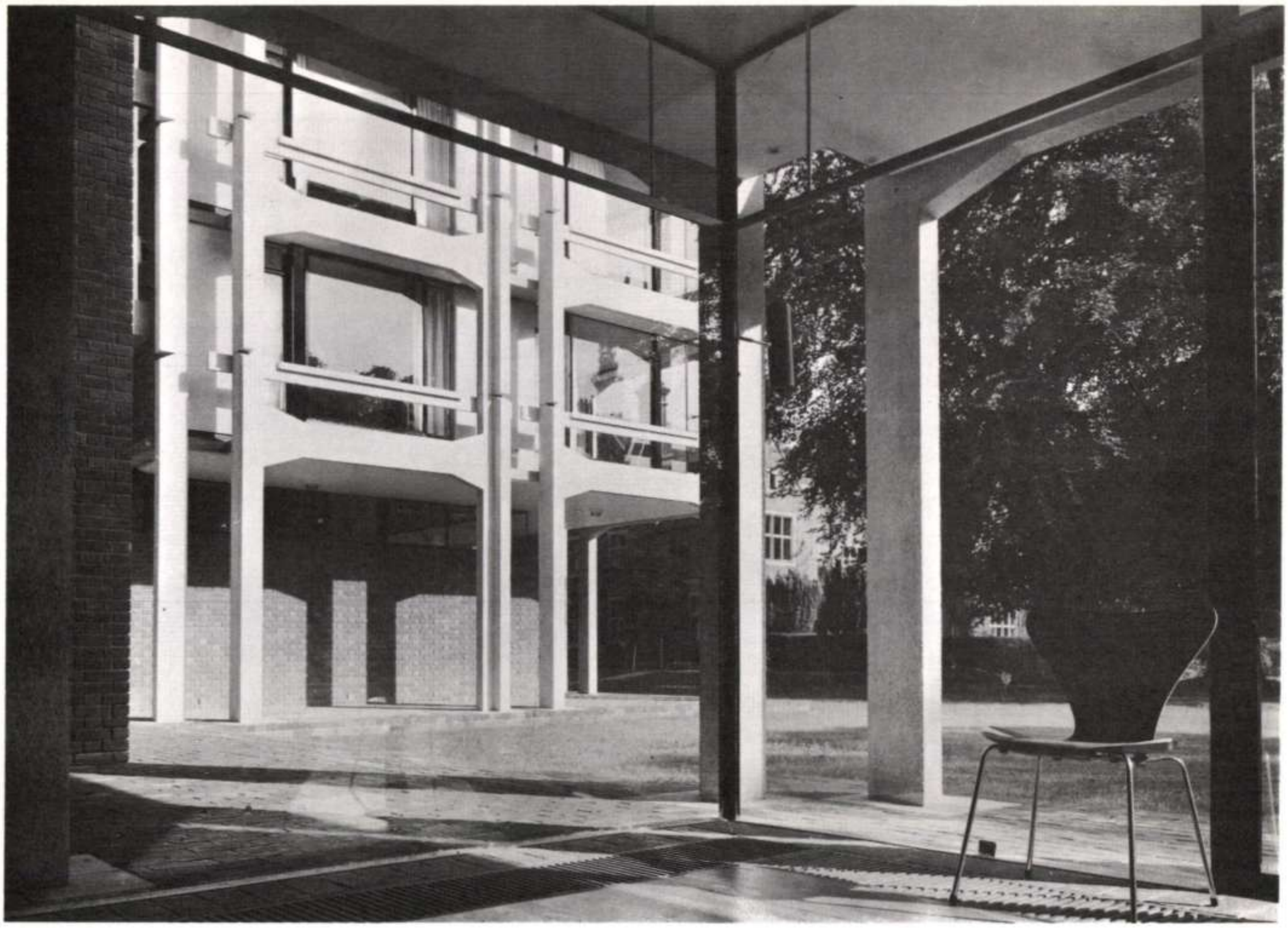
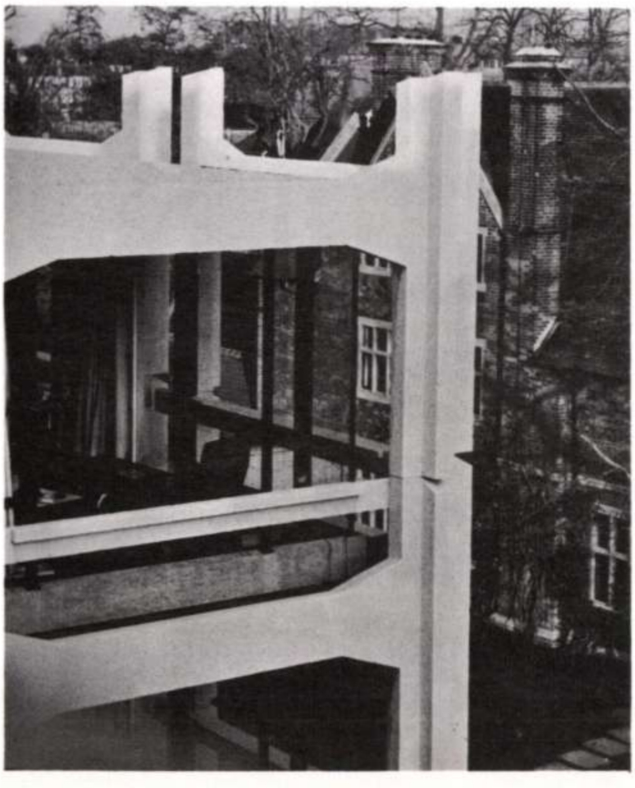


Fig. 7
Leckhampton. A close relationship with the garden is established by a continuously changing relation of the internal and external spaces because of parallax
Photo: E. Leigh

Fig. 8
Leckhampton. Relationship of a room to the garden spaces
Photo: H. Sowden

Fig. 9
Leckhampton. Interior of room looking out. 'Enclosure and release'
Photo: H. Sowden



about huge schemes but ultimately what most of them really love, I suspect, is a small house.

It has been said that all architectural students on qualification should be given a sum of money and a site and made to design a house for themselves which they then have to live in for a time. It might be argued that in the long term, this could prove to be a very efficient use of limited resources.

I am turning now to a small house in Suffolk. The site was an exposed one and sloped gently to the west with a view for about three miles. I wanted to establish a relationship between the hearth and the horizon and the spaces develop, each with their own function and influence, in graduated steps between these extremes. The instinctive place of rest, however, is at the point of equilibrium and in this case it is the hearth.

CONSTRUCTION AND STRUCTURE

Before turning to university buildings which reflect more closely our present thoughts, and where we are using more advanced construction techniques, I want to comment on construction and structure generally because they have been the subject of so much misleading discussion.

For me, the expression of structure or construction is not an end in itself, but a consequence. Buildings are nevertheless constructed things - they are not made of cheese or Pete Seeger's Ticky Tacky - and the way they are made, I believe, should be implicit in the result. I am talking now of construction rather than structure - if you like, structure plus the human element.

Any architectural expression, either of construction, circulation or of anything else, will be a consequence and not an end, if the design is to be a balanced reflection of the real relationship making up the pattern of the problem. It is easy enough to distort these problems - to take one aspect and exaggerate it - and then magnify these distortions to create interesting but irrelevant images.

I want always to know, or rather perhaps to hope, that a building when complete, could be cut in halves and its whole anatomy laid open, to reveal a consistency between the main aspects and the smallest detail, between the idea and the execution.

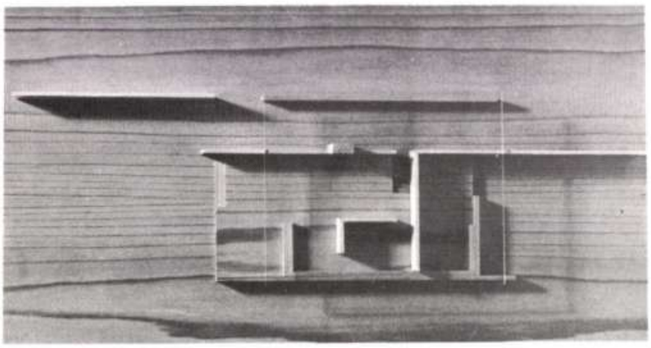


Fig.10 left
Plan model of a house in Suffolk.
Photo: H.Sowden

Fig.11 below
House in Suffolk.
Photo: C.Westwood

BIRMINGHAM

The first main university scheme is for some laboratories for the Departments of Mining and Metallurgy at Birmingham. These proved to us that it was possible, even with a first stage of less than half a million, to design a special system for a complex building on a particular site, using industrialized methods, and still be well below the University Grants Committee cost limit.
The construction method, based on an assembly of separate 17 ton, 20 ft. square precast concrete tables, was radically different from anything we had ever attempted before. We had no precedents - normal cost plan methods were therefore of little use - it had to be a calculated risk.
Archaic pricing systems, little research, a stringent cost ceiling and a system of competitive tender is almost bound to put the cork in most development work. The difficulty is that established methods, however inappropriate, are more easily costed, so outside these, there will be attendant risks.
Embodied in this scheme are ideas which we have been considering for a number of years.
A laboratory building is 'packaged services' and the structure becomes totally subordinate to their requirements. We don't so much build 'ducts' but ensure that the construction method provides a continuous horizontal and vertical network of spaces, a network of structural discontinuity.
We have been thinking for some time also in terms of 'deep' laboratories with all the service rooms planned internally, to serve laboratories on the perimeter, as they do in this building. Coupled with this, we have been experimenting with a three-dimensional geometry of multiple grids, which were related but not coincident, covering planning, services, structure, and so on. This geometry is essential to the organization of a highly disciplined and repetitive building of this nature.
Implicit also are ideas of growth and change which were put severely to the test while the first stage was still under construction. The Robbins Report was published and we were asked to proceed immediately with the construction of the second stage - doubling the size of the scheme - before a programme had been determined and I know of no better way than this of searching out the soft spots!

Fig.12
Birmingham University. Exterior
Photo: H.Sowden

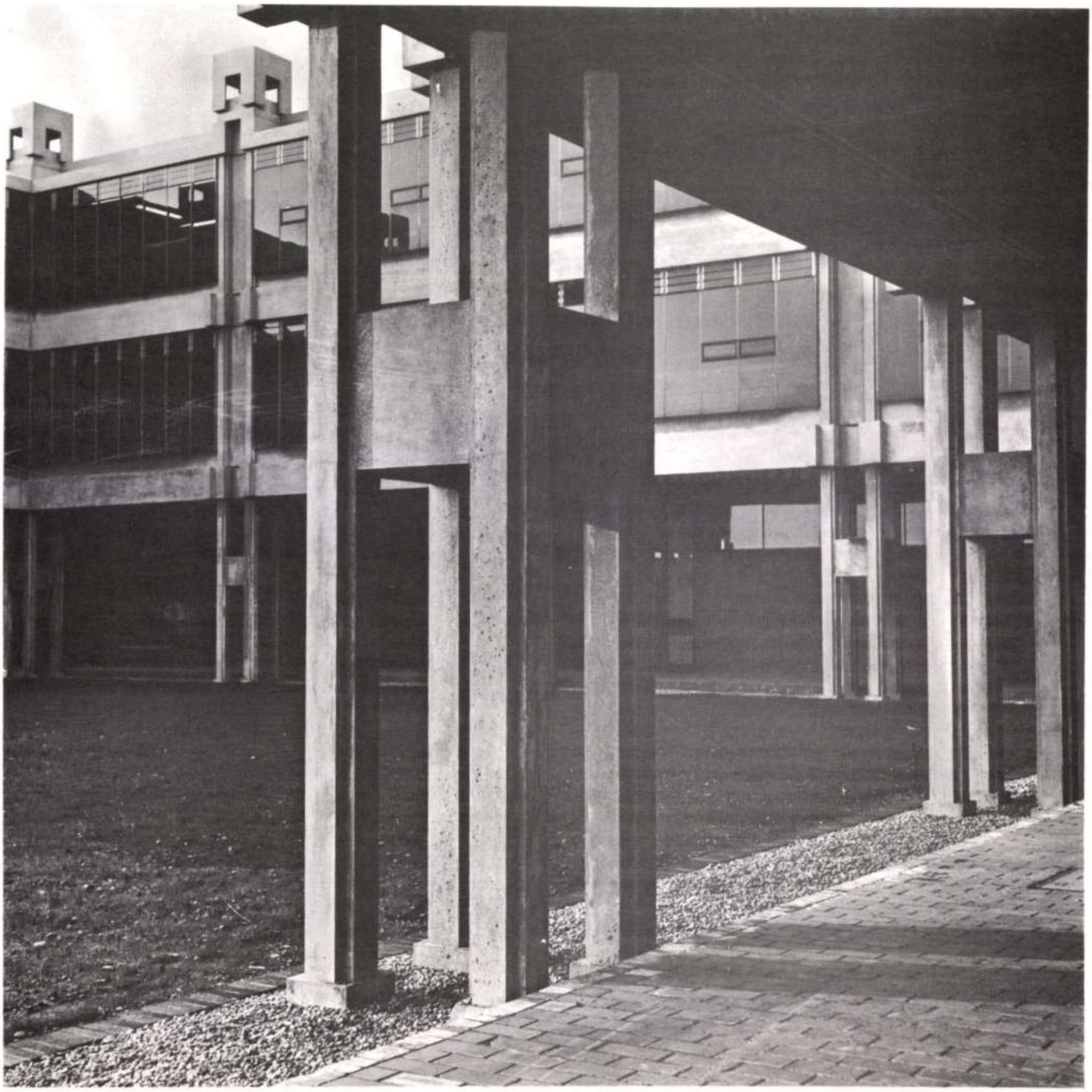


Fig. 13 above
Birmingham University. Main staircase
Photo: C.Westwood

Fig. 14 below
Birmingham University. Typical laboratories with a services boom on the left
Photo: C.Westwood

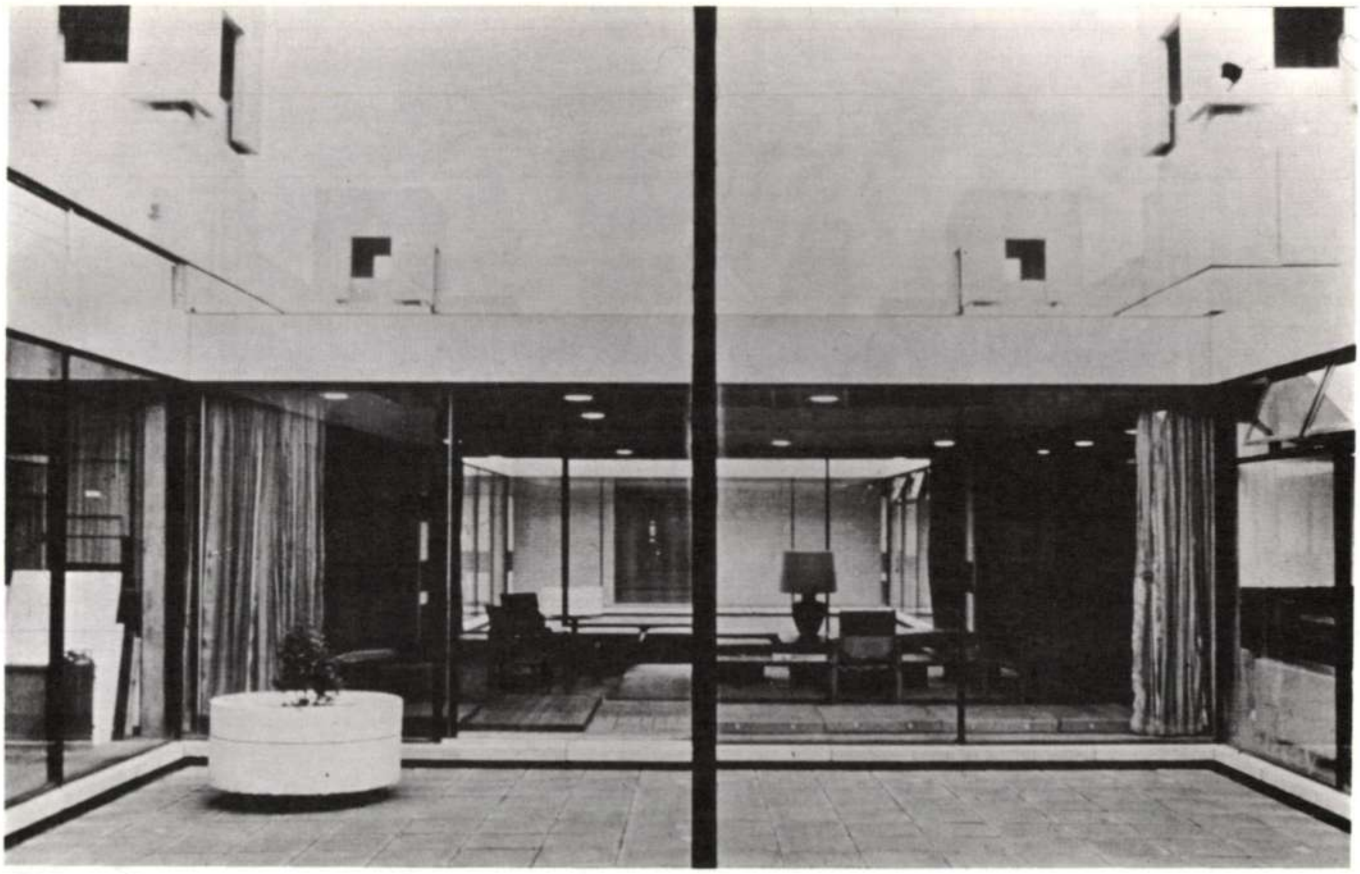
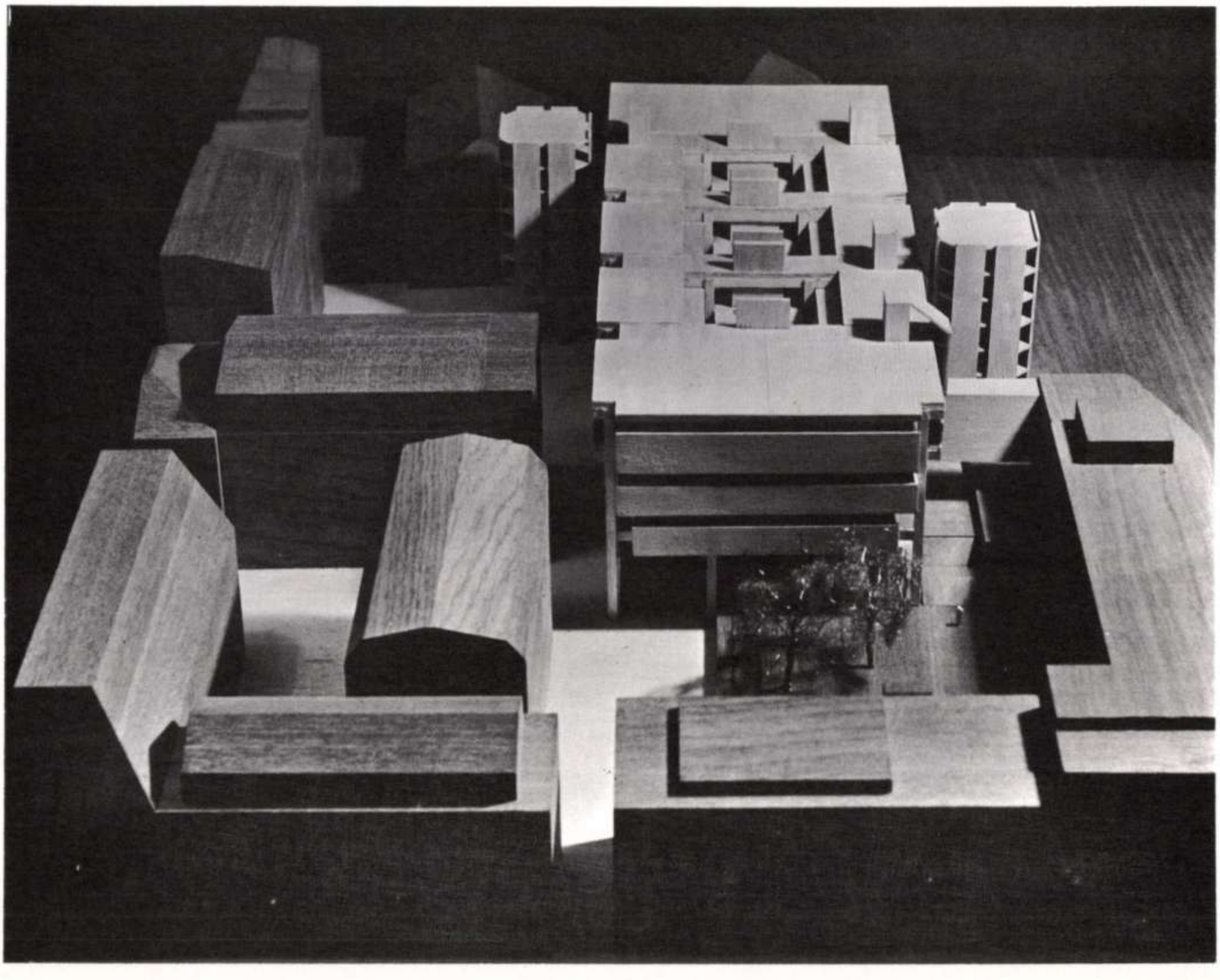


Fig.15
Birmingham University.
Internal courtyard showing
common room

Fig.16
Cambridge University.
New Museums Laboratory. Model of development
Photo: H. Sowden



CAMBRIDGE

Finally I am going to discuss two projects due to be started this year.

The first is the New Museums laboratory building for Cambridge University.

Whereas the Birmingham site was almost ideal, the Cambridge one could hardly have been more difficult. It has practically no access, is surrounded by hyper-sensitive scientific equipment and scientists and sits on a river. But then the consequences of designing a large building in the centre of any famous old town are almost certain to be both a restricted site, as well as a political minefield.

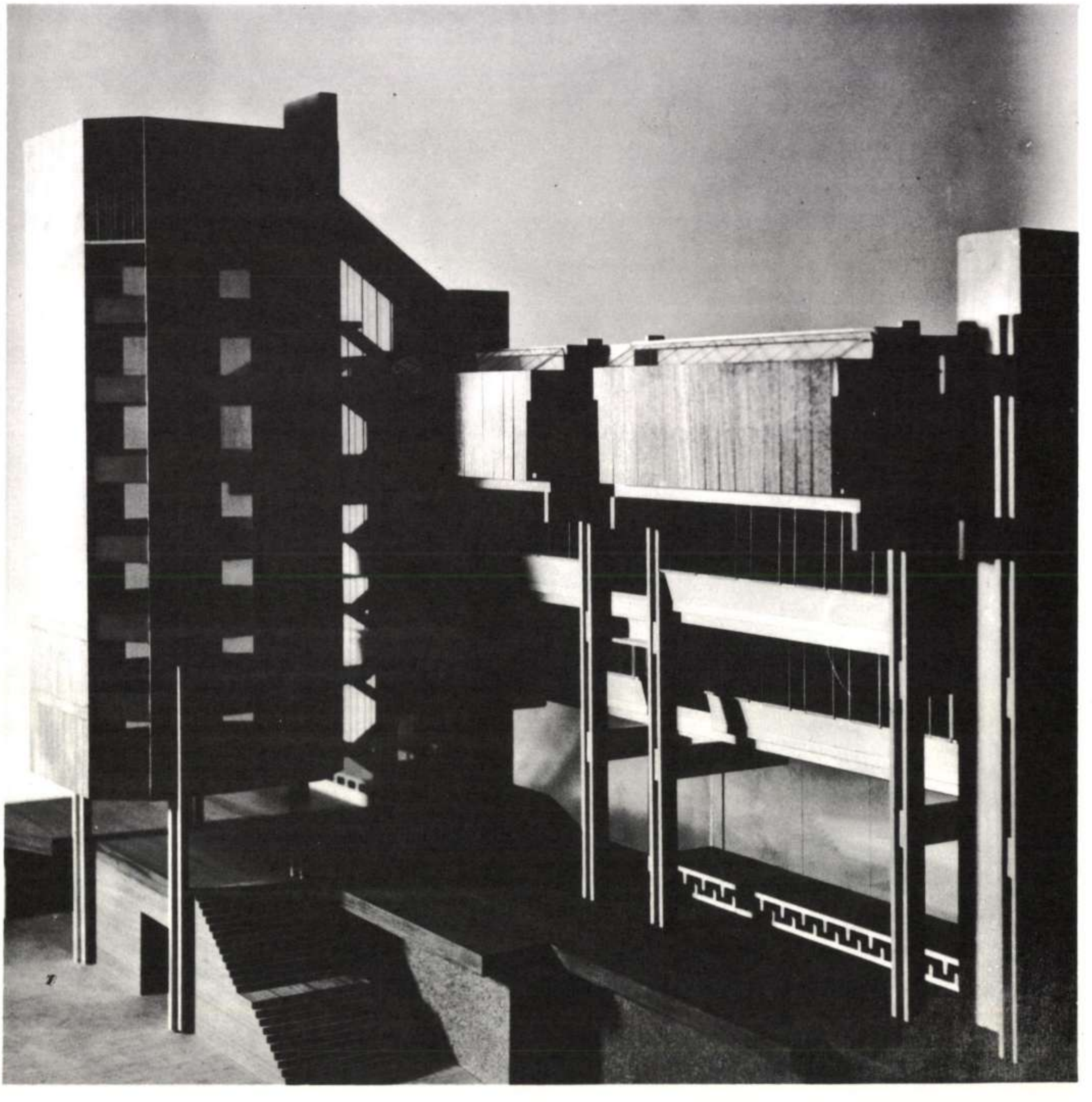
The New Museums building had to be considered as an extension of the new Lion Yard development on the one hand and on the other as a link to the old centre of the University, bearing in mind a future replanned science area.

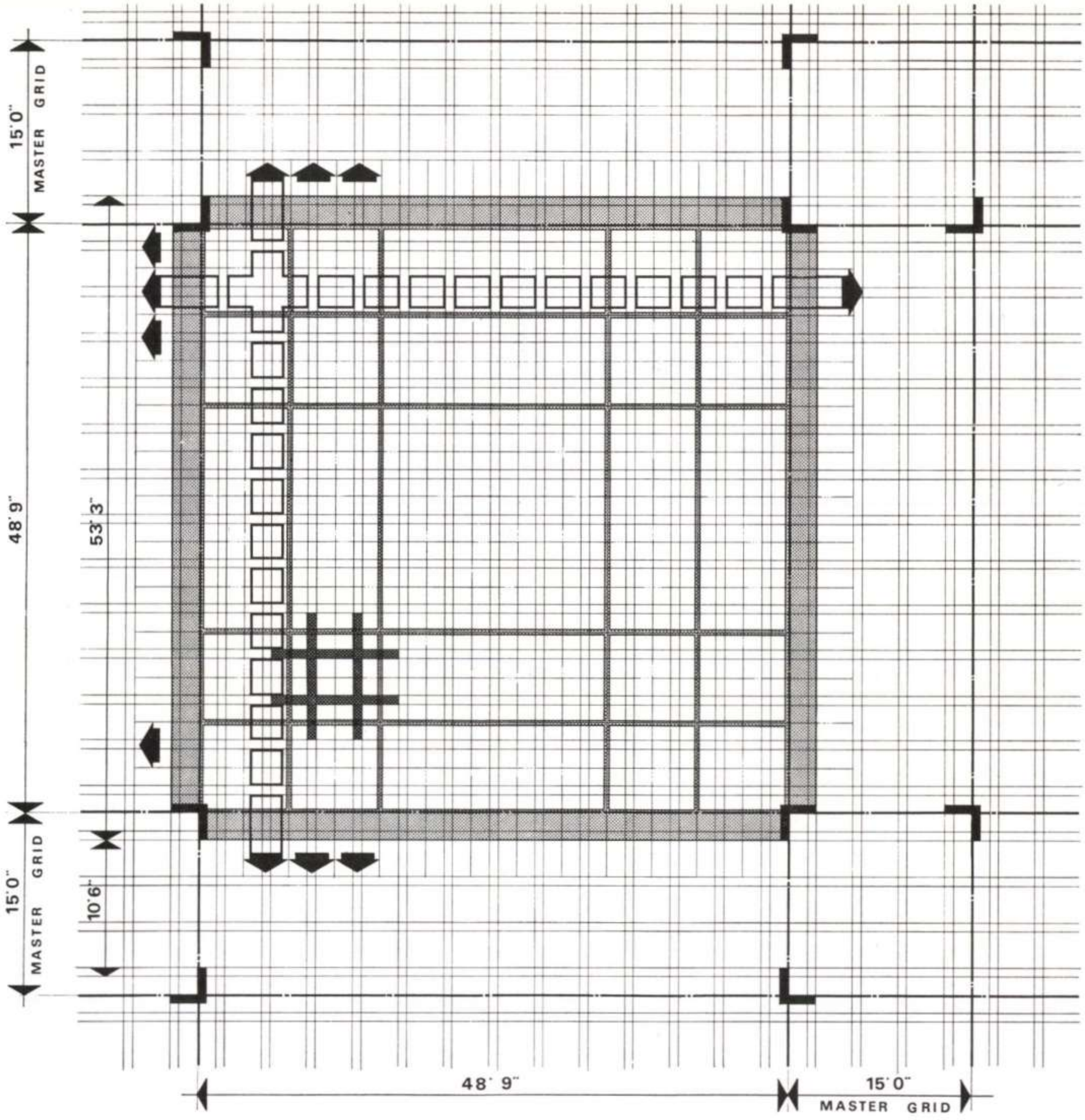
In the design of a large building, the shape of the circulation must provide for the needed sense of location within it - the sense of arrival and departure - of moving from one place to another place each with its own spheres of influence and which must have a relationship to the whole and reflect naturally the differing intensity of their use. It is the shape of the circulation that makes the anatomy of the building comprehensible to anybody moving about in it.

The sliced-loaf organization of this building reflects the circulation pattern, the construction arrangement and the main planning increments. The scale can be considered at the level of a unit, i. e. office, laboratory or lift, etc., or at the level of a main construction element, i. e. major bay or office tower. This is apparent in the assembly of the parts in the final design.

In its simplest terms this building can be considered as a precast frame containing continuous deep serviced floor space, to the perimeter of which are plugged offices, lifts, staircases, links and so on. The elemental nature of this design will allow for future extensions within the same context.

Fig. 17
Cambridge University. New Museums Laboratory. Model of part of building
Photo: H. Sowden





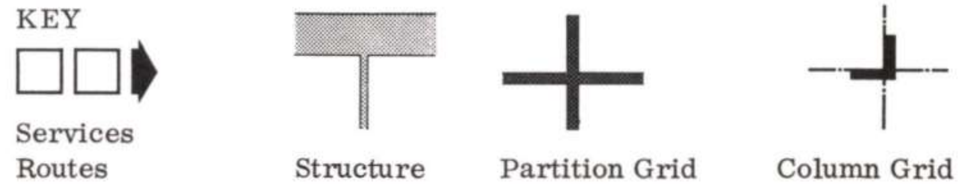


Fig. 18
Proposed Loughborough University of Technology. Relationship between all grid networks

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LOUGHBOROUGH

I have talked so far about individual buildings from a small house to a large industrialized job. The master plan for the proposed Loughborough University of Technology is in many aspects a summation of the ideas that I have already tried to express.

A group led by Peter Foggo has been working on this for the past two years. Our brief was very open. The University is to expand up to certain stages, over unpredictable periods of time and is to be fully residential.

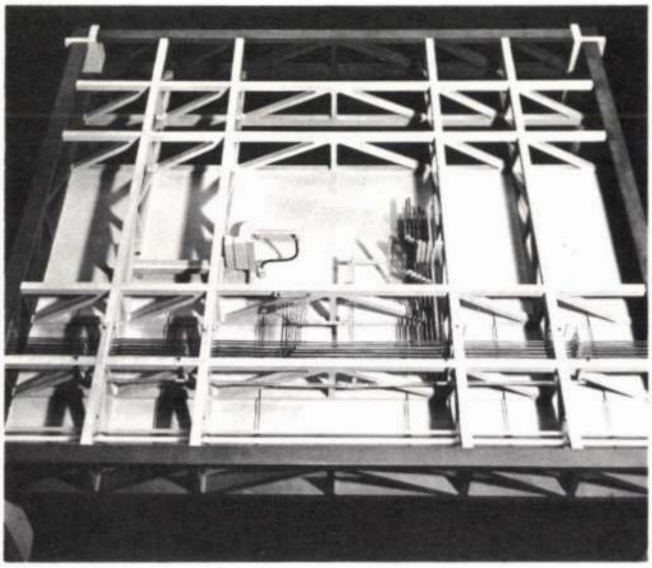
There is to be a minimum of departmental frontiers so great flexibility in the arrangement of the schools of study, both now and in the future, is necessary. Growth and change of course, are of the essence.

The plan is based upon a set of disciplines within which a randomness can exist - as a consequence of the brief - where the solution consciously reflects the indeterminacy of the problem.

The University is to be built on a steeply sloping 90-acre site. The growth pattern is linear for the communal and residential sections, with the academic and teaching areas planned to allow for concentric growth each side.

The system, as at Birmingham, is agglomerate, relying on repetitive elements - simple in themselves - to define a variety of spaces which evolve with the site contours. Some of these places will be quiet, secluded backwaters, while others will attract a concentration of people. The space planning will have to reflect what one might call this 'intensity diagram'. There will be a progression up

the site to the spine at the top of the development and along this spine to the various node points.
There is a close juxtaposition of teaching and living, meeting and recreation and all that makes up the life of a university. It is of course, upon the involvement of successive generations of students, which will change in emphasis as society changes, that the life and vitality of this community of learning must depend. A framework has to be provided within which this organism of individuals can evolve. It will be as varied as the people that compose it and while to work well it must encompass a host of activities, it yet must, in the ultimate, have a wider identity all its own.
The proposals for this University, its construction method and its basic building component, are all on a large scale. The tools and bricks are becoming larger, this is inevitable.



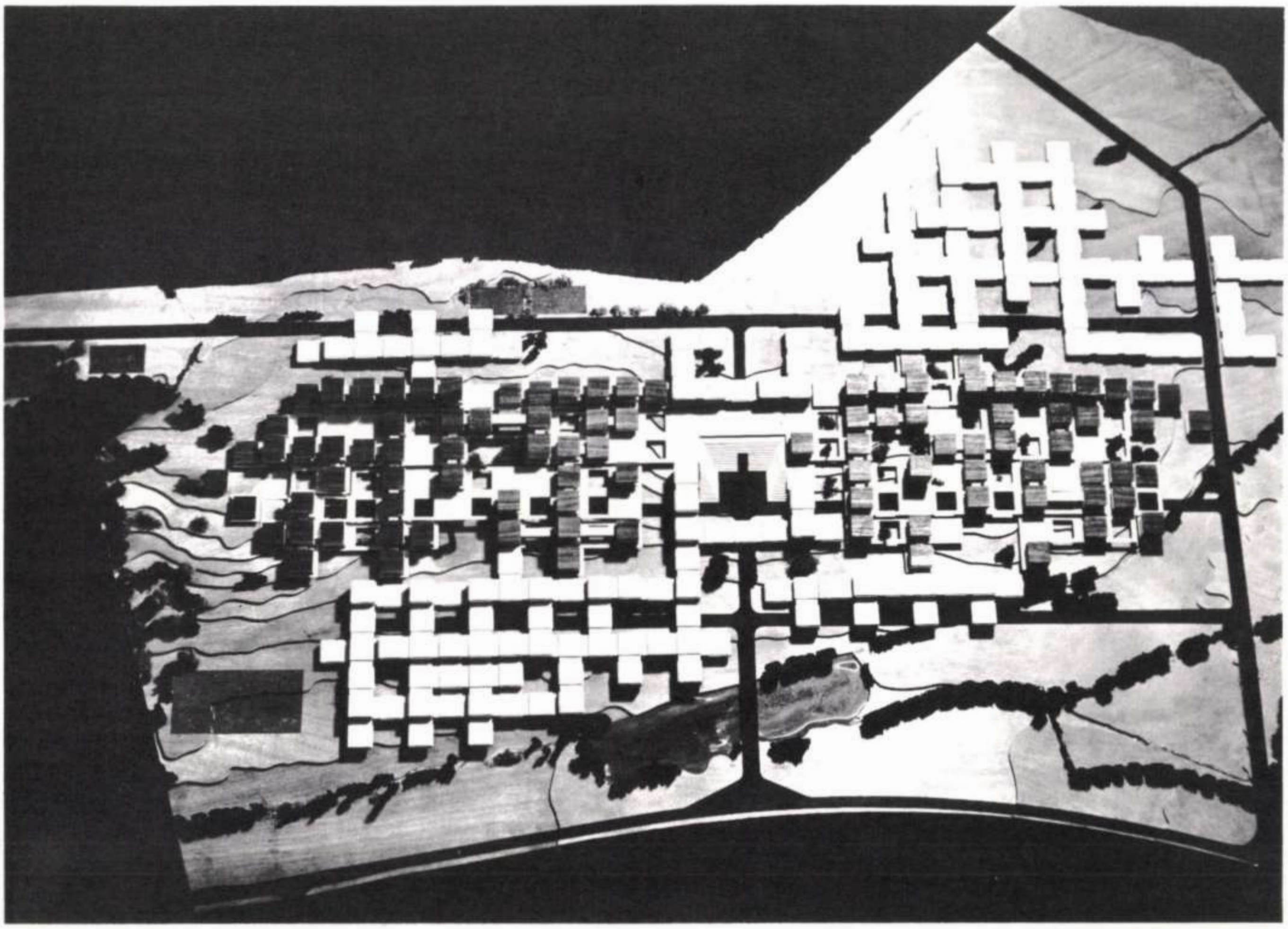
Loughborough University could be built very rapidly and may have to be at certain periods if funds are available. Speed though, is not the primary consideration. The repetition of elements, carefully designed and embodying all the various functional requirements, should, we hope, enable higher performance standards to be achieved within the same cost limits.
In these last university schemes we have tried also to exploit the richness and variety of space that can be created within the strict geometrical disciplines that are the reflection of an industrialized method.

CONCLUSION

This leads me to try to sum up though I am not sure that this is going to be possible.
The main question today is both quality and quantity - and quantity we shall certainly have because society will demand it - so unless we can ride this, then tomorrow the flood.
The general recognition of mass need is of fairly recent origin and we are all of us stalked by the problems it presents. The industrialization of building is a threat as well as a necessity. It is already compelling us the whole time to learn and develop an entirely new language of methods but then of course, on the other hand, even an exceptional command of a language doesn't necessarily imply the possession of any worthwhile ideas to express. It is, however, against this general background that I believe we have to work and it is within the context of this evolving language of methods that we are trying to find solutions.

Fig. 19 left
Proposed Loughborough University of Technology. Model of one construction element showing services. Photo: H. Sowden

Fig. 20 below
Proposed Loughborough University of Technology. Model of development
Photo: H. Sowden



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