BEAM PROGRAM

MODULAR COORDINATION

Lectures and Proceedings of a series of conferences on Modular Coordination held in six cities in Canada October 17 to November 1, 1967

CANADA DEPARTMENT OF INDUSTRY OTTAWA

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FOREWORD

The objective of this series of conferences was to broaden the knowledge of modular or dimensional coordination and promote its adoption as a means of improving productivity and efficiency in building. Such a step would reflect favourably on the economy of Canada.

The proceedings of the conferences, of course, gave rise to this publication and, as was the case in the conferences, the publication should go a long way to dispel reservations which have impeded the general acceptance of dimensional coordination for a generation.

Dimensional coordination implies rationalization, not regimentation. It implies the self-imposition of disciplines among manufacturers, designers, and contractors. Those concerned with the betterment of the building industry, with maximizing profits and with acting as responsible corporate citizens agree that the industry will benefit from the rationalization and the discipline implicit in the modular concept.

There may still be some who hold that dimensional coordination spells the end of good design. On the contrary, good design is promoted, is faster and more efficiently accomplished within the modular context. This is of outstanding importance inasmuch as the design professions are in the unique role of providing leadership to the manufacturing and contracting industries at a time when increases of productivity and efficiency in Canadian building would greatly benefit our economy.

R.D. Hindson,
Director,
Materials Branch.

INTRODUCTION

Modular, or dimensional coordination is not a new concept. Historical reports indicate that the builders of ancient Babylon, Greece and Rome utilized a form of modular coordination in the planning of their great structures. But, in its modern form, modular coordination was initiated in North America and was due principally to the work of Albert Farwell Bemis, a civil engineer, who dealt with the whole subject in great depth during the early nineteen thirties. His book, Rational Design, the third of a three-volume work on the subject first published in 1936, is a statement of the modular concept for the coordination of dimensions of building materials and components, using a module of four inches.

When the BEAM program was proposed in early 1966 with the general objective of increasing productivity and efficiency in the building construction industry of Canada, modular coordination was identified as an important means to this end. Much valuable work had already been done, arising chiefly from the initiative of Dr. R.F. Legget, Director of the Division of Building Research of the National Research Council of Canada. Professor S.R. Kent of the School of Architecture, Toronto University and the Division of Building Research, had been actively engaged in extending the knowledge of modular coordination throughout the design professions and the building materials manufacturing and contracting industries. Of Professor Kent's many publications, his Modular Drafting Manual (NRC No. 6344) is perhaps the most well known and widely read. The Canadian Joint Committee on Construction Materials, a committee of the Canadian Construction Association, had also been active in support of modular coordination, as had a few groups within the architectural profession. Because of this work and support a good base of knowledge of the modular concept had been created in Canada. The task within the ambit of the BEAM program was therefore recognized to be the organization and implementation of a continuing program aimed at presenting modular coordination as a tool for increasing efficiency and productivity throughout the building process, and as a discipline which is a necessary prerequisite to the intelligent and orderly industrialization of building.

It was with this end in view that the Industry Advisory Committee to the Department of Industry on Modular Coordination proposed the series of six regional conferences which have given rise to this publication.

The conferences were held in Halifax, Toronto, Winnipeg, Edmonton, Vancouver and Montreal between October 17th and November 19th, 1967 and were similar to one another in that each consisted of four lectures followed by a discussion period. The lecturers, in addition to being accomplished speakers, are internationally recognized authorities on the subject of modular coordination. Lennart Bergvall, from Sweden, is an architect and industrialist. He is also chairman of the International Modular Group, a working commission of the International Council for Building Research Studies and Documentation (CIB). Under Mr. Bergvall's chairmanship,

I.M.G. has been in large measure responsible for the spectacular international advances of modular coordination. Colin H. Davidson, an architect from London, England is an expert in the application of modular coordination in industrialized building, and a member of the Technical Committee of the Modular Society of London. Philip H. Dunstone is a quantity surveyor skilled in the use of computers in design quantity take-off and estimating. He also is prominent in the Modular Society as a member of its Council. Professor S.R. Kent has already been mentioned in this introduction. He is an architect and teacher, and his record as a knowledgeable and articulate supporter of the modular concept in Canada is well known and widely appreciated. A short curriculum vitae of each is included, and Part 1 of the publication records in complete form the lectures which they delivered at these conferences.

Part 2 of the publication contains the discussions which took place between the audience and the four lecturers. These have not been edited or shortened to any appreciable extent, and because of this, the reader may notice some slight repetition in both questions and answers. However, the decision on editing was taken in full cognizance of this, in order to preserve the flavour of the spontaneity which characterized this part of each of the conferences. The number and quality of the questions attest to the lively and enthusiastic participation of the audiences. An interesting corallary to this is that the volume may be opened at random in Part 2 and the reader is likely to find informative and thought-provoking reading.

The conferences were attended by about 1,000 architects, engineers, teachers, building materials manufacturers, contractors and representatives of the labor unions, all having positions of importance and influence in the building industry. More than 150 of those who attended subsequently wrote to the Minister of Industry offering congratulations and encouragement on the initiative displaced by the Department in organizing and presenting the conferences.

Special thanks are due to members of the Industry Advisory Committee on Modular Coordination for the assistance given in all parts of the country. Many of them participated directly in the conferences as chairman, panel moderators and in other supporting roles. A list of the Advisory Committee members is included as an appendix to the proceedings.

At the dinner which followed the final meeting in Montreal, Mr. Bergvall spoke to an audience of nearly 300 on behalf of the four lecturers. His expression of thanks was an appropriate conclusion to the events of the previous two weeks and it therefore seems fitting to include the remarks of this distinguished Swedish architect and industrialist as an epilogue, to which the attention of the reader is particularly drawn.

A D D R E S S E S

ADDRESS

BY

STANLEY R. KENT

ARCHITECT

AJAX, ONTARIO

TIME FOR ARCHITECTURE

There may be the thought in the minds of many of you that this series of conferences has been devised as another Centennial project. But it is not so. Rather it is just a coincidence that the development of the modular system for dimensional coordination and the evolution of the building industry to the point of industrialized techniques, have reached a common plateau in Canada in 1967. Throughout this day we will be examining this plateau for the purpose of coming to grips with the modular system, and to assess its potential for increasing productivity in building, while at the same time to assess the cost of change in adopting it. It is my belief that the potential outweighs the cost, so heavily, that we could look forward to achieving new heights in our industry.

As the plateau of the building industry is extremely large, and we are a heterogeneous group of Canadians - manufacturers, architects, engineers, administrators, contractors, tradesmen, and suppliers - I believe a few statements on each others' present and future situations may give us a sense of cohesiveness. By understanding our common problems our increasing dependence on dimensions in building will be observed, thereby giving rise to the need for a uniform system which will penetrate all uses of dimensions in building and provide a common basis for their communication. At this point, the modular system for dimensional coordination will be introduced. And since any dimensional system will affect building design, I shall conclude my remarks with this topic.

Changes in the Building Industry

Two years ago the Royal Architectural Institute of Canada examined the changes taking place in the architectural profession and published "The Survey of the Profession". In it we read: "It was generally considered, by those interviewed, that the architectural office doing work in the urban context would gradually grow larger to meet the demands for speed of performance and specialized knowledge. The consortia of already-large firms, in order to assume responsibility for very large projects, was noted. Small firms have also joined forces for the purpose of carrying out work too extensive for one to perform alone. The arrangement for combined operations appeared to present many favourable facets".

With this change in operations, architectural offices are experiencing a turnover of staff, a need to divide responsibility into departments for design, production and administration, and a need to standardize procedures and techniques. Each of these changes increases the problem of controlling communication of information, particularly building dimensions.

Similarly, industries are growing larger, not only by individual growth, but also by amalgamations. Such companies are faced with controlling large inventories. This operation can become exceedingly costly if much stock is accumulated and stays dormant due to its uniqueness of dimensions.

For example, in the Toronto area, concrete block manufacturers were producing blocks ranging in height from 7 inches to 8 1/4 inches and in various thicknesses and shapes. By 1963, the Primeau Block Company had on inventory 23,600 off-size blocks, and the Argo Block Company another 32,700. When these companies amalgamated, they co-operated with other large companies experiencing similar problems, one having 244,000 off-size units, in initiating a solution to their dimensional control problem which I will mention later.

Another amalgamated company, a producer of sheet metal building products, has for many years catered to architects, as have its competitors, providing metal door frames in any dimension desired. Production and inventory costs of this practice are now so expensive, that unless dimensional control is possible, the company must reassess its continued production of the product.

A third example is in the manufacture of lighting fixtures. A committee of the Ontario Association of Architects was informed by a representative of the Lighting Equipment Manufacturers Association, that nearly 50 per cent of the lighting fixtures for architects' jobs are of special dimensions. The carrying in inventory of the production over-runs of these fixtures has become so costly, that it is cheaper to throw away $1,000 worth of usable fixtures, than to keep them under inventory control. A few years ago, he said, this action would have been considered ridiculous.

I am certain that many of the manufacturers and suppliers here can quote similar experiences and during this conference I ask that you discuss them.

Another change, or more correctly an innovation, is the sophistication in our management and administrative techniques. Large companies have to know the operations which contribute to profit or loss. Owners are demanding a close control over building dollars, because often prior financing is required, and so we find specialists in estimating, evaluation, and management are playing new roles in the big business of building.

In contracting, generalization is impossible, but we all know the difficulty in finding the general contractor employing a permanent staff, who will carry out the major degree of site work. Contract documents must now be fully detailed because the unwritten tradition of crafts in which how is coupled with will is being replaced by controlling standards in contracts.

All of these changes have these important features in common - the control of variables in the communication of dimensional data: dimensional date within the architect's office; dimensional data of inventory; dimensional data for management; dimensional data for building.

Communication of Data

Communication of data within the building industry constitutes a vast unattended area of vital importance. Data can be of many forms and complexities but our field of dimensional data is precise, self-contained, and easily defined. But in spite of the apparent simplicity of dimensional data, it has become the most confused, inaccurate, costly and neglected of all the forms of data we try to communicate.

Dimensional data touches all of us, yet prior to these conferences the designers and builders of buildings in Canada have not been brought together, in such strength, to grapple with the subject. The reasons, I suggest, are threefold: first, our operations in Canada may have seemed too small or too dispersed to bother; second, we have not had a satisfactory method of solving dimensional control and communication; and third, we have been unaware of the hidden losses, growing in a cancerous fashion within industrialized building techniques.

But today our population is 20 millions and growing rapidly; modular coordination has been developed on an international scale to control dimensions; and we are sharpening our pencils in assessing costs.

Initiation of Dimensions

The initiation of dimensional data is on the drawing boards of the designer in the architect's office and of the product designer in the manufacturer's office. It is therefore appropriate to examine dimensional data created by designers.

In the design studio of the Department of Architecture it is my responsibility to teach working drawings. As an introduction to this subject, I ask the students to take one of the buildings they have designed in their architectural design course and determine what are the essential dimensions which must be communicated to give the building physical form, and to whom should they be communicated. When this has been done, thought is given to the most convenient form, that is, graphical or written, the best scale of drawing the components to show the dimensions, the size of sheet and the distribution of sheets.

If time permitted today, I would enjoy conducting such an exercise with this audience. It could be more valuable than all the words I can say. We are often too inclined to think of solutions before clearly examining the problem.

By taking this complete view of communicating essential dimensions, we see that two features become apparent. First, the need for a common linkage system for the dimensions being received by various people, and second, the need of a means by which each person may accurately locate his work in the building.

At this point, the students are ready to think carefully about modular coordination, as a solution to these problems - linkage and location.

What do we mean by the modular system for a common linkage? If we look at the builder's rule we see the dimensions of one inch, 1/2 inch, 1/4 inch and 1/8 inch and so all dimensions are linked by 1/8 inch. This small linkage provides virtually unlimited sizes for dimensions of components. The modular system introduces a module, or repeated common size of 4 inches as the linkage. It reduces the number of possible variations, yet provides sufficient flexibility in design dimensions for the scale of buildings, thereby simplifying many of our problems as we shall find out during our conference.

To assist in locating the work on the site, there is another feature of the modular system. Since building is three dimensional, and mainly rectangular, a three dimensional, rectangular grid is imagined to be superimposed over the complete building. The spacings of the grid lines are multiples of four inches. When modular components are used in the building, they have their joints, or their centre-lines, at the grid lines. Thus the grid controls both the dimensional sizes of components and also their position in the building by acting as a series of fences. The system neatly fulfils both our predetermined needs - a linkage through the common four-inch dimension or multiple of it, and a series of control fences for locating building components.

To communicate the modular system in graphical form, requires only slight, but very significant changes to our normal working drawings. Bearing in mind we now have an imaginary grid, those portions of the grid which pertain to our essential dimensions are placed on the drawing. Since grid lines are spaced at modular intervals, grid dimensions are always multiples of four inches - and never fractional numbers.

You may ask: "Is the change worth the bother?" My answer is most emphatically, "Yes!"

The RAIC Survey of the Profession gives us good reason to consider the change. It says that architects recognize working drawings as one of the major instruments of professional service. On these depend the meeting of the minds of architect and contractor and the degree of expedition and freedom from friction with which the project may be forwarded. Working drawings occupied third place in the national poll of urgency for improvement,and roughly in a similar position to specifications and field inspection, indicating a middling concern for this area of activity by architects responding. Of greater concern in working drawings, by those interviewed, is the large proportion of the fee consumed by their preparation. In reducing the cost of operating a practice, the reduction of time spent in the production of working drawings is an obvious starting point. Both architects and contractors interviewed expressed concern that this factor was entering into drawing preparation in many instances particularly where partial services at reduced fees were provided."

According to Mr. Ken Giddings, professional engineer with Precon, Murray Limited, manufacturers of pre-cast concrete, modular drawings can be an aid to the meeting of minds. He says: "So many architects seem unable to provide decent drawings, that it would make sense to insist that they all use modular practice without delay. The construction industry should insist that architectural associations join them in hammering out standards for contract drawings. Modular coordination provides a suitable framework for this long overdue co-operation. Where architects use modular practice, shop drawings are approved sooner and components are produced quickly and economically; schedules become more than pieces of paper. Co-operation between sub-contractors is also easier and altogether modular coordination speeds erection".

The cost of preparing drawings can also be affected by the modular system and one of the most vocal advocates of modular drawings in the United States, Mr. Cyrus Silling, had this to say to the Ontario Association of Architects, ten years ago, "To sell modular coordination to those with sensitive pocket books, I stress the profit motive by reciting personal history in a somewhat shameless fashion. I hope the points I make will excuse the method of attack. In our office, we have six architectural boards, a specification writer who doubles in shop drawings and trouble shooting, a secretary, a senior associate and myself: also resident engineer inspectors at the site. Some people explain our production by saying we draw on both sides of the board. In 1948, we certified to US Army Engineers a current workload of $31,965,000. In May 1951 our current work load totalled nearly $22 million and in 1952 we booked $20,300,000 new work. This year we have

over $42 million on the boards. We did architectural working drawings and coordinated the structural and mechanical work on a $3,750,000 hospital in 105 man-weeks (40 hours each). The fee was seven per cent. Its one sheet of modular window details covered conditions that would have required five sheets of non-modular drawings. We had eight construction bids. Six bracketed a five percent spread. Two men in our office did a complete set of working drawings for a $1,400,000 office building in nine weeks. We get six per cent.

"In my view, today's architect must be a businessman, as well as a professional and an artist. I think modular coordination is a business aid that offers larger professional opportunities to the architect as an artist. I think its use shortens the production period for superior working drawings; develops clarity of exposition; increases the architect's status among builders; furnishes a larger part of our time bracket for design considerations; furnishes a larger portion of the fee for profit." You will have noted the figures quoted are not recent, but I had the pleasure of renewing my friendship with Mr. Silling and his cohorts, now six in number, just three weeks ago when they were on an office holiday to Toronto, Montreal and Boston - they have such holidays twice a year - and Mr. Silling said they had work in the office to the value of $52 million. They are still enjoying modular drafting. And if you suspect the drawings are lacking in quality or completeness, I can assure you they are of a very high standard.

The advantages stated by Mr. Silling can be supplemented by Mr. Donald Blenkhorne who has used modular drafting in the large office of Shor and Moffat and Partners where he is a senior partner. He claims that modular coordination provides a definite system of drawing which can easily be adopted as office procedure and, as such, assists in the retraining of new personnel. The making of dimensional decisions is channelled into multiples of four inches or two inches, which is a speedy thought process that also reduces errors in communication both by word and by drawings. Mr. Blenkhorne will admit that at one time his engineering partners objected to the system but now they have learned to live with it. The only breakdown in the communication circuit is between the design group and the production group, and at present, the production group must make decisions in coordination which ideally should be made by the design group.

You will recall that in the exercise undertaken by the students in architecture, thought was given to <u>who</u> should receive <u>what</u>. From the analysis, we find that not everyone needs to have drawings with all dimensions and I suggest our present comprehensive drawings are necessary solely because our dimensioning is lacking in order.

A solution to this problem was devised by the Department of Public Building and Works in England, for documents of the Nenk method of building. Although Nenk is a specific form of prefabrication, the organization of documents had many interesting features.

An analysis was made of the structure and the items were classified as components, elements and job assembly. Another analysis was made of who required information on each item. Separate drawings were prepared for each item so that any participant in the building process received only the detailed drawings of interest to him. Of course there were hundreds of drawings, but by coding the drawings, sorting was a simple matter. The significant feature, of interest to us, is that all dimensions were dimensionally coordinated by the modular system, each component being a segment of the overall modular range of sizes. Without such control, there would have been chaos.

Much of what I have said applies to the industrial designer but he has economic restraints of a different kind imposed on him. He must consider the characteristics of materials available to him, both raw and semi-processed, as they have dimensional limitations, either in structural size or in secondary cutting. In addition, he has to have a crystal ball to determine what dimensions will be acceptable on the market.

This last point was the problem faced by the concrete block manufacturers when they were accumulating off-size inventories. They solved their problem not by a new crystal ball, but by applying modular dimensions to the height of their blocks. This was done through collaboration with the Ontario Association of Architects and to date, the association has not received one comment denouncing the dimensional control.

Shop Drawings

Within the building industry we have another form of communication known to all of you as shop drawings. They contain the final dimensions in the manufacturing process for which nobody really wants to take full responsibility. They, too, are made necessary by our lack of standards and disorderly dimensioning system, so let me give you one example of how they were eliminated.

When the architects of the Hertfordshire County Council were designing windows for the South East Anglia Collaborative system of school construction, they were desirous of obtaining a wide variety of metal window patterns and yet keep the total number of window segments to a minimum. To achieve this, they and a window manufacturer developed a glazing section set up in such a way that separate window segments could be added together to form the complete window. The key to the solution was an orderly range of modular dimensions for the segments so that they could be joined together with the greatest variety. As the segments were standardized, they were coded by number. and when combined into a window another meaningful code was obtained. It was then possible for the architect. to show all window codes on the working drawings, the quantity surveyor to record the codes in the bill of quantity and the manufacturer to feed the codes into the computer.

The computer printed all the necessary instructions for the shop floor and the shop drawings were eliminated. This removal of the manufacturer's greatest bottleneck would not have been possible without the range of modular dimensions.

The word "control" which I have used so frequently bristles the nap on the neck of many designers as it immediately implies a restraint on artistic freedom. But perhaps there will be a change in attitude as the work and theories of Christopher Alexander, of the University of California, Berkley and others, become better understood. In Alexander's book "Notes on the Synthesis of Form", he says, "The designer who is unequal to his task ...relies more and more on his position as an artist, on catchwords, personal idiom, and intuition - for all these relieve him of some of the burdem of decision, and make his cognitive problems manageable. ...Driven on by his own resources, unable to cope with complicated information he is supposed to organize, he hides his incompetence in a frenzy of artistic individuality. As his capacity to invent clearly conceived, well-fitting forms is exhausted further, the emphasis on intuition and individuality only grows wilder." Alexander's thesis is concerned mainly with activity components, but as he links activity components with physical form his design philosophy is appropriate to dimensional coordination. He concludes, "Every component has this two-fold nature: it is first a unit, and second a pattern, both pattern and unit. Its nature as a unit makes it an entity distinct from its surroundings. Its nature as a patttern specifies the arrangement of its own component units. It is the culmination of the designer's task to make every diagram both a pattern and a unit. As a unit it will fit into the hierarchy of larger components that fall above it; as a pattern it will specify the hierarchy of smaller components which it itself is made of."

Without any doubt, the contemporary designer's fear of mathematics entering design is based on the popular view that mathematics deals only with magnitude. But those of you who have attempted to cope with your children's new mathematics, recognize the relationship between their problems in sets and subsets of numbers and Alexander's pattern and units of design. Whether or not the designer realizes it, whenever he divides a space, he has immediately created a set of numbers. The modular system gives guidance in controlling the usefulness of the sets and one of your speakers today, Mr. Dunstone, who has published a most useful book on this subject, will discuss the topic further.

While on the theme of sets and subsets of dimensions for a single building, let us expand the thought to consider a hierarchical organization of dimensions for all building. If dimensions of all building form a set - a modular set - then those in any one building would be a subset composed of sub-subsets.

On the subject of uniformity, Philip Arctander, Director of the Danish National Institute of Building Research, in speaking to the CIB in 1965, said, "There is a widespread popular fear that modular coordination, standardization and industrialization will reduce today's individual variety and freedom to a dull machine uniformity. Much of today's variety is, however, nothing but lack of clear thinking and purpose-definition. And far from producing uniformity, industrialization may be used to reduce the present infinite, aimless variations to a large finite number of deliberate differences."

The dimensions we use have been one of the greatest barriers to productivity and economy in building. Dimensions have been, if I may twist the title of a well-known book, The Hidden Persuaders to The Hidden Dissuaders, - dissuaders to efficiency in communications. But now that dimensions are exposed as the cause they must be dealt with through the modular system. In the current Royal Bank of Canada Monthly letter entitled Communication is Vital we find this appropriate paragraph: "Silence and delay accomplish nothing, for even the greatest believers in good. Emile Zola mentioned in his letter to the President of France in the Dreyfus case, called J'Accuse: 'Two of the victims, two brave, open hearted men who waited for God to act while the devil was frightfully busy'."

ADDRESS

BY

LENNART BERGVALL

ARCHITECT

STOCKHOLM, SWEDEN

MODULAR DIMENSIONAL STANDARDIZATION AND THE MANUFACTURE OF BUILDING MATERIALS AND COMPONENTS

Industrialization

The theme of this conference is, of course, the practical application of modular coordination. But all the time, through the whole conference you can feel the broad, mighty understream of industrialization, which is characteristic of the building industry of our age.

Now, modular coordination should rather be called just dimensional coordination, because this name describes far better its whole purpose. Dimensional order is, of course, a key to rational building; order will always pay off through increase in productivity, reduction of work, simplification in the drawing office, in the workshop and on the building site.

But the need for dimensional coordination becomes a matter of another and higher power on the threshold to industrialization. Mr. Davidson in his lecture will deal in detail with this subject, so often talked about in general terms, but so rarely clearly defined.

Now, this process of industrialization may look somewhat different from the point of view of the manufacturer of building materials and components than from the point of view of, say, the contractor or the architect. Or, more precisely, for each of the many parties involved in the building industry the emphasis of this process may be on different parts or aspects of it.

However loose, though, that this term "industrialization" is, we have to accept it. But we talk too often about the "industrialization of the building industry", without making up our minds whether the term "building industry" should be understood as just the work on site or should also include the manufacture of building materials and components - which is most important, because the production of building materials and components has no doubt been "industrialized" long, long ago.

Nevertheless there are strong reasons to include the production of building materials and components in the general discussion of "industrialization".

First: There are many degrees of industrialization and the building materials and component industry is - to a large extent - only in an initial stage of what could be described as "paleoindustrialization".

Second: The whole building industry is in a period of swift changes, which will have many direct bearings on the production of building materials and components. One of the most important of these is the irresistible trend towards integration.

Third: The equally irresistible trend towards prefabrication - understood in a broad sense - will have the result that many products which are now produced by the "building industry proper", that is, on site, will tomorrow be made in factories, that is, be taken over by the building materials and component industry.

Let's take a look at the building materials and component industry in the light of these statements, which will enable us to see more clearly, where and why standardization and modular coordination enter the picture.

Degree of industrialization

Repetition of operations has been referred to as a means of effectivization of the building materials and component industry, but this is only the very first step in an industrial evolution, that can be described as follows:

- repeated operations
- long runs
- continuous production
- mass production
- automation

These stages do, of course, overlap to some extent and as a whole this classification does not pretend to be a very sophisticated one, but it describes fairly well to what extent we are beginners, compared with several other industries, when we strive to reach the stage of "repeated operations" and - in the most advanced cases - "long runs". In that light, maybe you don't find the term "paleoindustrialization" to be too much of an understatement.

In order to make it possible, however, for the building materials and component industry to proceed to more advanced stages of industrialization, the step must be taken from production to order for specific projects to production for stock, for anonymous

projects, if you like. This is the only way for this industry to overcome the very substantial seasonal variations in demand, from which I am sure the building materials and component industry in this country must suffer, just as in all other northern countries. But for such a continuous production for stock an effective standardization is an absolutely indispendisble prerequisite.

We can find an interesting example of this from France. When, some years ago, I visted one of the world-known French prefabricators, they declared that they had no need for modular coordination. "We do not work for stock but for projects", they said, "which are so large that we can always carry out the dimensional coordination within that framework with some mutual adjustments by the client and by us". But only about a year later, these same people turned to the French building research institute (C.S.T.B.) asking their assistance in selecting or standardizing a limited number of sizes for generally applicable components in order to enable them to produce for stock - not to order - during the winter months, thus enabling them to overcome the very cost-consuming seasonal variations in production volume. Now, if this goes for the mild French winter climate, how much more important must it not be in our climates?

Integration

The integration of all production activities - in a broad sense - involved in building production is one of the most important trends in today's building industry. It will interfere very deeply with existing practices and patterns and call for a much closer cooperation between the different experts or specialists involved. For the building materials and component industry, this will affect already - and particularly - the design and development of products. No materials or component manufacturer can now afford to develop his product with regard only to his own production conditions or to making his particular product as cheap as possible. The problem is no longer to minimize the cost of any one product, even as installed in the building, but an overall problem of designing and developing every product with regard to the minimization of the building cost as a whole. Those products, which subordinate themselves under this common purpose, will be the ones that survive in this age of swift changes, and this is another point where modular coordination comes in, because its purpose is precisely to provide a tool for the dimensioning of building materials and components with due regard to their interplay with the building as a whole.

Prefabrication

Prefabrication is perhaps the most striking feature of the industrialization process in the building field which we are now witnessing. For the building materials and component industry

this means that it can - and must - gradually take over more and more from the building industry on site. But this also means that all those new "prefab" products must be applicable to very different buildings, even if some components may mainly be intended for housing, others for schools etc. For this flexibility in application, however, modular coordination is the indispensable tool.

Closed and Open Systems

Since prefabrication means a changeover of production from the building site to the factory, this process can be approached from two opposite ends. Either the contractor equips himself with a factory designed primarily to provide himself with the prefab products he needs, concrete panels, wooden frames etc. Or the materials industry converts itself into a prefab component industry. The degree of prefabrication may well be the same in both cases, but the appraoch will be rather different - as experience shows.

Those prefab products which are developed by contractors are usually intended to serve that particular contractor more or less exclusively and to form a part of a more or less "closed system". With the contractor in the background, components are usually developed with the prerequisite that a fairly normal building organization is available on site. Furthermore, when prefabrication is approached from the contractor's end, it will easily be influenced by the handicraft tradition of the existing building industry. For these prefabricators modular coordination often seems uninteresting because within their "closed system" - which is usually closed only as regards the loadbearing structure - he feels he can carry out his dimensional coordination in his own way and if nevertheless something should not fit together on the building site there are always provisions for adjustments on site, cutting, filling out etc.

The industry on the other hand naturally tries to develop products with the widest possible application to various building systems and therefore sees a particular opportunity in "open systems". For him modular coordination becomes a welcome tool, the advantage of which to him is quite obvious. As he often takes over responsibility also for the erection of his product he wants his components to fit without any extra work on site, which he can achieve only with a general systematic dimensional coordination, that is, modular coordination. And if he conveys any tradition to the building site it is - in the best cases, at least - a fresh wind of modern industrial thinking.

Let me illustrate this with an example from my own country. Colleagues from other countries, recognizing the fact that Sweden has very early given some contribution to the development of modular coordination and also has a fairly well developed "industrialized" building trade, often take it for granted that in our country modular coordination should be very widely used and applied. That, however, is not the case yet, and precisely because in our country most of the industrialized building is developed by contractors, the result is more or less "closed system" building. But the picture is rapidly changing now.

General Remarks

Modular coordination can, within the building materials and component industry, promote an advanced industrialization and integration and also support prefabrication. How this is to be done will be dealt with in detail later.

What I have said may give the impression that modular coordination - as far as the industry is concerned - is only for the big mass-producing giants. As a matter of fact, even the small manufacturer of, say, concrete blocks or window frames, will benefit very directly from it, once it has been generally accepted and practised. Let me illustrate this with one interesting example. When, some years ago, I worked as a U.N. adviser, initiating some work on modular coordination in Ireland, we investigated the cost of conversion for various industries. We found, much to our surprise, that the Irish manufacturers of concrete blocks could get the modular moulds at a lower price than the non-modular ones then in use. The explanation was simple. Practically all machines for that industry in Ireland are imported from the U.S. and by going modular, they were in line with the large standard production of such moulds in the U.S. instead of ordering a rather limited number of special moulds, "the Irish way" so to say. This may illustrate the importance of modular coordination in general, but it also emphasizes the importance of an international modular coordination.

Now, it might be understood from what I have said that modular coordination can be rightly understood only against the background of a clear recognition of the period of transition, unparalleled in history, in which the building industry now finds itself. What is necessary is a totally new concept of the process of producing buildings - not of "building" in its old sense. That the old conception of "building" is kept alive also in quarters where one should know better is proven by the well known advertising slogan from G.M.: "When better cars can be built, Buick will build them." If there is anything that is manufactured, mass produced and not "built", it is certainly the modern automobile.

On the other hand those who advocate industrialization often compare the building industry with the automobile industry - a very unjust comparison, I think, because the conditions are so different. I believe the building industry will never copy the production system of the automobile industry, but could learn from another type of production which is also used in the automobile industry - the use of sub-contractors. Behind the automobile industry there are numerous specialized manufacturers who deliver ready made parts and these are afterwards assembled without any dimensional adjustments at all. One advantage of this system is that the various deliverers of these various items can specialize and thereby refine their products to a degree that could never be reached if the assembling industry had to produce all the parts itself. This could also be true for manufacturers of components for buildings. Modular coordination will thus rationalize the building industry be providing a firm foundation for a coordinated dimensional standardization of building components so that generally applicable components can be assembled with other components on the building site with no, or a minimum of, adjustments and waste.

But this type of industrialization will put new demands on the materials and component industry. Those sub-contractors will have to be far more accurate concerning control of dimensions and quality - within the limits specified in the order - as well as have an absolute respect for agreed delivery time. A sub-contractor who fails on these points will quickly cease to be a deliverer to the industry. Without such a discipline any truly industrial planning is impossible. That does not mean that modular coordination or industrialized production in general, must necessarily call for narrower tolerances, but certainly for control of dimensional deviations, so that these do not exceed agreed limits. The failure of many of the existing building materials and component industries to meet these requirements may well have initiated a good deal of the "closed systems" on the market - here as well as in other countries. And these demands for accuracy of precise fulfilment of agreed delivery obligations will only gain more and more weight, as the industrialization process goes on.

Restricitions On The Manufacturer

This leads us over, quite naturally, to the question of what restriction on design and manufacture of products for the building industry modular dimensional standardization will imply.

The answer - in principle - is simple - no more than standardization in general. And standardization - more or less rigid - is always a prerequisite for a rational industrial production and particularly so for mass-production for stock. And standardization, by nature, always means an optimum compromise

between the designer's - or consumer's - natural inclination for a rich assortment to choose from and the manufacturer's equally natural inclination for a limited number of variants, the manufacturer's dream being to have just one single variant. But there must always be a very distinctive difference between the building products industry and most other industries, if anything that could be identified as architecture - in its broad sense - shall be maintained. And this is, that most building components must be designed in such a way that they can be combined on the building site with a great number of other products in an almost unlimited number of combinations. And here modular coordination comes in, providing architects and manufacturers with a common dimensional language. Rather than putting anything like a strait jacket on the manufacturers, modular coordination aims at providing them with a set of dimensions, which assures them that their product will fit together with other products on the market, with which the architect may wish to combine them.

Cost Reduction

Of course, modular coordination is intended to contribute to cost reduction. Being a tool for standardization, modular coordination promotes cost reduction in principle in the same way and to the same extent as standardization in other industries, that is, by providing for longer runs, simplified administration routines etc. But for the building process, consisting in principle of putting together on building sites a large number of different components, modular coordination (dimensional coordination) in addition to the standardization effect, carries with it a general dimensional order, whose importance for the reduction of the building costs is very difficult to evaluate. But I think it is no overstatement to say that dimensional order is a key to rational building; order is always paying off through increase in productivity, reduction of work, simplification in the drawing office, in the workshop and on the building site.

Let me illustrate this with a very simple example, maybe even oversimplified. Say that you are a window manufacturer and want to standardize your window heights. But which heights should you choose? You would quickly find that the window height must be a whole multiple of the course height of the bricks, of concrete blocks, of light weight concrete etc. And the architect calls for a number of different heights on aesthetic and functional grounds. Now, can we avoid all those demands being directly contradictory without the tool for dimensional coordination that modular coordination provides? The only proper answer to the question in the example is: the window dimensions as well as the dimensions of wall materials and components must have

modular coordinating dimensions, that is all dimensions of those products which are deciding for their combination with other components must - as a first prerequisite - be whole multiples of the basic module, 4" - or as a compromise at least systematically coordinated with the module.

But very briefly, the part that modular coordination plays in cost reduction could be described by saying that modular coordination is a device by which the benefits of standardization - generally recognized in all real industries - can be made fully available also to the building materials and component industry. It could even be justified to say that the economic importance for that industry is greater than for the building industry proper. And as I said in the beginning, the building materials and component industry through prefabrication will gradually gain ground from the siteworking building industry.

Modular Co-ordination and Large Scale Production

It is often supposed that modular coordination, like other standardization, is of importance only for production on a very large scale. In my opinion it is not so much the magnitude of the scale of production that is the decisive factor, but rather the type of production equipment. For some types of production a rigid standardization to a very limited number of variants is a requirement at a rather moderate scale of production, whereas in other cases a large number of variants can be compatible with production on a very large scale.

But too often manufacturers are inclined to judge the possible benefits of modular coordination from their experience of the past. Very often they say - and I have met that argument in several countries - "we have been forced to meet all kinds of dimensional demands from architects, so now we have very good flexible equipment that allows us to deliver any specified dimensions. We do not need modular coordination". But they often do not realize how much more effectively they could use their equipment or - and that is the crucial point - what rational equipment they could make use of if the demand were disciplined to modular or - for some products - multi-modular dimensions alone.

Now, let us instead leave the past and try to look ahead into the future. We have witnessed how automation, based on electronic data processing (EDP), has conquered large fields of industrial production. There is no reason why it should not be used also in the building materials and component industry. That, however, would probably lead to a rather different type of standardization, allowing a rather large number of variants within the framework of the program of production, but an

absolute rejection of all kinds of "specials". Very different from today's situation, where many manufacturers with or without their knowledge are letting the 90% standard production heavily subsidize the 10% specials. But when we arrive at that highly developed production technique, the modular sizes provide an excellent tool for the dimensional programming of such EDP production.

Cost Reduction Through Reduced Inventory

When the rationalization effect of standardization - and thus of modular coordination - is discussed, there is a very general tendency to consider the influence on production alone. As a matter of fact, however, standardization is equally important for other links in the long chain of operations from raw materials all the way to the consumer.

I think that anyone who has dealt with the production of building components of any degree of complexity has found that the limits for the number of acceptable variants very often are set not by the production equipment or process but by the number of variants that the whole administrative apparatus from purchase department to final delivery and erection can handle at reasonable costs and without errors. Therefore the reduction of the number of variants that goes with modular dimensional standardization may well be of even larger importance for other operations than for production. On the other hand, this will vary so much with the kind of product, the type of production operation, production for stock or to order, etc., that no general conclusion could be drawn in this respect.

It is particularly important to keep this in mind today with an ever increasing trend towards prefabrication, that is, towards the transfer of operations from the building site to the factory. In such a transfer everyone is usually prepared to pay for the benefits of prefabrication with the acceptance of fewer variants, but it follows from what I have just said that the demand for a rigid standardization to very few variants might very well be much more severe with regard to the administrative handling of the product than with regard to the production as such.

Therefore, with the growing recognition of the fact that rationalization is more than just increased efficiency in production, we will no doubt increase the interest in modular standardization in the materials and component industry.

Responsibility For Modular Standardization

Now, if we agree that modular dimensional standardization is important, who should be responsible for really carrying it out? Carrying out modular coordination, of course, means two things. One is the analysis of the principal problems connected with the

introduction of modular coordination, the general studies of tolerances etc. and the issuing of modular standards. There the pattern is somewhat different in different countries, even if the last step - the issuing of a national modular standard is usually reserved for the national standards institute. But the studies of various kinds that must precede these standards are often carried out mainly by the national institute for building research (for instance in France and Denmark), whereas in other countries (Germany and Sweden for instance) this task is carried out by the national standardization body. But whoever is entrusted with this first step, the second one, the practical application of modular coordination must be taken by the industry itself. In most countries there is a general dissatisfaction with the slowness of the industry to go modular and various steps are suggested - or carried out - in order to more or less force the industry to convert to modular dimensions. Personally, I am confident that, before long, developments in building will lead the industry to recognize that modular coordination is not only desirable but indispensable. With increasing prefabrication of more and more components this stage may be reached any day. Then the question is not "what are the conversion costs and what will we gain by it?" but "can we afford to stay out?"

Conversion costs

Nevertheless, this question of conversion costs, so often brought up in discussions about modular coordination, deserves careful attention. Very often statements about conversion costs are based either on very superficial knowledge of modular coordination or insufficient analysis of the conversion costs for the particular production in question - or both.

First, it is necessary to establish which dimensions have to be changed, because even a 100% modular coordination does not call for all dimensions to be modular. Only the coordinating dimensions or, more precisely, the general coordinating dimensions have to be modular. Example: door frame and door leaf; this usually means that a conversion to modular dimensions often does not imply a full redimensioning of a component but rather adjustment that will only partly affect the dimensionally determining parts of the production equipment (machinery, moulds etc.)

Furthermore modular coordination - usually - does not have to be carried out overnight. And in most component industries those tools, moulds etc. that have to be changed at a conversion to modular dimensions, have a rather limited lifetime, so that the conversion can often be coordinated with the exchange of tools necessary for technical reasons.

Finally it is a recognized matter of fact in the industry that the various social and technical changes that take place in today's society often force the manufacturer to replace old machinery with more modern long before it is technically worn out.

My experience from discussions of these matters in many countries is therefore that the costs of conversion are very often drastically overestimated at first, when the problem is raised. After they have been carefully analyzed the result has often been that they have been found to be reasonable or even negligible.

Importance of Modular Coordination for the Economy in General

What, then, would modular coordination mean for the total economy in this country of yours? It is, of course, not easy to calculate the improved efficiency and productivity that can be expected from modular dimensional standardization in terms of dollars. It would indeed be a rather difficult task even for someone very familiar with the Canadian building materials and component industry - much more for me, a foreigner. And I will not pretend to be able to answer such a question. But maybe we can arrive at a quantified answer in dollars, although only indirectly.

The total annual production volume of your construction industry, exclusive of road building etc. and exclusive of repair and maintenance, is something like 5 billion dollars, if I have rightly understood your statistics. Now, suppose that the application of modular dimensional standardization, when the full benefits are drawn from it, should mean a cost reduction - on average - of as little as 1 per cent, this would result in an annual gain of no less than $50 million. On a 20 per cent return basis, this 1 per cent in increased efficiency alone would justify $250 million in investment. Now, all these figures are overall figures, of course. For some products the ratio of investment to annual gain might be much more favourable than for some others. It has been postulated, moreover, that gains of as much as 15 per cent in increased efficiency could accrue from the application of modular coordination. The corresponding annual saving in dollars could then be as much as $750 million. These figures, however crude, do show quite clearly the very great importance of modular dimensional standardization in relation to the total national economy.

When you have heard all of the lectures of this conference you will, I feel certain, have a realization of the great economic benefits to be drawn from modular dimensional standardization. You will also realize that, to capitalize upon these benefits requires

certain changes. These changes are not particularly in the form of technical conversion but also, and primarily a change of mind -- a change of attitude -- a fresh approach. Such is required, to be adequate in this age of industrialization. On this point, let me, finally, quote a few words of a great Irishman of the last century, "to live is to change and to be perfect is to change often." Now, if this was true in the old days, I think it is much more ture in ours. The whole problem is that the world around us is changing with usch a speed that one of the main human problems today is to be able to keep pace with that change, and therefore only those individuals and those countries will be successful, who are able to make the changes that our era is calling for.

ADDRESS

BY

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MODULAR COORDINATION AND THE BUILDING CONTRACTOR

A. MODULAR COORDINATION

It simply had to be a North American who said "If somebody tells you it is the principle, it is the money!" So that, although I am speaking on the principles of modular coordination what I am really talking about is the money.

When I went to Canada House in London to do some research on your construction industry they threw a quotation at me also; "Money speaks sense in a language all nations understand". Well, they did not actually say those words - what they did say was "Those boys over there like the crinkly stuff." And let us face it, it may be all right for the designers and engineers and to some extent for the suppliers to go a bit pie in the sky, but it is the contractor who stakes cash on the building project.

You may be saying to yourselves "what does a British quantity surveyor know about the Canadian construction industry anyway?" The answer to that one is - practically nothing, but what I do know, standing back and seeing most of the game as a quantity surveyor in Britain and Europe, is that modular coordination will increase productivity in any country's construction industry. While I can talk about the principles, I must of course leave you to interpret these into money in terms of your own industry and its special conditions. In other words I have not come to tell you how to suck eggs - only perhaps how to bore the hole in the shell a little more neatly. I am not promising that your profits will immediately go rocketing upwards but only hoping that in time they may become like the London miniskirts - delightfully immodest.

We in Britain are in the preliminary stages of progress towards fully industrialized building with still much to be learned about standardization and modular and dimensional coordination. We find ourselves at the moment with two conceptions of industrialized building, with which modular coordination is inextricably bound up; one is the idea of standardizing components to the extent that they are all interchangeable, leaving the designer free to plan the building in any way he chooses. This is known as the "open system". The other is the "closed system" in which the individual components are not necessarily interchangeable with those used in general building but which still offers cost advantages because of its origins in the factory. In practice, while a considerable number of closed systems exists on the market, it cannot be said that more than a few out of the whole range of components are on the open system. On the other hand the idea of combining the two is being looked at with interest so that, for example, the structure of a closed system (it would have to be a modularly coordinated one) is cladded, decked and fitted with

open system components. In what follows therefore I use the term "modular coordination" as being applicable to existing traditional methods of building but with a distinct bias towards the future standardization and industrialization of the industry. From what I know of it I think this applies to Canada.

We are at this time looking at our own construction industry in the fresh light thrown on it by the change to metric and what is blindingly clear is that modular coordination is one of the key factors which can improve all round efficiency and reduce building costs to the benefit of the nation's economy. It is a government decision to make modular coordination an integral part of the metric change. In any event modular coordination brings with it the reappraisal of all we do in building and I am sure that this new thinking would have come about anyway and the metric change is only serving to accelerate it. By building on our experience you should be able to use modular coordination not only for its own advantages but to refocus your thoughts on such interrelated subjects as communications, standardization of drawings and specifications, classification and variety reduction of products, many of the facets of which have already been discussed today. In short, to review the whole field of standardization of which modular coordination is a part. But let me return from the general to the particular, which is to suggest to you how all this benefits the building contractor.

Of course, compressing a subject like this into 45 minutes is like judging the Miss World competition - it's all good stuff but most of it has to be eliminated. I propose to deal with the matter by a series of rhetorical questions - all of which have been cunningly devised so that the answer is always yes.

1. Does modular coordination facilitate estimating and bidding?

Because it encourages standardization, industrialization and the "kit of parts" concept of building, modular coordination reduces measuring and estimating time. It makes documentation simpler, which enables the checking of the bid to be carried out quicker and with more precision. There are fewer unknown factors due to the virtual elimination of cutting, which means a closer control of the labour content and, since components are accurately sized, the risk element on those components, as distinct from that on uncoordinated traditional materials, is significantly reduced. Once the method is well known, the site snags which have to be allowed for in the bid become fewer. Again, because of standardization, there is easier feedback from the site to provide data for future bids. Similarly it becomes possible to pre-price lists of components and to hold these lists ready for the individual items to be incorporated in bids. If the contract is a negotiated one all the factors I have just mentioned make agreement easier and quicker, and equally everything I have said applies to sub-contractors' work and facilitates their arrangements with the main contractor. Lastly modular coordination paves the way for earlier

computerization on the estimating and bidding processes.

2. Is site layout facilitated?

If the site measurement is basically done in modules rather than in feet and inches, this makes setting out much easier and it is similarly easily checked. The usual way of doing this is to have rods marked in alternate black and white bands. Because components are in 4" increments the first "row", as it were, of components again checks the setting out and enables corrections, though still wasteful, to be made probably earlier than they would be with uncoordinated building methods. If components are used as part of the substructures still less trouble is experienced as this double checking occurs earlier on.

3. Does modular coordination help site management?

Management may be defined as matching available resources with the work to be done, and it is in this field where, given the right incentive, most organizations can improve. By its very nature modular coordination demands good management; the building methods are simpler, but they require to be better planned. Late deliveries or errors in ordering, for example, can hold up the whole job much more with coordinated than with uncoordinated building. Accepting that the quality of management will fit the job, the greater attention to efficient management which modular coordination calls for must result in greater efficiency.

4. Is job supervision simplified?

With the greater degree of component development which modular coordination brings, less supervision is required of the quality of "wet processes", but inspection, rather than supervision, becomes more important. Having approved samples and made random checks the quality of factory fabricated components is assured and as these progressively take the place of in-situ processes the amount of site supervision of mixing concrete and the like reduces. To be effective, inspectors must be different people from the site managers and completely divorced from them. This is rather like the position of the country's judiciary to that of its government.

They should report back direct to head office and thereby provide a check on site management, and they should make irregular visits to the site but provide a thorough check when they do go. The inspectors must understand about methods of jointing and the theory and practice of tolerances. They should provide regular statistical feedback from the site on these matters, not only for the benefit of the contractor but, probably more important, to the designer. Their reports may also influence

the decision of the contractor to buy or not to buy certain products whose tolerances are closer or whose joint widths are within the limits of what he has discovered his men can efficiently handle. I will say more about joints, fits and tolerances themselves a little later, but we must get away from the sort of thinking illustrated by one firm of timber panel manufacturers. In reply to a question "To what tolerances do you manufacture your products?" they replied "We do not work to tolerances, our products are entirely accurate." Obviously you see the stupidity of that remark but believe me, to change the attitude of such people will be a considerable task, which can only be accomplished through education.

Of course job supervision will slip up on the best regulated sites. There was one job in England where this became evident to everybody to the embarrassment of the foreman. They were building a pub (a very commendable project I am sure you will agree) and having completed the cellar and concreted the ground floor slab over it they realized that a concrete mixer was still down there. It took a mechanic several hours of work in taking it to pieces before it could be got out. However this solved another problem, that of a name for the pub, which the clients thereafter called "The Good Mixer".

5. What is the effect on individual workers?

One of the effects on the workers is the tendency of modular coordination to reduce site labour and replace it by factory products. From the point of view of winter working I should have thought this was very desirable in Canada where one of your problems is how to even out the employment of construction industry labour in winter and summer. The site labour remaining tends then to work in skilled gangs rather than on individual tasks and the men become erectors rather than tradesmen. There may be a movement for manufacturers to erect their own products where again the effect on the men is for them to be handlers rather than craftsmen. Mechanical handling will naturally be employed more and the use of equipment rather than of hand tools will become the basic skills of the operatives. Of course what I have just said could and does apply to uncoordinated industrialized building.

6. What time is required to develop skills and adapt to modular practice?

The general consensus is that it takes three jobs before the three main divisions of skilled personnel, operatives, supervisors and inspectors reach a reasonable standard of efficiency. Most people are convinced that the best results are obtained if there is a proper training program, preferably using programmed learning techniques, and that the necessary skill is then developed in one or two jobs. Once the new skills are learned there is a feeling amongst operatives of belonging to the

modular club and they are happily using all the jargon such as "minus tolerances", "grid lines", and "tartan grids" to confound their less well-educated mates. We are all rather like this!

7. How much job cutting of components is necessary and is the general waste of materials reduced?

One of the great savings due to modular coordination of course is the fact that job cutting of components is greatly reduced and it is expected that as the technique develops it will be eliminated altogether.

One contractor has estimated that with his traditional jobs the waste of materials factor is about 5 per cent whereas on coordinated jobs this falls certainly to 1-1/2 per cent and probably to nearer 3/4 per cent. This alone is a significant overall saving. Even so, in our evolutionary state of the art a decision to cut could be cheaper than a considerable juggling of parts. This is a decision which, however, must be made consciously.

8. How can modular coordination speed fitting, erection and assembly?

With components keeping station on the grid the problems of erection and assembly become easier than with traditional building methods especially if measuring by modules is adopted. Difficulties tend to repeat in the same sort of situations so that an original briefing can help to overcome them on the job while something is being fed back into the design to prevent future problems occurring. For example, if it is known that a certain lintel is difficult to fix without adjusting adjoining units, this will be dealt with more easily than if it came as a suprise, and because the trouble can be diagnosed the designer can get on with altering the offending lintel.

Payment by results is simplified and therefore there is every incentive to do the erection quickly.

Where applicable, erection manuals can be used to great effect both on the site and for study before the job starts and these manuals have the effect of highlighting special situations and where special difficulties are likely to occur.

Again training and the proper understanding of the techniques, particularly of joints and tolerances, is important and sometimes it will be difficult to spot where things are going wrong because the operatives are not trained to detect the abnormal. On one site which an engineer friend of mine investigated, the windows were supposed to be a push-fit into pre-formed openings in timber panels. He asked the foreman if there had been any trouble with these. "Oh no" said the foreman,

"no trouble at all". On closer questioning and investigation my friend found that over one third of the openings had been cut or adjusted in some way to enable the windows to be fitted into them. With proper inspection and feedback this difficulty could have been overcome for the future but the distrubing thing was that the foreman found nothing abnormal in this situation. It is a point to be watched in your own training of site supervisors.

9. Is coding particularly applicable to modular coordination?

Coding raises the whole question of communications throughout the entire industry and is one which we in Britian are trying to solve by means of a study commissioned by the Minister of Public Building and Works.

As a firm we are carrying out an experiment with coding in conjunction with the Cosmos system for housing. This system was designed by Colin Davidson who will address you later and it employs the principles of modular coordination. It is an open system although it tends for the present to be used as if it were a closed system. I should further explain that 4 years ago we bought our own computer and that for over 3 years have been processing all our bills of quantities through the machine which literally takes the unsquared measurement sheets in one end and produces a finished document on offset lithography plates at the other. As you know, our system of tendering in UK is different from that in Canada. We, in the main, have one quantity surveyor for the contract, who measures bills of quantities which form part of that contract and which all the tendering contractors price; they do not measure quantities themselves.

For Cosmos we have produced prefabricated dimension sheets in which all the possible situations of the components have been pre-measured. Taking a concrete wall panel, for example, we have recorded the panel and the different fixings it has when it is to be in the middle on an external wall, similarly when it is at a corner, or when it is used in a party wall. All the items in the dimension sheets are pre-coded for the computer, so that the surveyor has only to count the major components and record these in the spaces provided. The sheets then go directly to operators who punch the information they contain on to paper tape. This goes into the computer which prints all the documents required - a schedule of components, a schedule of fixing, and a schedule of ancillary items of work, all of which are incorporated in the bills of quantities. The codes which activate the computer are used on the drawings and are marked on the components themselves so that a complete chain of cummunication is formed from the preliminary sketch drawings right through working drawings and all documentation to erection. In each case a minimum amount of the code sufficient only to identify the part is used and superfluous facets of the code are discarded.

Time does not permit me to go further into this now but I am sure that Colin Davidson would gladly answer questions on Cosmos later on and I certainly would be pleased to do so on our computer application related to Cosmos or generally.

10. How does the adoption of modular coordination prove to be of benefit in increasing productivity and efficiency and improving profits?

This is in the nature of a summary of what I have said, but first I would like to say something further about standardization in general.

Standardization, and this includes the policy of adopting modular coordination, must be a national concept. In UK it was not until the value of modular coordination was recognized and given official blessing that any real progress towards its national adoption took place. In effect I suppose this hurdle has already been leaped in Canada.

The climate of standardization must be such as to allow long runs of materials or components so that prices come down. This again will tend to rely on government support in sponsoring large schemes initially.

There must be every incentive to reduce the number of sizes of components, what is known as variety reduction, for similar reasons. This required cooperation between manufacturers with their trade associations, or - whatever bodies may bind them together. In UK such situations are found in The British Standards Institution and The Modular Society.

Summarizing then, modular coordination has the following advantages over dimensionally uncoordinated building methods with advantages in increased productivity and efficiency as follows:-

Its discipline encourages standardization and industrialization.

It induces variety reduction in components.

It reduces and eventually eliminates cutting.

It is conducive to less waste.

Estimating and bidding time and effort are reduced.

Site layout errors are reduced.

It requires better site management, thereby demanding efficiency.

If inspectors are separated from site supervisors, important feedback is gained.

Provided that the principles of the method, and especially those of joints and tolerances, are known, site labour is reduced.

It will help to even out winter troughs and summer peaks of labour, particularly for Canada.

Coding, and therefore effective communication throughout the industry, is more easily applied.

In conclusion I would like to quote the Economic Commission for Europe report. It said "Dimensional coordination in building has now developed, from being an interesting subject of discussion among a limited number of experts, into a necessary means for a further significant increase in productivity in building. In other words the purely technical and theoretical stage of development has been passed and the implementation stage has arrived."

B. COMBINATIONS OF NUMBERS

I want now to change the topic, slightly, to another aspect of modular coordination, and in this would like to introduce you to the subject of combinations of numbers. In the time available it can only be an introduction, but I hope that not only contractors but designers and manufacturers will find something of interest in it.

What are Combinations of Numbers?

Combinations may be defined as the grouping of component sizes. They can best be illustrated by a simple example.

Take two panels, one of 3 modules (1' 0") and one of 5 modules (1' 8") wide. Using any number of each, these can be put together to form combined widths of 3, 5, 6, 8 and of every consecutive width greater than 8 modules wide. 9 = 3 at 3, 10 = 2 at 5, 11 = 5 + 3 + 3 each.

Combinations are, simply, the ways in which components can be put together to fill spaces.

Why are Combinations important?

Firstly, they help manufacturers to adopt the most advantageous component sizes - sizes which will (1) fill the most spaces and (2) give the greatest number of assemblies. In other words, using the principles of combinations, the right ranges of components will be produced.

Secondly, they enable designers to make the best possible choice from the component sizes available. This is extremely important because, with a knowledge of combinations, the designer can retain freedom and flexibility. Let us be honest about this. There is a fear that the use of modular coordination and the increasing use of industrialized building techniques will stifle architecture and reduce it to a Meccano-like process within rigid limitations. Nothing could be further from the truth if the practical use of combinations is fully understood. Furthermore, the proper use of combinations will also bring about greater efficiency in the use of traditional component materials.

Thirdly, combinations give guidance to builders, where the choice is left to them, on the optimum numbers/sizes of components which can be used to fill given spaces.

Combinations are, for these reasons, an important factor in the economics of building.

The Table of Critical Numbers

What is a Critical Number? Let us go back to the two panels. They combined to form 8 and every width greater than 8. 8 is therefore the Critical Number of 3 and 5. It is the number at which they begin to fill every space - the number at which they "spark".

From now on I shall refer mainly to whole numbers but, as you will have already realized, those whole numbers may be modules, miles, millimetres, rods, poles or perches; it is the interrelationship of the numbers which counts.

What are the Practical Uses of the Table of Critical Numbers?

One typical practical problem might be this. A manufacturer has decided to continue to make two sizes 9M and 11M (3' 0" and 3' 8") because of his existing plant. He would like to make a third size as large as possible but yielding a Critical Number not greater than 48M (16' 0"). What third size would he choose? A look at the Table will tell us that it is 30M (10' 0"). (Appendix 2)

What is the Combigraph and what can it do?

For architectural planning, we need to know not only that a particular space can be filled by certain sizes, but by how many of size a, how many of size b and how many of size c.

The Combigraph tells us. It is a design tool which has two objects. (1) to illustrate the basic patterns and (2) to enable us to read off the actual combinations. (For further details see: P.H. Dunstone: Combinations of Numbers in Building (Estates Gazette Ltd., London)).

CONCLUSION

In conclusion, may I say again what I said at the beginning about the importance of combinations?

1. They help manufacturers to choose the right sizes.

2. They enable architects to use components and yet retain freedom and flexibility of design.

I submit that architecture must move with the new methods of building which are emerging or be overrun by them and I believe that the use of combinations of numbers can be a big factor in its continued mobility.

C. THE MODULAR SOCIETY

Most of what you have heard at this conference originated in some way with The Modular Society of London. I would like if I may to take up a few more minutes of your time in telling you something about the Society.

It was established 15 years ago and since that time has been ceaselessly engaged in carrying out its aim "to increase the efficiency of building by promoting the development of modular coordination and to improve the standard of architectural qualities of standardized components".

During that time it has come from being a voice crying in the wilderness to one which has been heard and heeded by the government, which has now decided that, in conjunction with the change to metric, dimensional coordination shall be accepted by the constructional industries as a basis for future operations.

In all that time and in the struggle that has occurred the strength of the Society has been in the multidisciplinary nature of its members. Architects, contractors, engineers, manufacturers, quality surveyors, sub-contractors and suppliers have provided and are continuing to provide a forum and centre for discussion and experiment for the construction industries in the whole field of standardization.

I have taken most of my words from the foreword by Lord Holford to the 1967 No. 3 Special Issue of The Modular Quarterly which sets out to review the activities of the Society at a time when, having achieved its primary objective, it now goes on to widen its activities.

One of the objects of this series of conferences is to promote the acceptance of modular practice, through the dissemination of knowledge, as a means of increasing productivity.

May I suggest that you think along the lines of forming a similar society in Canada to do just that. As a non-profit-making company and with a membership drawn from all sections of the construction industry it would have the strength to carry out that object, which must be to the benefit of Canadians as a whole. I know I can speak for The Modular Society in London when I say that we would be glad to give you any help we can in the formation of The Modular Society of Canada.

ADDRESS

BY

COLIN H. DAVIDSON

CONSULTANT, INDUSTRIALIZED BUILDING

LONDON, ENGLAND

MODULAR COORDINATION AND THE INDUSTRIALIZATION OF BUILDING

At the risk of making myself unpopular with the sponsors of this series of conferences, I want to shift the title of our discussion slightly from its official MODULAR COORDINATION AND THE INDUSTRIALIZATION OF BUILDING to a wider one - INDUSTRIALIZATION AND COORDINATION. There is a subtle difference which I hope will be clear from what I have to say in the next few minutes.

I intend to make a few introductory remarks, talk about the Industrialization of Building as other people see it, then I shall have to declare what I mean by the Industrialization of Building so that we can communicate about it on the basis of a common understanding. I will postulate two notional rules about industrialization: the rule of "effective repetition" and the rule of "hereditary bias". I will give one or two examples of what people have been actually doing in the name of "industrialization of building". At the end, we will speculate about trends for tomorrow.

There are two things I must say, by way of preamble, about industrialization: Firstly, I do not identify industrialization with prefabrication; they are not necessarily the same thing. Secondly, much as I would like to think all industrialization is attuned to the great innovative capabilities of our century represented by the more novel forms of building, it is not necessarily so. In describing industrialization, I am talking about something eminently practical, something that we can do today without necessarily going out to the extremes of imagination and invention. We may think of a Fuller dome-house or an experimental Russian room-box made entirely of plastics or the folded-paper houses put up in the Sacramento Valley, California for migrant farm workers. I am not implying that these are not industrialized but I am saying that without doing this sort of thing, we can none the less qualify for the title of industrialized builders.

In the building industry, as illustrated by this diagram, we are - as we know only too well - operating in a fragmented way - as so many individuals. I must ask you to pay particular attention to this diagram (Figure 1); at several stages during the next few minutes, we will be looking at variations of this diagram and it is important to memorize this one in order to identify the variations.

This, therefore, is the situation today: we have a body of people known as the client, but as far as any one of us is actually concerned, there is only one client at a time. This client instructs the architects on a one-way, once-off basis (by the word architect I include the engineering professions). These people then interpret the client's requirements to carry out a set of drawings describing what is to be built.

The building contractor, at the end of this line, receives the instructions describing what is to be built and devises how to do it himself. We have, on one side, as it were, a group of other people: the category of manufacturers. They are not related to the architect. The manufacturers are linked to the contractor once an order for specific goods is issued; there is no other communication between them except perhaps through the mechanism of Sweet's catalogue and the sales representative.

Within this fractioned industry of ours, it is not surprising that everybody nowadays who is in any way involved with industrialized building defines industrialized building in a specific and personal way, suited to his own specific vested interests.

The client defines industrialized building in one way, the professionals in another, the contractors in a third and the manufacturers... in many other ways.

To the contractor the acme of industrialized building is the well-organized tract where everything is pre-packed, pre-cut, delivered to the site in house lots. There is, in fact, a production line set up on the building site with the workers moving from one work station to another (instead of the more typical industrial method where the product moves from one work station to another). The timber product manufacturer might identify industrialized building with pre-framed wall panels and pre-cut plywood sheathing - panel construction, in other words. The manufacturer of an ingenious cold rolled channel used for advertising hoardings and things of that sort, thinks that industrialized building is accomplished if he can penetrate into the building market with a space frame system using his cold rolled sections.

Jean Prouvé - working in France for a sheet metal concern (actually railroad car manufacturers) came up with an extremely elegant house-building system, obsessively slanted, however, towards use of sheet metal - as we would expect. Other people again will see the true industrialization in the Kozlov Rolling Mills in the Moscow region, which turn out ribbed concrete panels on a continuous conveyor belt.

And, of course, the mobile home, plausibly an industrial product. Nobody in the building industry would admit that this is an industrialized method of meeting a building problem because a very large and effective industry quite separate from building is doing a building job for us.

Other people, of course, have quite different attitudes to the industrialization of buildings. We note the activities of a plumbing sub-contractor working for the Balency System in Paris for whom pre-jig plumbing is a dream of what industrialized building should be. Not surprisingly, I must refer to the brick as an industrialized product; it is made on continuous production line principles by the million,

day in and day out (the number of bricks needed for the average British dwelling is about 5,000 bricks representing only 60 man hours of work, delivered in a load to site).

We must recognize that there is another category of person who has quite a different vested interest in (or feeling towards) industrialized building: the union members, who often have a vested interest in the status quo. I do not wish to appear cynical about their concern for the status quo. We are coming face to face with a management problem of some sort attributable to a failure in communications. Somebody does not know what the other person is doing and he gets worried — there is a typical lack of co-ordination.

From what I have been saying, it is not surprising that many people in the building industry should have many partisan views of what industrialization is. I must make it clear what I understand the industrialization of building to be. I am not going to invent a new definition of industrialization (as there are far too many already). I shall quote from Ciribini, INDUSTRIALIZATION IS A PRODUCTIVE METHOD BASED ON MECHANISED AND/OR ORGANIZED PROCESSES OF A REPETITIVE CHARACTER. We are concerned with the <u>way</u> things are done, the "how". The key to industrialization lies in the "mechanized, organized" processes, on the one hand and the "repetitive character", on the other.

We can visualize the process, the way things are done, the "how" as a question of degree, ranging from the manual operation (palpably non-industrial) to the automated cybernetic machine, programmed to carry out a set of operations. We have the embryo of a method of ranking of industrialization. It is possible (without for a moment going into a great deal of detail) to measure industrialization more systematically than by reference to such and such pieces of equipment used in the processes. For what it boils down to, is using mechanized and/or organized processes, as a substitute for manual labour of the more primitive sort, using in its place machines or organized labour working at a much higher level of sophistication and productivity. Therefore, we can measure the degree of industrialization in any process or set of operations by comparing the incidence of direct labour costs (L) to the value added by the process or set of operations (T-M where T is output price and M is input materials costs). I, the industrialization rating:

$$= 1 - \frac{L}{T-M}$$

Incidentally, T the total price, is made up from L (direct labour), O (overheads), C (capital charges on plant and machinery), M (materials input) and P (profits). This formula $I = 1 - \frac{L}{T-M}$ is valid as such in a competitive market situation, though in certain other circumstances a correction coefficient has to be introduced.

Industrialization is a question of degree; processes can be less or more industrialized. To put figures to this "I", I have made several surveys; for example: with traditional building as carried out in England, the index works out to about .25 or .3; in the field of heating and venting sub-contracting, the equivalent figure works out to .53. Mobile home manufacturers in the United States have an industrialization index of about .65, and .7 might be the highest figure to be found in today's materials or components manufacture. Let us remember that this index applies to process sets of operations; in any production sequence there is a large number of operations each of which may be at a high or low level of industrialization. If we consider, for example, the production of standard metal windows you recognize that some of the processes are fairly mechanized and some of them are still extremely manual, particularly the transfer operations — moving window sections from one work position to another.

We must recognize that if we consider the whole set of operations in a process, like, say, building, we can expect to see some processes which are highly industrialized and others that are less industrialized.

Looking at the industry as if we were in the position of "Big Brother" (or perhaps the Department of Industry), we might be able to take an unbiased statistical overall view of the building industry and see that, so and so is not doing very well in the industrialization of his processes, so we could warn him, so to speak, that in this mid-twentieth century of ours, he is less industrialized than all the other people involved in the other operations in the process. Conversely, we could look at the statistics and see that someone else shall we say making bricks, is doing very well in terms of industrialization rating; in fact he is not likely to represent a problem.

But the building industry does not operate in terms of Big Brother. The building industry, it is true, pays lip service to such things as the need for building or the need for greater productivity in the use of the Canadian dollar etc. etc. but — if truth be known — it actually reacts to immediate and real problems, to detect what we can do to improve our methods of operation at a much more industrialized level.

I mentioned that there were two rules of this industrialization game; the game in which we replace primitive forms of labour with mechanized and/or organized processes. The first of these rules of the game concerns "Effective Repetition".

From the evidence I have, there is no doubt whatsoever that where there is effective repetition, there is a good return in the form of a reduction of costs, leading to a wider margin — a bigger slice of the cake — to be split between the producer and the client. In order

to stress this point I want to quote from Conrad Wachsmann who has written: "The principle of industrialization is identical with mass production. The machine, or series of machines or an automatic factory constitutes completely irrational expenditure of capital or energy.... in relation to a single manufactured article. Accordingly, the machine can only be understood as a tool that continuously repeats a predetermined cycle of activity, becoming economical as a result. This self-evident fact is a source of all the consequences by which the industrial process is determined.

Statistics relating to the production of flush doors in Sweden show that the cost per door goes down from about 43 Swedish kroner for an annual production of 150,000 doors to about 35kr. when the annual production is 400,000. There are certain provisos that should be made which concern particularly the question of variety reduction. These economics only hold true if the number of models of doors (different types) being produced is kept constant at a fairly low figure. If the number of models of doors goes up due to an increase in the variety being asked for, then the cost savings factor is set back considerably, though probably not completely offset.

Operations on the building site also respond to the same sort of economics. French statistics relating to the placing of large concrete panels in what are now the "traditional" large concrete panel methods of prefabrication show significant savings in time as the number of repeats increases; (beware, time saved is not the same thing as money saved). This same phenomenon incidentally, has been observed on many different building sites with very similar results in each case. I must repeat, that these are times saved: whether this is money saved or not depends on all sorts of things such as the bonus rates being paid to workers, the importance of indirect costs and things of that sort.

In the hard facts of building today, these reductions in costs do in fact presuppose one thing; ultimately the best of success is being able to use this repetition effectively and continuously so that you get good utilization of whatever plant it is that you may have invested in to reduce costs below traditional. There is no escaping the fact that the manual operations that we have been using for the last two or three thousand years are extremely adaptable, whereas the mechanized process relies on repetition. If you cannot use the repetition — if the utilization of your investment is low, there is no escaping the fact that the cost will up and almost certainly go above the traditional comparative costs.

The next rule of the game, if you remember, relates to this question of what I call "Hereditary Bias". There has to be a decision about what is it that we are going to repeat. The answer to this question of course depends on who it is asking the question. It would be easy to find the answer; we would repeat 707's and 727's. We could afford to set up an enormous factory not only because we have this known market of, say, 300 aircraft, but we also know that we can sell each one for a price about 3000 times the price per square foot of the average house (with the 3000 times factor of safety it is possible to put up quite a big factory). In the building industry, things are not quite like that, and that is why I stress that the answer to the question, "what do we repeat", depends very much on to whom the question is being addressed.

I would like now to turn our attention to one or two case histories, showing the answers people have produced to this very question in various countries in the world. Let us consider first of all the case history of a building contractor sponsored method of industrialized building. (I am thinking of some in France but it could equally well be in Britain or this country or the United States.) Now what happens is this; the building contractor puts around himself a new kind of organizational network (Figure 2). He assumes the characteristics of manufacturer for a number - a large proportion - of the products that go into the building. (Admittedly, there are some manufactured goods left outside for I would not like to imply that the building contractor actually makes e.g., the electric light fittings and things of that sort). So far as the structure of the buildings is concerned, the contractor assumes the characteristics of a manufacturer. He also has somebody on his team to whom I have given the euphemistic name of Architect - he might be a production engineer, industrial designer of some sort or other, but there is somebody within this organization who determines what the product is going to be like as well as how it is going to be made. The client who may wish to purchase one of these buildings is left out of the organization; he may possibly retain an architect to advise him on value-for-money, so to speak, to advise him in a professional capacity that the package product being offered is or is not a good buy. There is quite a difference already in organization compared to the traditional disorganization to which I referred at the start.

To look now at the actual techniques of building used by this sort of contractor, the aim is to avoid the problem of organization, problems of logistics by which the contractor's life is bedevilled. It would be ideal to receive on the building site room-sized walls, and floors that arrive, (we shall see where from in a minute) complete with windows in them, inner face, outer face, insulation, electric conduits, casting and all that sort of thing. Once these things arrive on the building site a team of four unskilled men and a crane driver can enclose one room every fifteen minutes all day long.

To be able to do this on the building site, you have to have a factory with a stockyard in which to accommodate the wide variety of walls required for this site. In the stockyard we can expect to see stacked up in a very precise order floor panels, floor panels with the notches out of them, window wall panels, internal wall panels with a couple of ducts, internal wall panels of another sort, internal wall panels of kitchen vents, internal wall panels with a small and big door, etc. etc.; you can easily conceive the tremendous organizational problem that this represents. We shall soon see how this comes out.

The factory that this contractor sets up for himself will be a large covered area with steel mould tables, steam curing; the actual production processes are still pretty primitive - the concrete is spread by men with boots and shovels.

This arrangement was devised by the contractor in response to the question "what shall I repeat, I want ready-made walls that I can assemble very quickly on the site". The contractor is not concerned about achieving a high level of industrial efficiency in his factory. If the market were of the extent that the production engineers of the Soviet Union have for themselves, with building sites which stretch on for miles, it would be possible to set up a factory with mooring links where wall panels could be made all identical to each other, following each other past each work station. There would be another line for producing floor panels, also all identical to each other, and yet another line producing internal load-bearing walls.

This brings up another radical failing that the contractor by his nature was unable to overcome in asking himself "what should I repeat" and in setting up a new kind of organization. The "ideal" building to prefabricate is the large, rectangular slab-block. This is broken down into the different kinds of panels that are required and these are scheduled.

Industrialization is only possible with a program of building (spread over several individual projects); when one project is nearing completion, the sales representatives go out to look for new clients and find themselves forced to say "well look, we have got this capability already set up, I wish to goodness you would order some buildings of this sort from us". But if the client says, "well, I just do not like your buildings, I will not have this kind of building", the next suggestion has to be: "at least let us use our moulds - this one happens to be, say, five metres twenty-one long - let us have some walls that are five metres twenty-one long". (I can assure you that I have seen in the production department of one of these contractor-sponsors, several different projects for several different clients, where this particular measurement of five metres twenty-one occurred).

People have in fact been observing this sort of shortcoming, and have seen various other more recent approaches to the problem of trying to sort out dimensions to find some more natural common factors shown between successive projects. In the case of one system sponsored recently in the United Kingdom, it was appreciated that in pre-cast concrete technology, instead of producing identical components out of the mould every time, it is possible to devise telescopic moulds which will produce similar components, not identical ones. In this case the thickness is kept constant, as is the second dimension, the height in the case of wall panels; the length increases in a predictable way by means of adjusting the telescopic stop-end. In this particular system, for various reasons, the increment of length of mould was in multiples of four inches, (actually eight-inch increments).

There is another stand that can be taken where the panel sizes are standardized, in one case in multiples of four feet. In both of these cases, much more sophisticated equipment can be set up in the factory, because it is possible to predict what it is that is going to be repeated. The selling is also a great deal easier, because it is possible to describe to potential clients the factory capability in terms of the production rules. These are the rules of the game. It is no coincidence that the four-inch module is the basic increment common to these two cases. Other groups of people have been innovating. The CLASP* building system stems from an initiative by a building client - actually a group of school boards who, recognizing the fact that they had a continuous demand for school buildings for years to come decided to pool their demand and program it so that they could devise some new method of building to satisfy this demand. In terms of organization the client employs within his own organization an architect acting in a kind of industrial design capacity to develop the components. He also employs the project architect (within the same office) so that there could be quite a lot of communication between the industrial design type of system-architects and the individual project architects (Figure 3).

Some component manufacturers are involved to a certain extent in the co-ordinated activities by being given yearly program bids. The building contractor who has to put these components together is not brought into any new co-ordinated relationship with the client, designer or manufacturer.

From the programming point of view, annual charts are prepared with an entry corresponding to the name of each school, its national gross capital cost in pounds sterling, and the predicted calendar date of starting. We are clearly talking here about a co-ordinated program of building, the essential prerequisite for setting up a new method of building.

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*Consortium of Local Authorities Special Program.

The sponsoring team, architect-dominated as it was,set a high priority that schools should not all be identical; they devised a kind of erector set with a "hundred and one" different parts. Schedules of standard components, such as column heads and column bases are prepared, together with standard component and assembly drawings. In fact, all the working drawings are done before the project drawings. Standard drawings show how the various assemblies occur with relation to grid lines. Thus, when a start is made on the project drawings (after the working drawings as we saw) they can be simplified considerably. Some of the project drawings start as simple master sheets which can be built upon to produce not only framework drawings, but roof panel drawings and so on and so on, right through the whole building.

There can be no doubt, however, that it is possible to design quite different buildings with this kit of parts - these hundred and one components; the project architect can obtain steps in building height, junctions, offsets, underpasses, overpasses, junctions between single-storey and two-storey buildings etc. etc., reflecting what he feels the particular school program requires. The manufacturer, as I said a moment ago, may well find that the component ranges still contain too many different types - too many for effective variety reduction. In an attempt to bring site assembly under control, it has been necessary to produce a network analysis - while it is time that this network is common for all buildings constructed with these components, it represents a considerable complexity for each job for each individual contractor. Incidentally, if we were to have drawn up the network analysis for the large concrete panel system that we were looking at earlier, the "network" would have been a straight line (perhaps the ideal from the building construction point of view).

It is found that other groupings of people have been organized. I refer to the SCSD program in California, where the manufacturer was brought into the picture, in a really deliberate and considered way. The client with his program advisor sent out a big bid invitation to manufacturers, in the form of performance specifications. It was suggested that to respond to this invitation, they should form themselves into groups to tackle the program of work.

The manufacturers, as you well know, provided the systems responses. However, the individual project architects were not brought into the coordinated organization, indeed there was very little communication between the project architect and the system-manufacturers (Figure 4).

The component ranges, as you know, for the SCSD project comprise: structural steel frame, the heating and ventilating system, the lighting and ceiling system (with the heating and lighting outlets in it), the fixed partitioning and movable partitions.

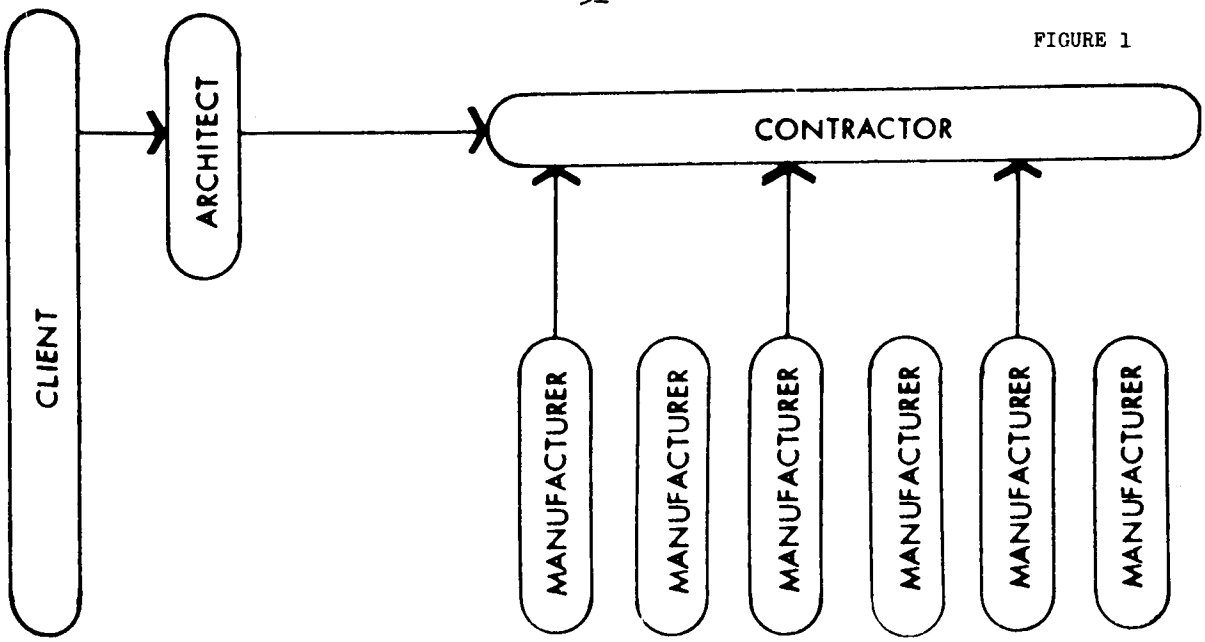
Other combinations are possible. For example, there is the example of a building system that was developed a few years ago in Great Britain, where we find a group of manufacturers who, on their own, formed a consortium together with an industrial design team, to devise a sort of co-ordinated meccano set for low-rise housing performances. There is good co-ordination between the manufacturers and the contractors and their design team, but they are not attached to, nor co-ordinated with, any specific program of building. They are not attached to the client (Figure 5).

All these arrangments are showing that present day attempts at co-ordination - total organization co-ordination - are somewhat incomplete. Coming back then to our point of departure, it is clear that we have been discussing various deliberate systems responses to the question, "What is it I shall repeat?". To do so, new organizations were set up. As I have also been implying, none of them have a complete co-ordination coherence. In each case, it is either the client or the manufacturer or the contractor who is left out of the organization, so that system response is only partially complete. There is another kind of industrialization which I would like to discuss and that is the kind of industrialization or innovation that does not require the systems approach of the sort that we have just been reviewing. An increase of efficiency can be obtained through ingenious ways of doing small building tasks. I refer to the kinds of innovation such as sprayed plaster, dry lining, nailing machines use of skill-saws on the site, little fixing accessories sold with basic materials and all that sort of innovation. These are little ingenious ways and means that make building a great deal easier. They mainly affect the building as a product, but have a considerable effect on the way it is built.

Precisely because of the significance and efficiency of these small innovations many people are claiming that the way forward lies in recognizing that the building industry is made up of independent parties; we should avoid, it is stated, the systems response, and concentrate on the small innovations deliberately. We should increase its scope by introducing into it the kind of rules of co-ordination typified by Modular Co-ordination.

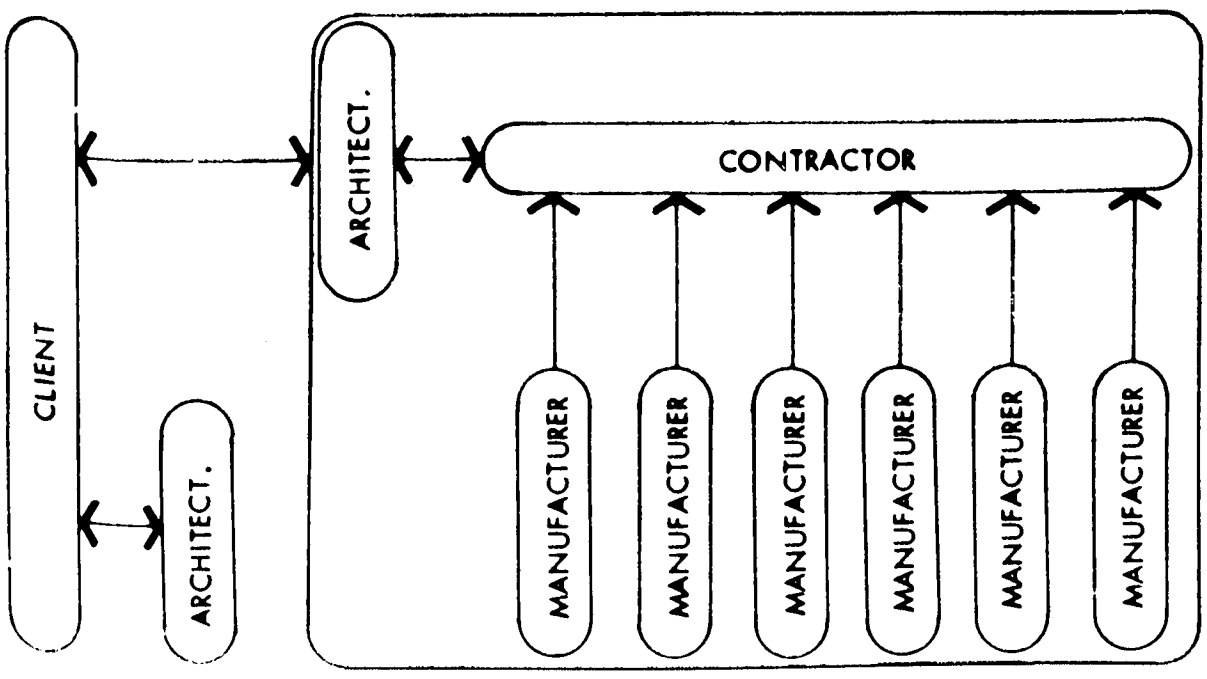
If the way forward is to be through taking advantage of this kind of innovation in building it is absolutely indispensible to impose as many rules of co-ordination as possible, to make up for the absence of systems disciplines. Let us get the dimensions right first of all, then come face to face with the other equally important problems; jointing techniques, tolerances, assembly rules, handling procedures etc. We have, on the one hand, the systems approach, with deliberate - if incomplete - attempts to co-ordinate the organization as well as the techniques of building. We can have, on the other hand a general level of improving methods, co-ordinated only by a new building knowledge. Modular co-ordination is necessary for both. It is a first step without which it is not worth proceeding any further.

FIGURE 1



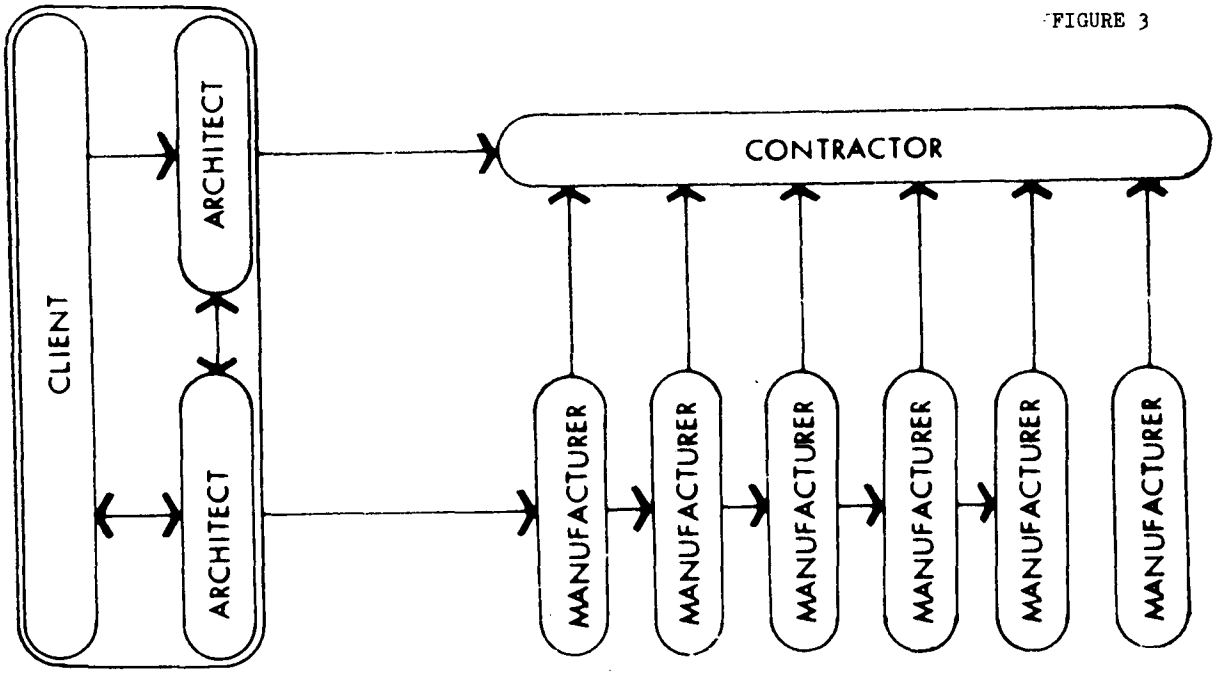
The architect as independent designer. The participants in the building activity are only connected by the one-way flow of information or instructions. Some manufacturers sit on the side lines

FIGURE 2



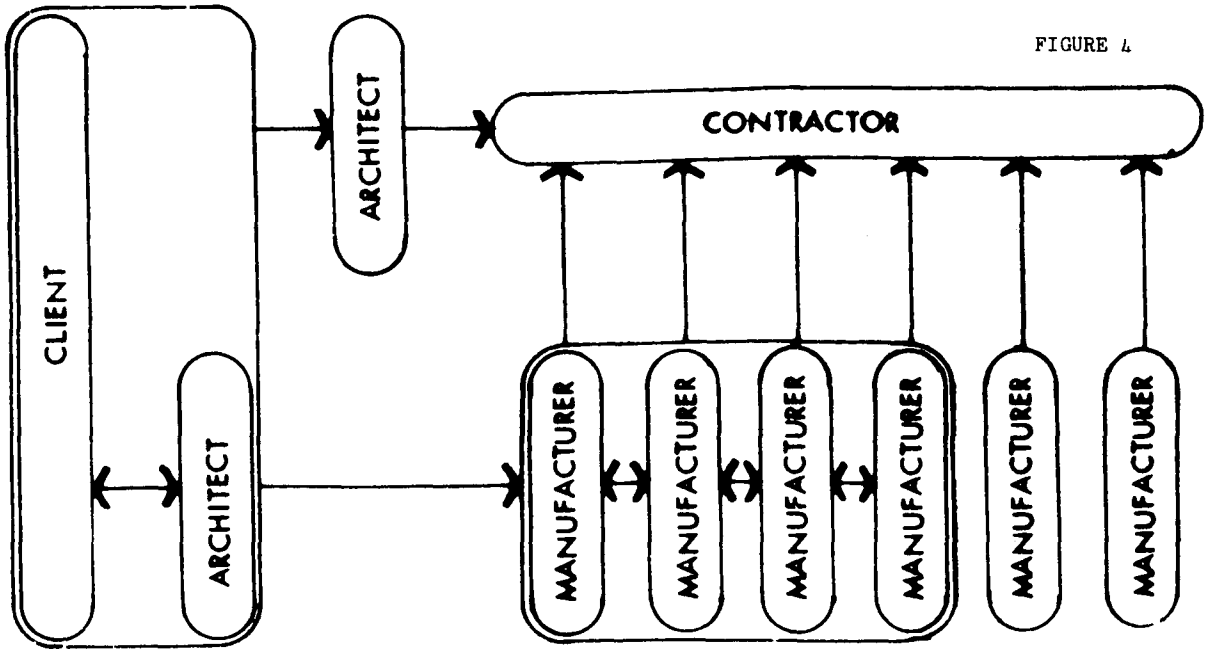
The architect as consultant to contractor. Here the contractor takes on an organising role involving design and manufacture; the market is still outside

FIGURE 3



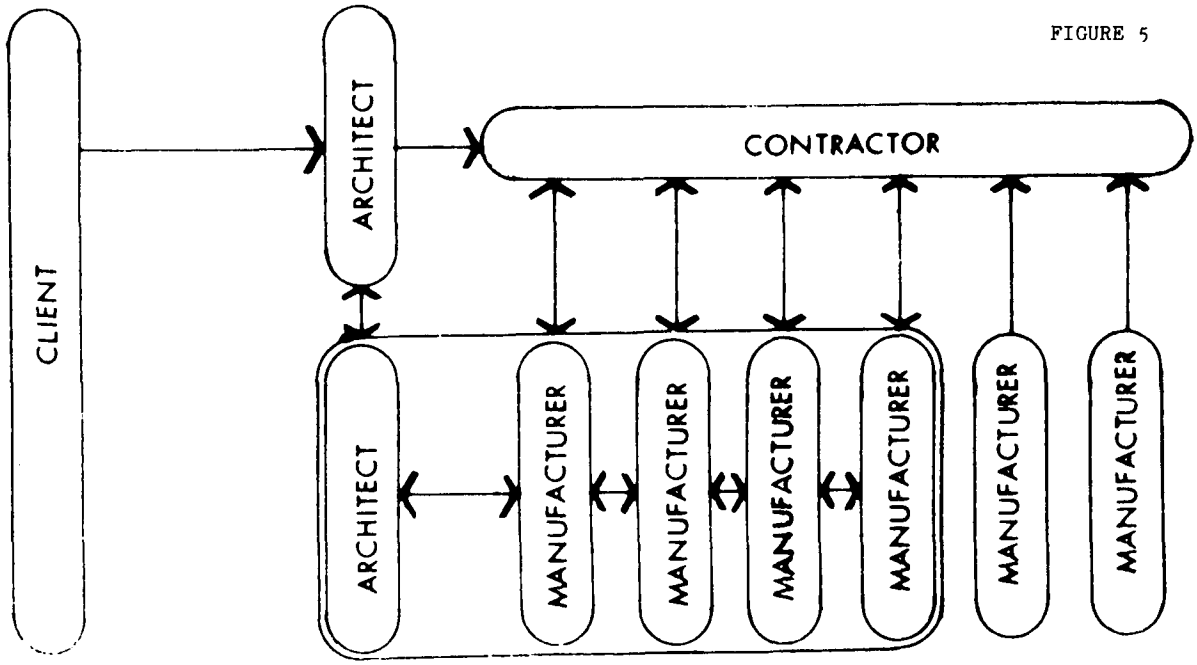
The architect as consultant to client for system development and project design. The design and market are closely related; some connection with manufacturers are established

FIGURE 4



Architect as consultant to a client, for system development only—for example, SCSD. Manufacturers are now fully involved, but links with project architect and contractor are weak.

FIGURE 5



Architect as consultant to a consortium of manufacturers. Another method of involving the manufacturer, but exposed to the uncertainties of the market

P A N E L

D I S C U S S I O N S

BIOGRAPHICAL SKETCHES OF LECTURERS

LENNART K. BERGVALL holds, among other appointments, those of Chairman of the Swedish Committee on Modular Coordination, Vice-Chairman of the Technical Board of Standardization in Sweden, Chairman of the International Modular Group and Adviser to the U.N. on Modular Coordination.

He obtained his architectural degree from the Technical University of Stockholm in 1934, and since 1944 has headed, with E. Dahlberg, the Home Building Research Cooperative, a private company in Sweden dealing exclusively with development work in the building industry.

COLIN H. DAVIDSON obtained his Bachelor's degree in architecture after training in Liverpool and Brussels, and took his Master's degree at M.I.T. in 1954. Following work on a number of housing projects in Italy, Britain and the U.S.A., he studied the use of industrial techniques in building and set up his own office as consultant in 1962.

At present, he is teaching at Washington University, St. Louis, Mo., and is part-time Director of a Building Industrialization Research and Development Unit being built around his course. He is also engaged in a project for Building Research Station, and has a number of other consultancies.

PHILIP H. DUNSTONE is a member of a family that has been associated with the building industry for six generations. Beginning his career as an assistant quantity surveyor in 1938, he started his own firm in partnership with Kenneth Monk in 1951, and has a vital interest in the application of computers to the building industry.

Of Mr. Dunstone's extensive published work on computers and the metric system, one book, Combinations of Numbers in Building, is a pioneering work, highlighting modular coordination and industrialized building. In Britain, he is a member of several government and professional committees on computer and metric work, and is also a member of the Council of the Modular Society.

STANLEY R. KENT received his Bachelor's degree in architecture from the University of Toronto in 1944, and a Master's degree from the University of Liverpool, England in 1966. Following a number of years in private practice, he joined the National Research Council in 1950 and was appointed Principal of the Council's Division of Building Research in 1956, with the part-time duties of Assistant Research Officer and Consultant in charge of the Modular Coordination Project.

Professor Kent has held several academic appointments at the Schools of Architecture of both Toronto and Liverpool Universities. In addition to publishing many articles on the subject of modular coordination he is the author of the NRC's Modular Drafting Manual, and has delivered a number of papers on the subject to professional groups in Canada, the United States and Europe. He is a member of the Royal Architectural Institute of Canada, the Modular Society (U.K.) and the International Modular Group.

PANEL DISCUSSION

at

THE NOVA SCOTIAN HOTEL, HALIFAX

on

OCTOBER 17, 1967

PANELISTS:	L. K. Bergvall C. H. Davidson P. H. Dunstone S. R. Kent
MODERATOR:	D. M. Blenkhorne
CONFERENCE CHAIRMAN:	L. E. Shaw

MR. D. M. BLENKHORNE: I have a question to start the discussion: What training facilities and requirements are needed to assist the industry in adjusting to changes necessary in the adoption of the modular concept?

MR. C. H. DAVIDSON: The compartmentalized training we are offering architects and the more practical training of the manufacturer or contractor result in not understanding each others' problems. When we know more about putting things together as they arrive on the site, we will then immediately identify all the aspects of modular coordination which we have talked about today.

MR. BLENKHORNE: How does the saving of time relate to saving money?

MR. L. BERGVALL: Time is money. You may save time all through the whole building process by modular standardization from the design function to purchasing, and until the building is delivered to the owner. Everything could be put in terms of time, even materials, as they have certain costs because of the amount of time it takes to produce them.

MR. J. DEROME: With respect to the big demand we have for schools, due to the population explosion, and the increased need for housing, the saving of time in the production of a building is very important. I think, therefore, that this question of the time factor is very important.

MR. BERGVALL: You mean, regardless of the dollars saved, time is often the important thing?

MR. BLENKHORME: Yes, but frequently time is saved at considerable cost.

MR. S. R. KENT: There are two additional points I would like to bring in here. The first is the cost of money. Most of our projects are done with borrowed money. Money costs money and the longer money is tied up in a building project, the more expensive the project is for the owner. The second point ties in with industrialization and the utilization of labour. On the construction of the University of York, England, the project had to be completed by a specific date, and if the work was to be done by the traditional method, it would have required the whole labour force of the city of York and surrounding area for the duration of the project. This, of course, would have been completely impractical because of the intensive construction in that part of England. For this reason the CLASP system of modular components was selected, so that labour in factories could be utilized to make assemblies which could be site-installed with the available work force.

MR. BERGVALL: Often shortages, such as shortage of labour, buildings, or both, tend to result in innovation. When we talk about modular coordination, we are talking about building a foundation for the future of the construction industry. The distinct pattern on which we create the industry should be based on the fact that time is money and money earns money. Whatever situations we may foresee resulting from present or future

problems, we should recognize that modular coordination is a means of saving time with little expense on our side. That is very, very important.

MR. R. E. JOHNSON: I believe most of the modularly designed buildings from your office, Mr. Blenkhorne, are of conventional construction. If so, will you comment on modular coordination in conventional building.

MR. BLENKHORNE: I am not too sure if I know exactly what you mean by conventional. Do you mean masonry?

MR. JOHNSON: That is correct.

MR. BLENKHORNE: I do not see where there is any difference in designing the building using masonry or more highly industrialized methods. I would like to bring out the point that a coordinating system is equally beneficial for conventional or industrialized building.

MR. KENT: In the examples illustrated by Mr. Davidson this morning, where the so-called industrialized work methods were used - precast walls, floors, beams, etc. - you may have noticed that they were supplemented by traditional trades as well. Both were brought together efficiently through the modular system.

MR. BERGVALL: As a matter of fact, very few systems of building are really conventional and many conventional buildings of today are well advanced as compared with those of yesterday. No system is fully closed. No one is making his own paint, pipes, boilers etc., and that is because these items are available for open system work. Also, most of the more advanced and familiar systems show the buildings in cities, which is one reason that only rarely are they very much cheaper than conventional methods employing much less skilled labour on the building site. The flats in the U.S.S.R. are known all over the world for their use of prefab components which are made in a continuous operation: concrete is poured in one end and finished components are produced at the other. But the interesting thing is that the reports from people who have travelled much and studied these matters, show that outside particular regions, very rarely can one find any place where fully prefabricated buildings are erected. Usually all the floors or subfloors are made of prefab slabs, and the walls are of brick, etc. Now these prefab components can be combined, and every company must have a good stock of wall-bearing components and a good stock of floor components. But suppose that one of these companies concentrates on floors and another concentrates on exterior walls, etc., you would then bring all your products together to achieve a previously unknown perfection.

MR. P. H. DUNSTONE: I would like to give a direct and simple answer to this question. Let us assume we have a transformer chamber and we have a shelf to go into a transformer chamber. If we could design the transformer chamber on a four-inch modular system, and the shelves were in increments of four inches, we should be able to arrange the shelves without any cutting.

MR. MARSHALL: I understand the manufacturers of doors in Canada have standardized the height of doors. Will you please comment on what the modular height should be.

MR. BERGVALL: The size of door leaves fitting into ordinary door frames was discussed at the International Standards Organization meeting in Brussels and it is an interesting problem. When you have a concrete floor and the blocks are being laid up from the rough surface of the slab, then coursing begins from that surface. Then if you invert to make the door modular, the door frame starts from the finished floor and the top of your door will be just so much higher than the level of the nearest modular block.

MR. BLENKHORNE: We have solved that problem by building up the rough floor under the walls to the height of the finished floor, or by using a six-inch block.

MR. KENT: There is another point to be brought out and that is: Do we standardize door and door frame, or just the leaf?

MR. MARSHALL: Well, my opinion is that it is not the door which matters, even when the door is made in standardized sizes. To me, modular sizes should allow for the frame and trim. In talking about your concrete block, I would like to think you are working to a four-inch module, so that the door frame should fit within an eight-inch multiple. Don Blenkhorne said perhaps you would want to introduce the idea of building up from the subfloor with the finished block, but I think you are aware of some of the problems that can happen.

MR. BERGVALL: You will remember that I made the distinction between general coordination dimensions and modular coordination. The door leaf should be coordinated with the door frame, and nothing else. The door frame is the only thing which must be modulated, but both of them must be standardized,as you quite realize.

MR. RUSSELL: I would like to ask how saleable are houses in the U.K. which are not given to people. In Russia, houses are given to people, and they have no choice as to what they get. When it comes to the construction of a house for private enterprise, the problem is one of sales only. As a contractor I am completely sold on modular coordination.

MR. DUNSTONE: I do not know the proportion of houses built for sale, but people who can afford to, buy them. No houses, at the moment, are being built for sale in the better suburbs.

MR. DAVIDSON: I think there are political overtones in this question, which I shall avoid. About 50 per cent of the housing is private enterprise in small group developments. For reasons of consumer resistance, as well as the result of the small size of the contracts, these houses have few component parts, but rather plaster, water and the conventional things. It is not until the last moment that items go into them that are highly standardized, such as kitchen fittings.

MR. BERGVALL: I would like to touch on a subject you mentioned: Is there any point in using modular coordination? That is a question that has been put to us many times. Sticking to the example of doors - if you simply standardized doors, you would have the advantage that they would be cheaper. When they are designed as modular components, they are just as standard, but also, they coordinate with everything else. You can always gain from modular coordination, and never lose anything from it.

MR. KENT: Not all parts of all buildings will be modulated, and such is not the intention. The City Hall in Toronto certainly appears to be unmodulated, but on examination you will note that many parts are. The grade paving which surrounds the building is a positive grid, and the floors and ceilings are modulated. Vilgo Revell, the architect, was an ardent modular enthusiast in Finland.

MR. BERGVALL: He was very early in modular coordination, dating back to 1943.

MR. JOHNSON: I have another question. How could my suppliers and I have our draftsmen and supervisors obtain training in the necessary details and drafting techniques of modular coordination?

MR. BLENKHORNE: I was hoping this question would come up. I understand the Department of Industry is planning clinics for this purpose and I would like to ask Mr. Dawson to speak about them.

MR. J. A. DAWSON: As a subsequent endeavour to this series of conferences, the Department of Industry is planning a series of modular clinics. About 15 architects, from various parts of Canada, have met with Mr. Kent to become instructors, and now we hope to work closely with manufacturers and professional associations to organize clinics where there appears to be a demand. In this way the instructors should cover from 1,200 to 1,500 people - architects, senior draftsmen, engineers, building managers, manufacturers etc. This will be a continuing program to fill the need as required.

MR. BLENKHORNE: I would like to have a question by a contractor.

FLOOR: Does the federal Department of Public Works require modular drafting on all its projects?

A PUBLIC WORKS DEPARTMENT REPRESENTATIVE: It is a very good question that many people ask. We would like to say yes, 100 per cent. However, letting out commissions as we do, we leave it to the commissioned architects to design the projects. I believe the day is not too far off when we shall begin to move in that direction.

MR. BLENKHORNE: I believe I am correct in saying that buildings emanating from the D.P.W. office are done on a modular basis.

FLOOR: Yes, that is quite true.

MR. KENT: It is fair to say that the architects' department of the Department of Public Works encourages the commissioned architects to work in modular, but does not stipulate they must.

MR. SULLIVAN, FOUNDATION COMPANY: I gather the whole question of piece-work is being accepted on the Continent, and I would like to ask what reaction there has been in the U.K.

MR. DUNSTONE: Yes, there has been a reaction, of course, against this, but the situation is that there is not enough labour to do all the work available and there is no way one can get a decent plastering job done, for example. The architects are trying to move away from these processes, and now the productivity of the gangs is improving. The deciding factor was that they found they can get fairly good money doing this. The industry is beginning to change over to the gang concept of building and to allow piece-work on the site.

MR. BLENKHORNE: I would be interested to hear of the reaction in Sweden.

MR. BERGVALL: It is important to make clear distinction between reactions and opposition, which are two different things. From my own experience in building houses in the factory for the past 15 years, we have had a favourable reaction. The factory workers have been organized in the wooden building labour organization, and yet they are doing all the electrical installation. There are so few qualifications needed for the electrical work inside the factory that there is no reason to insist on a particular trade. The economy benefits, of course, but it is worth mentioning that, even though many people were absolutely convinced the labour unions would not permit such work, we discussed the problem with the union at a very early stage and agreement was reached.

MR. DAVIDSON: We had a case in England where completely finished rooms of timber framing, including all the finished materials, were to be used in an emergency housing project in the London metropolitan area. The unions made it quite clear that they would not handle the rooms until there was an arrangement made that balanced the work of each trade done in the factory, and was in the same proportion as the work on the site. As it turned out, anyone who went around the factory would notice that the electrical wire that had to be pulled through, would be pulled by the person nearest to it, regardless of whether he was an electician or not. Thus, despite what Mr. Bergvall has just said, I think it dangerous to transpose the experience from one country to another without asking many functional questions. In France, where they have one industry, the fabrication of large housing blocks represents no problems whatsoever along union lines. In England it is not so clear, and even the designer avoids putting electrical conduit in concrete panels.

MR. LAPLANTE: I would like to point out that the Department of Industry is considering these problems very seriously and on its Advisory Committee on Industrialized Building there were three representatives from labour organizations giving thought to the effects of industrialized building. In the spring of next year, there will be a conference in Ottawa to discuss these problems. You might as well get down to business right at the start in finding solutions.

MR. BERGVALL: I agree it is dangerous to draw conclusions from other countries.

MR. KENT: I would like to come back to the use of modular coordination on the building site. I asked a Toronto quantity surveyor what reaction he had received from contractors who were doing work from modular drawings. He said the only comment was that they claimed to take more time in ensuring the building was accurately laid out. I therefore make the point that more time will be spent establishing building dimensions, but this will result in fewer adjustments as the building proceeds.

MR. STUART CAMERON: I am speaking as a contractor. I think I am entitled to speak in Canada, after 30 years' experience in England. I have never known a man object to a job being done in the factory instead of on the site. Good results can be obtained by incentives and payment by results - it is not the same as piece-work. This problem of ease in working and factory work, I am sure,is entirely a question of labour insecurity.

The idea of modular coordination is most acceptable to anyone in the industry. The benefits to the general contractor of the greater use of components produced to modular sizes is that it tells him what problems may be anticipated in fitting things together, such as tolerances, seals, and joints.

MR. DAVIDSON: Since we have been talking about industrialized building, and have been implying, through it, the value of coordination, there is the danger of believing that when we get things all modulated, we will have solved all the problems. In a closed system, where the design group takes under its control the whole process and seeks out a pattern for obtaining a spectrum of answers, there are going to be a great number of problems for a number of years. Dimensional coordination emphasizes the fact that we have got to co-ordinate, in detail, a great number of things. We talked about tolerances of components, tolerances of erection and a little about jointing conventions; we could have talked about jointing coordination for the whole seminar. Similarily we could have talked about the problems of handling, packaging, etc. In traditional building we know how to solve these problems, as we have skills that date back a few thousand years. Modular coordination, if we take it in its basic form, is one of a long list of building problems, but once we start modular coordination, we can begin to solve all these other problems. The Department of Industry has a lengthy job ahead.

MR. BERGVALL: Modular coordination never imposes anything new about tolerances, but it does offer certain directions for their control.

MR. BLENKHORNE: It is interesting how closely one follows the other - to have good industrialization in building, one must start with coordination of dimensions.

MR. KENT: In Canada, we have no standard on building tolerances, and I would like to refer to two European countries where standards have been established. There, the standards have set up a scale of tolerances for buildings of different types. For buildings such as factories, there may be coarse tolerances, and for hospitals, fine tolerances. The first thing we must do is look at the dimensions and ask ourselves what variations can we tolerate from these dimensions without affecting the assembly process.

MR. DUNSTONE: Close tolerances cost money and you must decide how close you really need these tolerances. It costs money to make them closer than you need.

MR. DAVIDSON: In my office, even for drawings for traditional construction, when we are showing the joining of two parts that have been pre-shaped, we use a small, white gap, with a little margin around the parts. You have to allow a little more room between things than you think. And in cases where the tradesmen are getting standard wages and then receive a bonus for speed, you must be careful that the work does not suffer.

FLOOR: In cases where the tradesmen receive a bonus for speed, does the quality of work suffer?

MR. BERGVALL: Everything is so prefabricated in the houses we manufacture, that speed of erection cannot influence the quality of the job very much. Actually, in the beginning at least, the premium they got was such as to make the men go on working, even on Sunday, without an hourly wage so they could catch the premium. But perhaps that was not the way you intended the question.

MR. BLENKHORNE: I have a question for the British panelists. As Britain is changing to the metric system, is metric being taught in all the schools of engineering and of architecture?

MR. DAVIDSON: No. Not as much as it should be.

MR. ASHTON, DEPARTMENT OF LABOUR, NOVA SCOTIA: I am interested in the application of modular to the instruction of apprentices. After listening to the speakers at this conference, I am left in no doubt that the course outlined for the instruction of apprentices is lagging behind as you cannot change overnight from the conventional. We are still instructing in the conventional manner. It would seem to me that there are certain

trades today in which modular coordination and industrialization will make a drastic change. What to do and where to begin is the question. The Department of Education is taking steps in teaching new mathematics, and it must be very complicated for the children to understand why certain methods are being used. I have a little girl of nine who has just started the new method, one of eleven who has not been taught it and a young fellow who is not yet in school. Each one will be approaching it in a different way. Now I would like to ask if you could give us some way an approach can be made to the instruction of apprentices, when you do not know whether or not they are going to fit into the overall picture tomorrow.

MR. KENT: We have neglected the area of instruction of apprentices and workmen, and also instruction in technical schools. I think the instruction should begin at an early stage, informing the students just what is meant by industrialized building. When this concept is clear, then of course, modular coordination is apparent. In Ontario, we are preparing a new course of study for the secondary school subjects in building construction, and while the present course provides elementary instruction for traditional trades, the new course will include guidance instruction which will open up the whole building industry to the student. Instruction in the trades will carry on to a lesser degree and the new post-secondary school community colleges will provide trade instruction in depth.

MR. BLENKHORNE: Thank you. I think we have time for two more questions.

MR. FOWLER, HALIFAX ARCHITECT: One of the questions facing all design groups is the problem of changing over to modular. I would like to ask Mr. Blenkhorne how long he has used modular drafting, and what did his office need for the change to full modular coordination in design?

MR. BLENKHORNE: We have been using modular drafting for about 10 years. The length of time to change would depend on the size of one's office. To begin with, some of your staff would attend one of the 10 modular clinics - this doesn't cost you anything, and six hours of time is required. The first building you do will take more time than usual; I would think you could expect an increase of about 10 per cent. Although modular is a simple concept, it takes time to re-train old dogs - they are always reluctant to make a change. It is most important for designers to have complete knowledge of modular coordination so that the building is designed on a modular basis from the very beginning.

MR. KENT: When you decide to give modular a try, pick a building which is obviously suitable to modulate, such as a small building, simple in its geometrical form. After your staff has had this experience, then go on to larger, more complicated structures.

MR. COLLIER, FREDERICTON ARCHITECT: How are you able to design modular buildings? Do you limit yourself to modular materials, or do you find you have unlimited scope?

MR. BLENKHORNE: Getting the manufacturer of masonry products to modulate was probably the greatest step. On this basis, you in Nova Scotia had a steal on the rest of Canada. Once brick and block became modulated, we had something to work with. It is hard to say how many, but there are components other then tiles, etc., that come within a hair of being modular. If they are not, there is no other choice than to make them fit. This does not make the building more expensive, as it is what is already being done at the present time.

MR. DAWSON: The modular program includes the publication of a directory of modular materials. There are, in fact, a good many materials that can be classified as modular, and we are just in the midst of conducting a survey so that we may list these materials and their manufacturers in a set form.

MR. SHAW, CHAIRMAN: We all had high hopes and anticipations for the panel this afternoon, and I am sure that it has been not only informative but also exciting and has lived up to our expectations. I ask you to show your thanks to our speakers at this time.

PANEL DISCUSSION

at

THE PARK PLAZA HOTEL, TORONTO

on

OCTOBER 19, 1967

PANELISTS:	L. K. Bergvall C. H. Davidson P. H. Dunstone S. R. Kent
MODERATOR:	D. C. Aird
CONFERENCE CHAIRMAN:	John Cochran

MODERATOR: MR. DAVID C. AIRD

BEAM PROGRAM
MODULAR COORDINATION

MR. DAVID C. AIRD'S INTRODUCTORY COMMENT: Ladies and gentlemen, it is a distinct pleasure to be here this afternoon, although I am not quite sure that I am the right person to be moderating this panel. I think it is a reflection of the genius of the Department of Industry to pick out the most ignorant person on modular coordination to moderate this group. It may be, and I am not trying to cast reflections on my counterparts in the other conferences, that this was done to set up a contrast between what I can contribute and what the panel can contribute. I think from listening to the panel they do not need any contrast to justify their existence as experts and advisers to us in presenting to us the process of modular coordination.

One of the problems one runs into, particularly in my new position, is trying to define our problems, to make sure we are on the right track if we try to solve them.

Unfortunately or not, I had received from the Department of Industry the task of Panel Moderator here today, and therefore we probably ought to set our own definitions and our own ground rules as to how to operate here. I do not want to talk very much, because I think you want to hear the people who have contributions to make, but it is quite clear at the outset that I am an outsider to the industry, particularly the design side of the industry, and quite ignorant of the problems involved. I am tremendously interested, but ignorant.

However, I do have a manufacturing orientation, and do have a fair appreciation, based on several years' observations, of the problems of the contractor and the field problems of actually putting up plants; therefore, if you combine these two experiences it is to me entirely logical that we side together on industrial building, with all the many complications this brings.

This panel today is supposed to be talking about modular coordination, and I think we would be well advised to bear in mind that this is the topic for discussion.

Unfortunately, as pointed out, modular coordination is only one aspect of the very broad problem of industrialized building.

This is going to bring to the industry, and to all of us, a number of very severe problems. We will have to recognize them, work them through and resolve them. There is going to be a substantial restructuring of the industry, and I have my own prediction to make about this, but I do not think the present contractors need to be complacent about where their competition will be coming from. The construction trade unions are concerned about this, and I expect the professionals are concerned when their profession falls into these new structures. So, we have a beast that seems awfully awesome and which poses a tremendous threat -- and also a tremendous challenge we cannot grasp at the moment, and we have to try to determine how specifically we are going to meet this challenge.

I would like to initiate a discussion; we need one question, probably, to break the ice, so I would ask the panel whether modular coordination is as applicable in traditional building construction methods as it will be in industrialized building techniques?

MR. L. BERGVALL: In a way, I think I answered that question in my speech this morning, when I said that for traditional building, modular coordination has a number of advantages, and advantages could always be converted into money. However, for intelligent industrialized building it is a prerequisite.

I think that the people more connected with traditional building than I am, since I work exclusively in industrialized building, could better answer that question -- Professor Kent for instance.

MR. S.R. KENT: I think we are finding it more and more difficult to define what is traditional building, because in many instances the industry has by-passed traditional building and we are finding that even so-called traditional building is characterized by many industrialized processes of some degree or another; so let us not talk about the many degrees of industrialized building. I think if we put this in its proper context we will begin to recognize that we can apply the modular system to the lesser degrees as well as to the more complicated degrees of industrialized building.

MR. BERGVALL: We all realize, I suppose, that if everything were executed on the site, absolutely everything, manufacturing and assembly of components, there would be no need for modular coordination for any building. In this country, however, as in most other industrialized countries, a number of components do arrive at the site in a prefabricated state even in the most so-called traditional building.

Now the interesting thing about modular coordination is that for those parts of the building project which can be obtained in modular sizes, all the advantages of dimensional coordination can be realized, while for the remaining parts of the building there is no disadvantage whatsoever. In other words partial modular is better than non-modular.

MR. HAL WILKINSON (SNC-Filer Ltd., Project Engineer): Mr. Bergvall and Mr. Dunstone both mentioned that the degree of shop fabrication would be increased considerably with modular coordination, and I was wondering what the problems would be with regard to the unions.

Problems of this type are very common and are well known, I am sure, to all of us. I will give you one example. In an industrial plant with which I am familiar, there was a particular piece of piping involving a manifold which had several special valves made from high alloy nickel, but it looked like mild steel. When it came to the field it was dismantled and reassembled using mild steel welding rods, and it had to be scrapped. The result was sixty thousand dollars extra cost to the owner, and six weeks delay and waiting time for everybody.

This is not uncommon, and it is a serious problem in construction. I was wondering if this had been encountered in England and Sweden, and what we could look for in our industry?

MR. AIRD: Thank you. I will ask Mr. Dunstone to reply to that question.

MR. P.H. DUNSTONE: I think it is important to consider the application of modular coordination in the two generally defined types of building, that is in traditional building and industrialized building.

With traditional building, of course, workmen may not be aware of the coordination. Superficially the material and components appear the same. This situation in uncoordinated structures will improve with training, but as far as the unions are concerned, the work involved is not different except that it will proceed more efficiently.

With regard to industrialized building, major differences tend to arise. What happens, and I think what you were referring to is a draining away of the site labour into the factory. Site labour is reduced and factory labour and the operations performed in the factory increased.

What is the reaction of the unions to that? I think in England developments of this type have not become so apparent as to attract the attention of the unions, so there has been very little trouble or discussion over this particular subject. I do expect it to come, but I suppose, looking at the union picture, so long as the men in the factory are unionized and the men on the site are unionized, there should be no argument in this day and age with the shortage of labour, as to whether the work is done on the site or in the factory.

MR. BERGVALL: I would say, very generally, that whether or not difficulties with the unions are encountered in trying to transfer some operations from the site to the factory, is very closely connected with the situation prevailing in the building industry at that time. If there exists a situation of over-employment, then much less difficulty arises than if there is a situation of under-employment in the building industry. This is quite natural.

Now our experience in Sweden is that the transfer is possible, with the pattern of negotiations between industry and labour. To reach an agreement, for instance, for certain types of systems, labour organized in the woodworking and building unions does not only direct construction, but all the plumbing, electrical wiring, etc. on the site. However, the conditions for this agreement were that everything was so prefabricated that no one could claim that any kind of professional skill of the labour force was necessary.

Now on the other hand, a company with another system tried to copy this system, but was unwise enough not to make an agreement with the labour unions first. This company simply sent out their erectors, who were organized as industrial workers, from the factory to the site. Now in our country the situation is that construction workers are paid much more per hour than industrial workers, so of course, this company was met

with absolute refusal by labour. That only shows that every operation must be very carefully designed with regard to the precise situation in the country and with the trade union system prevailing.

I would add that it is assumed that money is gained only by transferring the job from site to factory, but that is not necessarily so. Very often the effectiveness of industrialized building is measured with relation to how many man-hours are required on the site. It is no wonder that sometimes the unions react against this practise being carried to the extreme. Labour disputes so precipitated may actually result in higher costs in the factory operation than would have been the case had the work been done on the site.

Prefabrication has no purpose of its own, but it is very often the answer to our production problems. Let me add, again, I understand very well that it is extremely dangerous to draw any general conclusions on this particular field of labour-management relations from one country to another. I know that the situation here is completely different from the one we have in Sweden, and the one in England is different again.

We have been asked for our experiences, and I can relate what experiences we may have had in this field but do not consider our experiences as necessarily providing answers for Canadian conditions.

MR. KENT: Mr. Moderator, I think it appropriate to mention at this time that Mr. Hindson referred to the BEAM Program this morning, and that within the BEAM Program there is an Advisory Committee on Industrialized Building. I think this committee recognized the problems which may arise from jurisdictional matters, because in industrialized building one area of activity encroaches upon another. As such, the Advisory Committee does have in its membership union representatives, in order that this problem can be discussed freely in committee work.

MR. AIRD: Perhaps Mr. Dawson and Mr. Hindson would like to add to that.

MR. JOHN DAWSON (Department of Industry): Professor Kent has indicated that we have as another integral part of the BEAM Program, an Industrial Advisory Committee on Industrialized Building Techniques and Systems.

Now the membership of this Committee includes architects, engineers, contractors, and manufacturers. Also the Committee is cognizant of the question that Mr. Wilkinson raised, and because of that representatives of the two major unions concerned with building in Canada, namely the C.N.T.U. and the C.L.C. are members of this Committee. The Committee looks forward to free and open discussion on this very matter. In this way it is hoped that some of the pitfalls which may have occurred in other countries can be avoided in Canada.

I think that Mr. Bergvall's statement that these problems are not really comparable in different countries is very appropriate too, and recognizing that Canadian problems might be somewhat unique, it is hoped that solutions suitable to Canada can be found.

MR. CLAYTON (architect, Ottawa): We have been talking about modular coordination, which is one thing, and we have also been talking of the 4-inch or 10-centimetre module. Am I not right in saying that there has been a lot of discussion on the choice of module, and that it has not been accepted by everyone that the 4-inch module is in fact the only module. I seem to recall that in Britain there has been fairly recent discussion on whether the 4-inch or the 10-centimetre module is the right one to use?

MR. DUNSTONE: Certainly there was a great deal of discussion about the size of the module. There was a group known as the brick lobby, which advocated the 3-inch module. There was considerable discussion over this, but I think it is pretty well accepted now -- in our case the 100-millimetre (10-centimetre) module will be the one. I do not think there is any great current of opinion against this.

MR. BERGVALL: Maybe I should just add, in my capacity as chairman of the International Modular Group, that there is no country in the world concerned with modular coordination nowadays, with one exception, that is interested in any other basic module than ten centimetres, and, in the few inch countries in the world, four inches.

The only exception is Germany, which is now carrying the burden of being a pioneer because Germany was the first country in Europe, possibly the world, to go modular. The Germans originally adopted the 12.5-centimetre module, and they have a problem now for conversion to the international 10-centimetre module.

There was no discussion whatsoever about the size of the module when Germany adopted its module. An internationally workable modular coordination could have been built on the 12.5-centimetre. The only merit the 10-centimetre-4-inch module has is that it is internationally agreed upon, but that is a great deal and it is enough.

MR. KENT: There is an interesting story, and since the story of the brick people has been brought up, and the adoption of the 10-centimetre or 100-millimetre module in the United Kingdom, it is appropriate, Mr. Chairman. For a number of years the brick industry resisted the adoption of the 4-inch module in the British Institute Committee on Modular Coordination, and in the meeting in 1964 the brick representative said to the committee, with a little skulduggery in mind, "No, we will not accept the 4-inch module, because if you suggest that we should change we would adopt the 10-centimetre module". So the committee put their heads together and said to the brick industry, "We will accept the 10-centimetre module". That was the first break-

through in the Committee, and very shortly the B.S.I. standard of modular coordination was achieved with the 10-centimetre module as its basis.

MR. T. BJORNSTAD (Associate Professor of Environmental Studies, Department of Design, University of Waterloo): I am an architect with the University of Waterloo, and I have a great deal of respect for the lectures given here; I agree in principle with their content.

I think there is a need to improve the vehicle. I still have a very strong feeling we are discussing wheels - horses and buggies - when what we need to decide is what is the reason for going into new modular units.

We are discussing it entirely from a construction point of view, and it is like remedying a bad situation after the fact. The real need for modular coordination is right in the planning stage. We are talking about the tremendous amount of data and the standardization of data. Immediately we get into the correlation of this data, any decision we would have to make might involve maybe a hundred-thousand-dollar decision. We have to use the interpretation for solving these problems.

At the present time I think that the change that will dictate or formulate what the unit is going to be will come directly from the architectural group. Even today many plans are made from computers, and the problem we have now is not whether it should be four inches or six inches, but the capacity of the computing equipment. This is going to dictate the size of the modular unit, because every modular unit will call for storage space in the computer and it will depend upon what is available.

The computation equipment being designed today -- the compilers being designed for architectural problems -- are going to be standard equipment on the market in the next five years, and for the next ten years. They will surely have to be interpreted, and I think that before anyone sits down and decides on the size of the modular unit, they should refer back to see what the planners are going to do, whether the bricks will be four inches, three inches, or two inches.

This is a question of definition. It is possible to quote module and use it, but it has to fit into the mental processes. I would like to ask Mr. Dunstone what his thinking is on this.

MR. DUNSTONE: Mr. Chairman, I cannot answer from a design point of view; I am not allowed to be a designer. But I can answer from a computer point of view, and that is: the computer does not care. We sort out the sizes we want from any particular standpoint we care to take, and the computer is our slave, it does what we want it to do.

Therefore, as you rightly state, the crux of the matter comes back to design, a planning matter. I would have thought this had been gone through by the planning people and I am sure other members of the panel will come into this; but planning people have agreed upon the 4-inch/100-millimetre module. Since the decision has been made all that is needed is to bend the computer, it being a tool, accordingly.

MR. BJORNSTAD: To accept a 4-inch standard just because it is almost equal to the European 10-centimetre is certainly unacceptable. In my opinion, the determining reason for picking the size of a modular unit must be found in planning requirements, or, more specifically, in computer determinates. With the present and upcoming employment in analytical analysis and matrix notations in planning we find that, for instance, to co-ordinate into a plan a hundred activities would regenerate ten thousand simultaneously interdependent relationships which will affect and influence each planning decision.

Such complexities can only be dealt with by use of computers. To manipulate all the planning factors involved in even a medium-sized planning effort calls for immense computer storage requirements, and the determining question thus becomes: what is the smallest modular unit we can apply and still satisfy those planning definitions on computer storage limitations? Thus, before a module is decided upon, should we not study this aspect of its limitations in an attempt to minimize its usefulness?

MR. KENT: The question is certainly a good one, and I think it indicates that something needs to be done about reducing the number of variables in the building industry. The questioner has indicated that variables every four inches give too great a number of variables for the computer's memory. I agree this is correct, but perhaps the idea of a range of sizes means that components in multiples of the 100-millimetre (10 centimetre) module or the 4-inch may be considered. The complete range is not used because it is not necessary.

There were ideas of introducing a 300-millimetre module comparable to a foot, so in general it may be found that the 300-millimetre module is being used as a multiple of the 100-millimetre module, and at times the 300-millimetre module is broken down into the 100-millimetre module. I am also wondering if this was what Mr. Davidson indicated as having been recommended in England wherever possible.

MR. A. A. GOLDES (President, A. A. Goldes and Associates Limited, Consulting Engineers): I would be most interested to hear from our European panelists as to the steps that have been taken in the initial stages of industrialization to preserve the pretence or posture of the contractors as far as competitiveness in bidding is concerned.

Primarily, in the early stages of the introduction of industrialization there was a narrow spectrum of industrialized structural systems available. This, I should imagine, would produce a situation where the structural system was delivered, bound hand and foot, into the hands of one or two suppliers of such available systems without benefit of competition.

MR. E. J. SIMPSON (Architect, Ontario Housing Corporation): I would just like to ask this general question of the panel. I am not sure who should answer it, but just what role should the Government take in developing new building techniques in this country? I think the Government can be a catalyst and certainly encourage new methods and techniques. Is it asking too much of industry to underwrite the necessary development work and research which would be required to go into developing new methods and new techniques?

MR. DAVIDSON: Mr. Bergvall and I have been arguing about this, so I had better give straight answers. I myself believe, and believe very strongly, that the best way to get innovation in the building industry now, is for the client side of the industry to put out big orders to industry. If big orders are knocking about, big innovations will take place to satisfy them.

I suggest this is the only way -- well, the most rapid way to make progress, because the building industry is apt to be chary about investing in development costs, approval time, and the tooling required to come up with the new answers.

MR. BERGVALL: It might be of interest for you to hear what is being done in other countries. I do not mean particularly my own country. Also we can disregard the Eastern European countries because they have special methods of pursuing this modular coordination. In some Western countries they have tried to use modular coordination on a quite voluntary basis. In other countries the governments have taken some steps. In Denmark, for instance, where there has really been a great deal of success with modular coordination, the government, I think two or three years ago, issued regulations saying that any residential building intended to be rented must be modular.

They also set up a staff of modular consultants to help contractors, architects, etc., in the adjustment period. There has been a lot of success in Denmark with concrete prefabricated systems, precisely because they installed, as a foundation, these modular regulations.

In France, the experience is similar in a way. In my own country the government, just before I left, issued some regulations saying that all buildings being erected for the government, or any governmental institution should be made according to Swedish standards, which means, amongst other things, that they should be modular.

That could, of course, be considered as the same approach that Mr. Davidson talked about, the government being a large client. Regulations were also issued permitting those governmental institutions of various kinds, which in some way or another give financial support to school buildings, residential buildings, etc., to issue similar regulations.

Personally, I believe if this approach is carefully and wisely handled so that these regulations are not enforced in cases where it is obviously not promoting development, it could be valuable, but it takes a very, very wise hand to handle it the right way.

MR. KENT: I hope that there is a sufficient number of government personnel here, and that they have been convinced that there is merit in the modular system. I hope further that governments will now use their wisdom as all government people are expected to do.

We are, I think, attempting to use a soft-sell approach in Canada. Mr. Davidson did mention the consortium system for CLASP*, and did not mention the fact that here there were a large number of owners pooling their requirements in order to get a program under way. Much the same thing happened in the Southern California Schools Development.

The first thing the research group did there was line up the potential clients in order that a large volume of building could be established. In Denmark it was essential that the government stipulate that over a period of five years ther would be a stipulated number of housing units built. When this period was over they again stipulated a certain number of housing units would be built in a certain time.

With this as an incentive then, manufacturers had some basis for changing, and involving their companies in the financial capital outlay which was necessary to make the change and at the same time have some assurance that they would be getting their money back again.

MR. BERGVALL: It should be added that at the same time the Danish Government clearly declared that there must be one building code for the whole of Denmark. Also, that whatever the reason, this one building code would not be subject to any change within five years, so that the manufacturers would know what the situation was.

MR. AIRD: Again from my ignorance and being an outsider, it strikes me that a very real problem here is that the initiative, which I believe most people here feel should be with the architect, planner and designer, is going to shift to the government or to the supplier, these being the ones who can amass the most capital.

* Consortium of Local Authorities School Project

MR. JOHN CAULFIELD SMITH (Executive Director, Canadian Structural Clay Association): It seems to me while talking recently about the housing situation that the government itself, particularly the senior levels of government, is probably the biggest single client or customer of the construction industry. It might seem logical at first glance to assume that the Departments of Public Works of the Federal and Provincial Governments might show some leadership, quite apart from industrialized building, in the construction of public buildings - post offices, and various other institutional structures of that kind to modular standards. I believe something of this sort may have been taking place. I wonder if Professor Kent would care to speak on this briefly?

MR. KENT: In reply to Mr. Smith's question, may I say the Department of Public Works does have a small post office building design, examples of which are being built in various parts of the country. The planning has been done on the modular basis, and I believe there has been no difficulty in any part of the country in having the work done.

This may be subject to correction. We have a representative here from the Department of Public Works, and I would appreciate him carrying on with this discussion.

MR. D. H. MILLER (Federal Department of Public Works): Mr. Smith is quite right, we do have standard post offices. Actually, we have about six models. They are very small and they vary from about one thousand square feet up to two thousand square feet, and these are designed on the modular basis.

They vary in cost from probably thirty thousand dollars to seventy thousand dollars. We have never had any complaints from any of the contractors who have bid them, or have built them. It involved some of them in masonry, brick, stone, and as far as I know we have had no trouble adhering to this modular coordination.

I think it is a very good start for the government. Whether it is worthwhile getting into larger construction at this time on a modular coordination basis I am not convinced myself. If we take a million-dollar building and tell our consultant that he must design it on a modular basis, I am sure this would probably give a great impetus to this system, but would it add to the cost of the building at this stage, or would it make it more economical?

I am not sure of this, and I would like to have some comments on this if anybody could assure me. But by telling our consultant architect that by adhering to the modular basis he would obtain certain economic advantages and would not be restricted in the aesthetics of the building, we would have a very pertinent point.

MR. KENT: Mr. Chairman, if I may have the panel duck this question, could we ask Mr. Don Blenkhorne to speak to you on this, simply because his office has been using modular coordination for a number of years with great success.

MR. D. M. BLENKHORNE (Shore and Moffatt and Partners): Mr. Chairman, I do not think it is possible to state categorically whether buildings designed the modular way can save money or not. However, we have been doing this, as stated, for ten years or more and there is certainly no indication that it costs more than the conventional method.

I do not know if I can add very much to that, really. If there are some contractors who perhaps have been building modular buildings in the area, they may be able to give a better answer.

MR. G. KAFAROWSKI (P. Eng., Artex Precast Limited): Mr. Chairman, with precast concrete, of course, we do lots of work with other trades. The modular system so far has always proven more expensive than the conventional method. The reason is, perhaps, that when we talk about modular coordination we are confusing the terms.

I hope the panel would agree with me that modular coordination is nothing but a tool, and if you give the tool to a craftsman who knows how to use it he will make a work of art, but if you give the tool to a kid who does not know how to use it he will just finish with a mess. There are many brilliant designs on modular coordination right now that were actually designed to suit the bricklayer, and every other trade has to follow the brick work or precast concrete, which results in much higher costs.

The number of drawings or designs on modular buildings is always greater, because inter-trade dependence is increased. Consequently the number of details increases, the number of specialties increases, and there are very few buildings built on the modular system that really prove economical.

I think that if the architect uses the system, applies it to one particular building, carries it through and is consistent to all the trades, then that building will be more economical than a building not based on a modular system. It is the man behind the pencil, and who manoeuvres the tool, who will determine the cost of the building. If we speak of industrialization and economy, we are talking of a goal that we have to reach, and to get there we all have a lot of work to do. There is the question of what should be done about applying modular coordination.

MR. AIRD: I think the challenge has just been thrown down, though I am not sure the panel would agree with all your remarks. Mr. Davidson?

MR. DAVIDSON: I agree with a lot of what you said, but I can only repeat something I was trying to say earlier on this afternoon. If the way of building is to be changed, a lot of other things also need to to be changed; who does the plans, who does the design? I am not speaking of the demise of the architect, I am simply challenging him to get involved in other things, as it were.

MR. KAFAROWSKI: I think that, in order to apply modular coordination the role of the architect has to be much greater and he has to make things simpler for the trades. In order to do so, much more ingenuity and efficiency are necessary on the architect's part in the conception of the design as applied to the trade. The cost of shop drawings is nothing compared to the cost of the building.

MR. KENT: I have enjoyed this question very much, because I think the questioner already answered the question he has put to us.

First of all, the questioner indicated that the modular system did not save money, yet on the other hand he did make the point that it is essential that an architect establish a system and carry it through.

Now gentlemen, this is all we are trying to do, to establish a system and carry it through. However, and here is the big difference, we are not going to have one architect develop one system and carry it through, and the next architect develop a system and carry it through, the intent is that all architects would work with the one system and carry it through.

In other words, we are simply co-ordinating all the systems into one.

MR. KAFAROWSKI: I would like an answer to my question, how do we go about applying modular coordination? I mean, I would like to know what we should do to learn how to use it?

MR. KENT: If you want to know how to use the modular system, you are not going to find it in a meeting of two hundred people, and because of this the Department of Industry has been organizing in conjunction with these conferences - which are merely to whet your appetite as well as instruct you in some of the basics of modular coordination - a series of clinics which you and your staff may attend and learn in more detail the use of the modular system. These clinics will follow in the New Year.

MR. AIRD: I would like to interrupt and ask if perhaps John Dawson of the Department of Industry would like to enlarge upon this point of the follow-up to these conferences?

MR. DAWSON: I think Professor Kent answered the question very succinctly. It is the Department's intention, as an extension of this series of conferences, to organize fifty or sixty clinics of modular practice across Canada. We are hoping to start those as soon as practically possible after the conclusion of this series of conferences, which would be after November 1st.

Now in this connection, we have already received the support of the Architectural Institute, and component associations in the provinces of Canada, and we have had some fourteen architects volunteer assistance to us to act as directors of the clinics.

We have one or two of them with us today. Mr. Peter Popovich of Ryerson Institute will be one of the directors, Mr. Peter Haensli of Shore & Moffat & Partners, another. Professor Kent will also participate.

There are fourteen such instructors, and we look to each of them to instruct at about four clinics. We also look to people from this audience. We look to having your input. You may wish to request a clinic in your area. If we can get sufficient support in terms of numbers, we will certainly see that this is done as a service to your profession and to your industry.

I would like to go back, if I may, to Professor Kent's answer to the comment about the development of systems. I think he did that very well; it is a very important point which deserves some emphasis. All that is being attempted is to order the development of one modular system. The building industry does not require a conglomeration or whole multiplicity of unrelated systems development in Canada. Rather, we would like to tend towards, or converge towards a universal system based on modular concepts which will in the long run, and for the short run, be of service to our industries and professions.

When I think of industry, I think of it in its total concept from a manufacturing standpoint, from a design standpoint, and from the contracting standpoint. By considering all the aspects and by applying modular practice in each, I believe that the productivity and efficiency of building can be increased.

MR. SIMPSON (F. B. McFarren Limited): I am a member of the so-called "brick lobby", as somebody remarked earlier. I would be curious to know the history of the choice of the 4-inch module and secondly, I would like to know why a 3-inch module cannot fit into a 4-inch modular system.

MR. DUNSTONE: I think this was hashed over fairly well. I have quite forgotten all the detailed arguments there were about this subject. Of course, the 3-inch and the 4-inch together have been argued over the combinability of the 12-inch and so on.

I think this is all fairly well documented historically. I personally want to go forward instead of looking back into history, and it has been decided internationally that it is better to have one system rather than two. We do appreciate the difficulties - let us not minimize these - but so long as one system works satisfactorily, then we should have only one system.

MR. KENT: Mr. Chairman, as Mr. Dunstone indicated, the Swedes have a remarkable degree of understatement because actually, Mr. Bergvall is one of the prime leaders in the development of the 10-centimetre module. It was from his work in the early 1940's, leading to a comprehensive report, that a study was made on what would be the most desirable size to give sufficient flexibility for building components.

However, let me just mention, since the subject has come up, that in England there was a most delightful report that they were trying to organize amongst themselves as to whether the module should be the 3-inch, 4-inch, or 6-inch and so on. It reminds me of the story of the three bears when they were testing the chairs, you know - not that size, not that one, but this one just fits, and this is really one of the ways in which they rationalized acceptance of the 4-inch module.

In other words, the idea is to cut down on the number of sizes and the number of variables, and so the question must be asked, "Does the 3-inch module give me too many variables; does the 6-inch module give me enough variables?" The British said "Well, four is just right".

MR. BERGVALL: Mr. Chairman, maybe I should add some information there. It was recognized very early that the size of the basic module must be something of the kind of 3-inch, 4-inch, 5-inch, possibly 6-inch. The problem was to establish which of these was right, and a certain experience was found already in Germany, the 5-inch (or approximate metric equivalent of 5-inch).

Now, a rather interesting experiment was made at that time in order to see how large the module could be without putting a strait jacket on the architect.

We asked two of our foremost architectural firms at that time, and they gave us their facade drawings for one of their projects, a large school. These facades were re-drawn on a 4-inch, 5-inch and 6-inch modular basis.

We invited the two architects to come into our office and tell us which of them they made themselves. They were immediately able to single out those which were adjusted to 6-inch, and said, "We did not design those", but as for the rest of the sets of facade drawings, they were completely unable to tell us which were in accordance with their own design.

Now another remark was important. Why was there such a discussion, particularly in England, of the 3-inch module versus the 4-inch module and not in the rest of the European countries? Because if you have a metric country you find very quickly that a lot of your dimensions are already in centimetres, and therefore the equivalent of 4-inch, namely 10 centimetres, quite natural for all those countries. The situation was far less natural in a country like England with an inch-foot system together with a predominance of brick buildings.

MR. B. BATCHELOR (Queen's University, Kingston): I am a professional engineer and I am wondering if Mr. Bergvall would enlighten me with regard to an international agreement on the adoption of the coordinating unit of 10 centimetres, particularly in the United States.

On the North American continent, whatever the United States has done will largely affect what the other countries do, and it seems to me there are other members of the building industry, especially with respect to timber, cement and other products, who would be interested to know what has been the stand of the United States on this modular coordination. How have they progressed, and what has been the stand of the other North American countries?

MR. BERGVALL: Well, as I said, there is a full international agreement on the 10-centimetre module as the basic module in those countries using the metric system and those using the inch system.

It is, of course, of very great importance for international trade that we have an agreement of this kind. I also know that there is a great deal of interest in modular coordination and the possibilities and opportunities that go with it, in the Central American countries. Mr. Kent and I had the privilege of taking part in a seminar some years ago in one of the Central American States, and I understood that they were thoroughly determined to go on with modular coordination. However, unfortunately we cannot disregard the difference between 4 inches and 10 centimetres, 4 inches being 1.6 millimetres larger than 10 centimetres and that, unfortunately, has the consequence that a 4-inch modular component cannot slide into the space allotted for the 10-centimetre modular components, whereas a 10-centimetre modular component can always slide into the space allotted for a 4-inch component. To the advantage of whom, this I leave to you, but it is an advantage.

There was an occasion when a lot of dishwashers were exported to Europe from the United States. Now in most countries where they care about modular coordination at all they allow a space of 6 modules for a dishwasher. However, the American dishwashers were 2-1/2 centimetres out, and would not slide into the 6-module space allowed for the dishwashers in European countries.

This caused a lot of problems and, worst of all, when the Americans set up factories in Europe in order to produce dishwashing machines for Europe, of course they made them in accordance with the best way they knew about, the American way.

MR. AIRD: It has been drawn to my attention that there is a representative of the United States Standards Institute in the audience, and I wonder if he would speak to us.

MR. R. W. SMITH, JR. (National Bureau of Standards, Washington, D.C.): I am Secretary of the United States Standards Institute, which is the Modular Committee in the United States Government. There has been a standard on the books of the U.S. Institute since - I believe the date is around the late forties, maybe the early fifties, when the 4-inch module was adopted. The problem of the dishwashers that was referred to results from the fact that our kitchen cabinets and appliances are on a 3-inch module basis and have been for years and years. The industry sees no reason to change, although there has been quite a bit of pressure applied to move the industry from this module. I think the U.S. 4-inch module goes back to around 1938 when the Bemis Foundation began this on single-family housing and laid the groundwork for the whole theory. At that time the masonry was a determinant as was a co-ordination with the then two-by-four. So the U.S. masonry industry is now on a 4-inch-module basis, both the block and brick industry.

I believe that answers the gentleman's question.

MR. GOLDES: The various participants in the building process have been gently grilled here today, and I just wondered whether we might not perhaps elevate one other party to the hot plate, the universities.

I would be interested to know what initiative the universities have taken in Europe in developing a base of knowledge for further progress in industrialization.

I would be interested to know whether the universities contemplate the establishment of a chair of industrialized building, or another discipline chair of a post-graduate nature.

I would be interested to know if the Department of Industry would contemplate endowing such a chair in a Canadian university?

MR. DAVIDSON: The answer to your question is, let us "grill" the universities; they deserve it. There is, as far as I know, one school of architecture in the United Kingdom, which is attached to the University College of London where a chair of building has been set up, building implying building as a whole, all of the building processes, if you like. This not necessarily slanted towards industrialization, but in fact industrialization, as can be expected is one of its main concerns.

There are one or two others in science and technology that have had some concern, but nothing like enough in the ordinary departments of the schools of architecture or even in the engineering departments or in the engineering schools. Engineering and architectural design are unfortunately taught in the usual way, as it were, with more concern directed at what is built, than at how it is to be built.

In the United States there are the beginnings of moves towards the setting up of special courses in this field, either within the schools of architecture, or in one instance shared in a common department of engineering and architecture.

Now in the case of the initiative in England, the idea is that people going through this building department can then go on to become architects or building managers or professionals of that sort by having further specialized training over and above the shared basis. On the other hand, in one or two of the schools I am thinking of in the United States, after having become an architect or an engineer in the more conventional sense of the word, there is no further exposure to this kind of disciplinary education.

MR. BERGVALL: I think we have talked too much about top-level education, if I may say so, when talking about the education of architects. It is important, of course, that the architects should be informed about modular coordination, and these people taking courses to be architects should have modular coordination as an integral part of their education, but it goes much further than that. You must have education on all levels, all down through the apprentices in the various trades, and that goes both for those who are already at work and those who are just starting.

It is a two-fold task of informing those who are already educated and have modular coordination as a part of all their training and also those, whatever the level or whatever the time, who have not had university training in architecture or engineering. I mean those at the working levels of the industry.

I could add that, in my own country we do not have that wonderful chair you are asking for. I know they have in some of the Eastern European countries, where they are concerned much more keenly with the industrialization of the building industry than we are.

MR. KENT: I think it would be of interest to know that at the present time the Ontario Secondary School Curriculum Committee is advising on the curriculum for the technical schools, and in this, thought will be given to the industrial process side of building, of which modular coordination is such an important part.

I might say that the curriculum being replaced was established in 1928 to 1930, and it is, shall we say, time for a change.

MR. H. COCKER (McKay-Cocker Construction Limited): I do work in the general contracting field, and I also happen to be Chairman of the Training and Education Committee for the Canadian Construction Association, so I am very vitally interested in these comments Mr. Bergvall made regarding training at the various levels. However, from a general contractor's viewpoint we are very much concerned with the cost factor, and I do not think there is any general contractor present here who has not had to come to grips with costs in his experience.

Even with the modular components that exist in our industry today, such as in block and brick manufacturing, it seems an awfully difficult task to get a design created that makes these two components fit, whether it is relative to the doors or the windows.

Recently, on one of our jobs, in our masonry estimate we found we went about 34 per cent over cost, and I checked into this very, very carefully. I got the bricklayer foreman and we went over it and we found out that there had to be two bricklayers continually cutting to keep four other bricklayers laying blocks. Because of the layout of the door and windows on this job every door jamb block and every window frame block had to be sawn, whether at the jamb or at the head. If we do not do anything else at this conference but alert each and every one of us to think of the inaccuracies and how much layout affects cost, I think we will be well on the way to success, and my own honest opinion is that you fellows are on the right road. Keep it up. (Applause).

MR. AIRD: Thank you very much, sir. You are obviously getting support. I think there was only one question posed by the last gentleman from the audience to be answered, and this is probably a good time for me to ask Mr. Hindson of the Department of Industry for his views.

MR. R. D. HINDSON (Department of Industry): Certain universities have already been well enowed by the government, and it is up to the individual university as to how they apply the endowment. I see nothing wrong with industry introducing modular coordination, but I do not think they need a chair endowed to teach this subject.

However, since education is a provincial matter and not a federal matter, I will transfer this to my colleagues from Ontario.

MR. V. S. RISTIC (Industrial Research Institute, University of Windsor): Although I am not implying there was arbitrary decision put into the sizes of 3, 4, or 5-inch modules, there were only two or three mentions of the structural members in modular coordination, and I would like to ask a double-barrelled question. One, do the sizes of sawn timber, as, say, represented by the Canadian Institute of Timber Construction, or the rolled steel member as represented by the American Institute of Steel Construction, fit modular coordination; if they do not, why not? Secondly, do the dimensions of the structural members - as we all know there is

nothing subject to judgment or arbitrary decision about structural members - clash with the modular system, and if they do clash, how can we combat such difficulties?

MR. BERGVALL: I think several of your questions could be answered with reference to the distinction I made earlier between special co-ordinating dimensions and general co-ordinating dimensions.

Now the way timber or sawn lumber is applied, in Canadian house construction, the most is made of the dimensions, at least of the wood frame special co-ordinating dimensions, and the same goes for steel columns. Nevertheless, the question touches on an important problem, and that is the question of the thicknesses of structural parts of the building.

For example, there is a load-bearing partition wall between two apartments and it is known that for structural reasons and for acoustical reasons it is necessary to make this 14 centimetres thick (slightly less than 6 inches); from the modular point of view the wall should either have a 4-inch thickness or an 8-inch thickness. In the latter case, as some people actually said at our conference last week, there would be a little less than 3 inches of good solid concrete for no purpose whatsoever; my answer is, if the wall is made of a modular thickness in this clumsy way the loss of 3 inches of concrete is deserved, because if the solid concrete wall is the obvious solution to all the thicknesses, a little less than 6 inches, that is acceptable. But there are advantages in designing the wall so that the total thickness of 8 inches is obtained. Some other type of panel might be used, for instance the type having a cavity, and a lot of other possibilities are open to any engineer with imagination. What is gained by that? Well you may have to pay a little more, of course. To have, for instance, the cavity I mentioned, but the wall of modular thickness will not cause a lot of trouble when other components are put into play with that wall of the building. These factors must be weighed against each other.

I think this answers this rather specific question of materials, but I think no one necessarily expected either sawn lumber or rolled steel beams to be modular, because their dimensions are not usually generally co-ordinated dimensions.

MR. W. N. DICKIE (Wardic Limited): I am an industrial designer, and I know this is a general question, but I noticed in the examples that were used, that all except one from the United Kingdom were either masonry or concrete panels of the industrialized system. Is this significant, that the United Kingdom and Europe are using more concrete and masonry than other types such as sandwich panels and various other materials, or was this just coincidental?

MR. DUNSTONE: In any substitution from traditional building to any other method of building there is a pitfall which must be avoided, and that is to start thinking in terms of more expensive materials. It so happens for us that timber is often a dollar commodity and often avoided for this reason. I am sorry to say that here, but I suppose I must. So if the tendency is to start by changing the building materials from our indigenous bricks, mortar, and pulverized lime with a substitution of timber, sheet metals or plastics, we are getting into a domain where basic material costs are much greater. This is not to say that with considerable ingenuity the increase of basic cost cannot be offset, but experience shows it is a very hard fight to win. The first attempts at industrialization, and attempts will be going on until the market is really big, must involve the use of basic cheap traditional materials in new ways.

MR. KENT: There have been examples in the United Kingdom where pressed steel panels have been used in conjunction with structural members. The Oxford Regional Hospital Board has devised a system in which steel panels have been used. I think it rather interesting also, that the Pressteel Company, the company which stamped out bodies for Jaguar cars and mini-cars, collaborated, preferring metal panels and a metal structure to some of the other materials, but as is indicated, many of the Europeans are utilizing the traditional materials in new ways in industrialized building.

MR. G. M. FRANKFURTER (Garcy Company of Canada Limited): I am in the hardware manufacturing business, manufacturing structural wall members as well. I would like to hear someone on the panel discuss the one aspect of modular construction that has not been mentioned today, and that is the advantages for building additions and renovations.

We hope the modern buildings outlast the original tenants, but if the construction people and the manufacturing people are going to be required to supply renovation material for these buildings, it seems to me there must be some built-in advantage when it comes to renovating or adding to a building that has been built according to a set standard.

MR. DUNSTONE: I would agree there are advantages, of course. If the building is dimensionally co-ordinated, it is obviously more convenient to reorganize the internal partitions with co-ordinated materials than it would have been previously where completely chaotic measurements had to be dealt with.

There would be less cutting to reorganize partitions in a modularly coordinated building. I do not think this is going to help - probably other people will argue with me on this, but I do not think it will be an advantage in existing buildings which are not coordinated. Certainly when one turns over to coordination, then maintenance or alterations are going to be much easier to do.

MR. BERGVALL: May I briefly draw your attention to the comparison I made to screw threads and screws and modular coordination. That, in a way, is a short answer to your question.

MR. D. L. TARLTON (Canadian Institute of Steel Construction): I just want to make a comment first, if I may, Mr. Moderator. One of the questions asked earlier was concerned with whether metal was being used in various European countries in industrialized building.

I have recently visited several of these countries, and I can assure the questioner it is being used in Europe, primarily for schools, factories, housing, and several other building types. One of its advantages, of course, is that it has a good dimensional control which is important in any industrialized modular system.

I have a question I would like to ask. I have been listening to the discussion, and I would like to know this. It seems to me desirable, as I am sure all the people on the panel have said, that we should have a standard basic module. This has been reported to be 10 centimetres or the 4-inch module in those countries that are using the inch system.

Surely it would be better in the long run to adopt one or the other of these, since they do vary by a fraction. If 10 centimetres is the most desirable one from a world-wide point of view, why should we insist on saying that a module of 4 inches is acceptable in some countries? Surely the basic unit is the module, and the building plans are going to revolve on this module and not necessarily the dimensions of feet and inches or centimetres. What difference does it make to us, may I ask, whether we have a basic module of 4 inches or 10 centimetres. Surely it would be better to be using a universal module if 10 centimetres is the accepted answer?

MR. DUNSTONE: I think in a way you have answered this yourself, and it is of course a politically-loaded question. The change-over to the metric system should, I feel, be expedited but this being a political question I will turn it around the other way. What should not be done is to delay the change to modular coordination while the politicians make up their minds whether to change to the metric system or not. The decision to change to "metric" could take fifteen years. Now if the change to the metric system is not likely to take place for a number of years it is better to adopt the modular coordination system based upon 4 inches. This will facilitate the transition to the metric system when the time comes. Do not delay the change to modular coordination while the political estate is making up its mind whether Canada should go metric or not.

MR. BERGVALL: In a way the size of the module must not necessarily be so closely related to the system of measurement in the country, because when modular coordination is practised one of the advantages is that on drawings, particularly the drawings for the building site, nothing appears except modular numbers, but one thing is sure, when modular coordination is adopted components which have exactly modular dimensions are not the rule, that is one thing that is sure. This is precisely because allowances for joints and tolerances have to be taken into account.

That means that the drawings in the workshops, whatever kind they are - they might be for the brick factory or the window manufacturer or other sub-contractor - and whether the metric system or the inch system is employed, awkward, broken dimensions would have to be shown. If Canada did something so bold as to adopt a 10-centimetre module when the country was otherwise on a foot-inch system, that in itself would not make drawings any more complicated, because they were complicated enough already. That is not to advocate that Canada should go that way, I only wish to show when modular coordination is adopted a new unit of measurement is introduced, the module, and that is the unit of measurement on the building site from then on, and it simplifies everything on the building site enormously.

MR. DUNSTONE: I wanted to take issue with Mr. Bergvall earlier, and this question enables me to do so. He said, if I may put it in the vernacular, a 4-inch modular component will not fit into a metric unit. In the reverse, if a metric unit is applied to a 4-inch module it will fit perhaps rather sloppily. What is not realized, is that the jointing materials often cost more than the components.

MR. J. C. RANKIN (Metro Toronto School Board S.E.F., architect): Mr. Davidson gave us a very graphic demonstration of the development, as he sees it today, of the construction industry. Could we impose on him to ask him for another two or three minutes to look into his crystal ball? I think we would all find it very interesting.

MR. DAVIDSON: Yes, I suppose you are entitled to get your own back that way. If I look into my crystal ball - let me start by looking into somebody else's crystal ball where I do not have first-hand experience, and I can therefore make generalizations without embarrassing myself.

If we look into the meat packing industry we find that over the last twenty, thirty, forty, fifty years, I do not know exactly, but there has been quite a change from the small herder, the small village abattoir and the small local stores each serving people in their own locality on a specialized basis, to the present-day situation with large ranches, vast herds, and the Safeway-type retail outlet and so on and so on. The only survivor of the small outlet sort of operation is the kosher butcher.

The moral of this, I think, is that in the convolutions and convulsions going on in any industry - I have taken the meat industry because it is far enough removed from my sphere - people are constantly trying to find new roles for themselves.

Those who succeed are those who in fact find a role which did not exist before, but for which there is a need, or who amalgamate several previously existing roles into one which they can conduct more efficiently. I am afraid that unless the architectural profession is careful we will find ourselves as "kosher" architects, if I can put it that way, and no doubt "kosher" contractors will be found, too.

There is not too much more I can say, but I tend to think that each of us has to find new groupings of the roles to play in the coordinated industrial building industries I was talking about.

FROM THE FLOOR: Very well answered. (Applause).

MR. AIRD: I cannot think of a better reply to a better posed question to wind up this panel this afternoon. It would almost appear it was planted, but I assure you it was not.

I think your questions indicated your great interest and concern about modular coordination, and in order to earn my daily bread, as it were, as moderator of this panel I would like to simply sum up my feelings by saying that the problems which we are facing in modular coordination are great, and not easily resolved. Obviously, it is going to take time to spread the gospel throughout this country. There are many approaches and strategies which could be adopted, and as individuals we will perhaps be in conflict in looking at the overall problem. However, in the broad and vast construction plan it will be reflected in the long term.

We can take a look at the industry and examine its operation. We can use this, as one of the panelists pointed out this morning, as the track into the problem - not necessarily in itself, it is the problem we are interested in, or we can be very singular in our approach and say that the salvation of the industry is the 4-inch/10-centimetre module, and that is the system we must have if we are going to improve productivity. There are a number of approaches we can take, and the problem now is how to get it inserted into industry.

All this leads us to conclude that there is required a massive educational follow-up, both in the broadest sense and specifically, to a meeting of this type in order to translate our thoughts and questions at this point into some concrete action.

I am glad to see the BEAM program is helping to get this spear-headed, but suppliers, contractors and all of us interested in this problem have to make our contribution.

I would like to thank, on your behalf, the four members of the panel specifically for their contributions, their responses to your questions and for a very informative day.

PANEL DISCUSSION

at

THE FORT GARRY HOTEL, WINNIPEG

on

OCTOBER 24, 1967

PANELISTS:	L. K. Bergvall C. H. Davidson P. H. Dunstone S. R. Kent
MODERATOR:	J. S. Sugiyama
CONFERENCE CHAIRMAN:	J. D. Wood

MR. J. SUGIYAMA: I should like to ask the panel what effect, in their experience, modular production has on the aesthetic qualities of a building.

MR. L. BERGVALL: I think I can answer that question by citing a rather interesting experience. About 25 years ago we started discussing dimensional coordination in Sweden. The question was whether the module should be the equivalent of four inches, five inches or six inches. We invited two of our leading architects to submit facades of a school they designed, and these were redrawn to conform to modules of four, five and six inches. We then invited these two architects to come to our office and say which facade they had designed. They were able to single out immediately those facade drawings adjusted to as rough a degree as six inches, but as for the rest they were completely unable to differentiate between them and their original drawings. That seems to me to tell the story. The module is such a small unit and permits such flexibility that it does not restrict the architect's freedom of design, nor does it impair the aesthetic qualities of the building.

MR. C.H. DAVIDSON: I should like to put it this way -- that if the architect does not develop a design aesthetic compatible with modular coordination, then perhaps somebody else will. In other words, if the architect tries to put his head in the sand and say, "I can't do it", somebody else is going to do it. Perhaps it will be the engineer -- if I may say that to the architects.

SPEAKER FROM U. OF M.: I think that the four-inch grid does not give enough flexibility. I say this because the four-inch grid dimension in a large office building, for example, might have to be increased from four feet, five inches to four feet, eight inches to conform to the grid. In this country and in the United States such an increase in size might mean a considerable increase in cost. This points to the need for a smaller module than four inches.

MR. P.H. DUNSTONE: I would prefer the architects to answer this one, because this is really a planning question, but I would like to clear up this business of the combinations, on which you touched. The combinations, of course, will work with any numbers at all. They will work with integers. Whether you call those integers millimetres or modules or miles, does not matter at all. So that in this way, the combinations have nothing to do with the question of whether the module is small enough. I believe, personally, that the four-inch module is a sufficient gradation to deal with any planning situation, but I think it ought to be turned over to the architect members of the panel.

A MANUFACTURER: If I may add something to this; in the manufacture of partitions, prices do not relate especially to minor differences in dimension. A four-foot, eight-inch partition would probably be priced the same as a four-foot, five-inch partition panel. The larger one might be less if it

was the standard and the other a special.

MR. DAVIDSON: It's well known that the building industry prices things in the most hit or miss and the most absurd way imaginable. It is perfectly possible in the building industry for prices to be struck in much the same way as in the used car industry. "Special" costs apply almost universally. But if standardization through the standardization of basic dimensions were to become something meaningful to the manufacturer, he would at long last be able to produce a price structure which reflected the actual cost of production. He could then say, "This product can be sold for so much, and the price to you is a reflection of the cost to me." But at the present time, because there is not very much demand for standardization in many countries, we tend to find that the relationship between special cost and standard cost does not reflect the actual production costs. So the sort of reply you had from the manufacturers will not hold good, I would hope, very much longer.

MR. S.R. KENT: Mr. Chairman, since the subject of office partitions has come up, I might mention that I made a study of office partitions in the city of Toronto. At that time some manufacturers were concerned about the prevalence of five-foot office partitions. This immediately seemed to me to be a particularly large module for office partitions. As I looked into the subject I noticed that office buildings were being divided into two major categories. In the first category, the company building the office building intended to occupy the building itself. In this case the company was quite happy with five-foot partitions which gave 10' x 10' offices, 10' x 15' offices, 20' x 20' offices and so on. This arrangement fitted nicely with the priority of management for the particular company. And so they worked only with these very large partitions, and they were not concerned about whether the dimension was four feet, eleven inches; five feet, two inches; or five feet, one inch. The other group of office buildings were those which were being erected for rental purposes. Here we found that the rental agents were not happy with the five-foot and not even happy with the four-foot. They preferred something in the neighborhood of two feet which would give them a multiple by which they could get smaller offices for secretaries and so on. The point is, however, that at no time did I find anybody splitting hairs with inches; they were quite happy working with multiples of feet. Rather interestingly, in Montreal one of the large office buildings was laid on a five-foot module. The owners wanted to replan one of the floors, and so they scrapped all the five-foot partitions and introduced two partition sizes; the four-foot and the three-foot. By combining these, they increased the number of usable offices by forty per cent. A good example of good combinations of numbers.

MR. BERGVALL: I think it is important that people understand that there are always, in our times of swift changes, reasons to mistrust any such very detailed calculation of how large an office should be. Let us take an example from industrial buildings. Everyone, at least in my country, and the other European countries, is agreed that there is not very much point in having smaller increment steps for industrial buildings than six modules -- that is,

24 inches. Why? Simply because, even if you can calculate very carefully that machines and equipment take so much space -- so much for the existing and so much for future machinery, etc. -- and presuming these odd figures are precisely what are needed for optimum layout, in five years I submit that, because of new machinery and equipment, such a calculation is useless. As office equipment is developing at this time, it is very likely that a similar situation will apply for office buildings too. There is a general tendency in Europe to believe that what we will produce in buildings in coming years will be just space. Buildings will be built in such a way that they will serve a lot of purposes. To expect that you could calculate your office to the nearest inch is not a valid expectation. Such calculations could only be rationalized if no benefits whatever could be expected from standardization.

THE FLOOR: Can the panel comment on why the companies which have attempted prefabrication of single family dwellings in the United States, have failed.

MR. DAVIDSON: Not all have failed, but I agree with you that a large number have, and usually very spectacularly. I think the reason is a fairly simple one. They all rushed headlong into a program involving a considerable amount of investment without having done their homework properly. For example, General Panel Corporation approached the question of providing houses from a belief that standardized panels would lead to a particular aesthetic consequence. They believed that there was such a need for housing in an abstract way that the house, for all its peculiarities, would be highly saleable. They did not do a proper market analysis and they failed. If you take the example of "all size" homes, this company invested a considerable amount of money in order to use aluminum metal products in which they were interested. They produced a range of house types, the only possible buyer of which would be the multi-millionaire G.I. being demobilized with no possessions whatever. The house was complete even down to the wardrobe with the hangers in it. This company did not do its market analysis properly and the people in Michigan and Indiana did not buy the product. On the other hand there are one or two examples of firms which have succeeded, for example National Homes in Indiana, who are making an almost traditional house, almost traditional except that it is made in the factory. Why they are succeeding, I suspect, is that they have also set up a mortgage company, a management service and a complete dealership organization. They have taken a comprehensive view of building where these other companies did not do so. Now there are cases where the big industries, General Electric Corporation, and various others are advertising that they are just about to build new towns, as though we did not know how to do it. I think that we can sit back in about five years' time and have a big laugh at their expense, because I rather suspect that they are not asking the complete question.

MRS. P. HUNT, MANITOBA INSTITUTE OF TECHNOLOGY: Do you have knowledge of any school of architecture, university or technical school that is teaching modular process drafting, and if so, who did the work in preparing the curricula and so on, and organized the changeover, or are you interested in

starting that now?

MR. KENT: That was a most penetrating question. First of all, let me start at home -- the School of Architecture, Toronto. I might point out immediately that in all the schools of architecture we face the problem that I think I touched on rather delicately this morning in my talk. That was that in the schools of architecture, we are trying to train designers, and immediately the designers feel that they are being restricted as soon as any sort of control is mentioned. I might say that I think our problem in the university is not how to train the students but how to train the staff. So at the University of Toronto, let us say, the students are exposed to the modular concept, which I think is the proper academic way in a university. Professor Gillmore may speak about the situation in the University of Manitoba. I think at the University of Montreal the students are exposed to "modular". At the University of British Columbia the students are exposed to it, and I might say that it is only as the students mature that they recognize that it is essential that they employ the modular system in some way or other. Now, with regard to work in the technical schools: at Toronto a technical school does instruct the students in the modular drafting system. In Calgary, one of our instructors for the clinics is now familiar with the modular system. With regard to the teaching in the technical schools in Ontario, the curriculum is now revised for the technical courses and modular systems will be introduced into a series of courses.

MR. SUGIYAMA: I wonder if Mr. Gillmore would care to add to Mr. Kent's remarks?

MRS. HUNT: Where is the curriculum available? It is fine to say that exposure is being given. I am well aware of what it is like to train staff -- that is why I am here -- but where are these things that you talk about being exposed. Where can you find these curricula? Who would have knowledge of how to obtain this information?

MR. SUGIYAMA: I wonder if this would be an appropriate time for Mr. Dawson to speak to the group and indicate when this information will become available.

MR. J.A. DAWSON: It is the intention of the Department of Industry, as a follow up to this series of conferences, to initiate and organize a large number of clinics of modular practice across Canada. These will be organized, we hope, in co-operation with the various associations, especially the component associations of the R.A.I.C., and others, such as construction associations and consulting engineering associations. The objective of these clinics will be to acquaint architects, chief draftsmen, building construction site supervisors, and people of that type with the best known information on modular practice. We have, up to the present time, organized two seminars, directed by Professor Kent in Toronto, and we have drawn architects from all across the country, from the teaching profession and from architectural practices, to assist in the role of instructors at these clinics. We have one or two here today -- Professor Lewis, for example, of the University of Manitoba, and Mr. Ross Johnstone from Regina,

who will act as instructors. Their role will be to instruct people who will use the modular concept in their everyday work, in the best means of modular practice. And in this connection we have also formulated a bibliography of publications that will be used and distributed at these clinics. We hope that through the organization of these clinics a great many people in the country will be exposed to modular coordination and will become familiar with the modular concept, so that knowledge of the concept can be broadened in the country very rapidly and within a very influential group of people, namely the people at the working level of the professions and the industry.

MR. SUGIYAMA: I wonder if Professor Gillmore would care to comment upon this matter of education as a means of furthering the concept of modular coordination.

MR. R. DOUGLAS GILLMORE: Could I ask Professor Lewis to answer that because I think he could answer better than I could.

MR. J. P. LEWIS: As things stand at the moment, we do not definitely teach it as a method; however, in view of the impetus given it by the Department of Industry, obviously we will teach this method. Because it has not been used widely in office practice, we have not stressed it to this point.

MR. KENT: I think, now that industrialized building has become the "in" thing in the universities or in architectural thought, that modular coordination will very nicely drop into its proper place in the teaching curriculum.

MR. BERGVALL: It is all very well to instruct your professors and their architectural students, but I think that if you really want modular coordination to break through you must see to it that you get the proper instruction on all levels of industry, not only the top people, but all the way through. All echelons of the industry should be exposed to the modular concept, not just professional and senior executives; everyone, including the workers at the shop floor level. This is most important.

MR. GREENBERG, CONSULTING ENGINEER: In actual modular practice, we have many materials that have a nominal size; lumber is two inches, but the actual measurement is only 1-5/8 inches. How do you deal with this when you do your work on modular detailing?

MR. SUGIYAMA: This all stems, I think, from the question of tolerances. Whereas in the past we have worked on nominal sizes, just as you say, I think now we have to give sizes of the member, whatever it happens to be, and the tolerance separately.

MR. BERGVALL: I stated in my speech today that only the general coordination dimensions of a component have to be modular. Now, the way in which you use two-by-four-inch lumber, for instance, is such that those dimensions rarely appear as general coordinating dimensions. The lumber, of course, appears in various states, from the sawmill where it appears as green sawn lumber, then in the dry state where the dimen-

sions are smaller, then it is planed and the dimensions become smaller still. All this time, "two by four" is the nominal size. But these are not the actual coordinating dimensions, they are the general coordinating dimensions and this is what counts.

THE FLOOR: Is there a standard that has been set in the U.K. for allowable tolerances for materials?

ANSWER: I think there is a misunderstanding here on this question of nominal size in the modular sense of the word. A nominal size in the lumber work sense of the word, as you are aware, does not conform to the actual size -- a 2 X 4 is not 2 X 4 inches; it is 1-5/8" X 3-5/8". When we talk of nominal size in the modular sense of the word, we recognize that the components are not the sizes of general reference. In the modular sense of the word, the nominal dimensions deviate from the actual sizes by various allowable amounts. These are tolerances for various purposes. Now, coming back to your point,I think I have understood you correctly regarding the 3-5/8" dimension -- the thickness of a stud wall, if you like; it is not critical that this dimension is not four inches, because in all probability when you "set out" according to the "Unicom" manual, the face of the stud will be on the grid line. The other face is not on the grid line because there is probably sheeting or lath and plaster applied to it. Similarly, if you have something that has non-rectangular shapes, like a lavatory basin, for the sake of argument, the back face of the lavatory basin is a coordinating face, and the curves, provided they do not fall outside the expected size, say 2 feet by 1 foot 8 inches or whatever it is, do not interfere with the coordination.

MRS. HUNT: How long has dimensional modular coordination been a general practice in England, and what percentage of the industry uses it and how long has it taken to get to this percentage of use?

MR. DUNSTONE: That is a very good question. I cannot answer on the total percentage of use, and I have no figures on that. I do not think statistics exist. As I mentioned this morning, however, there has been a long hard battle of about 15 years in Britain and in other countries up to 25 years, and general use has still not been achieved entirely. I can say that the U.K. Government, at any rate, insists on modular coordination with regard to public building and it is linking the change to metric with modular coordination. Now this is being brought about by the fact that British standards are being changed into metric modular sizes rather than metric analogue sizes from the existing foot-inch system.

MR. DAVIDSON: I think we would be doing a great disservice to everybody in this room if we let the notion get about that modular coordination has got anything to do with a change to the metric system. We had made a decision in England that we would go modular before we made, but not very much before we made, the decision to go "metric". The fact that the decisions followed quickly after each other means that they are now chasing each other, and that both can be used at the same time.

MR. DUNSTONE: I should add again to that, as I have done elsewhere, that you in Canada should not wait for a change to "metric" before changing to dimensional modular coordination. The question of changing to metric is an industry-wide thing; it is a political thing. It cannot be judged at the moment when or whether Canada will adopt the metric system. All I can say is that if the change to modular coordination were made, it would be valuable in future changes to "metric". It would have been most advantageous if Britain had adopted modular coordination fully before changing to metric.

MR. SUGIYAMA: I wonder if Mr. Bergvall would comment on the experience that he has had in switching to the modular system. Was there as much problem as switching from left-hand drive to right-hand drive?

MR. BERGVALL: The switch from left-hand to right-hand driving was carried out in Sweden with astonishing ease and rapidity. Now leaving that subject, I would say that about the same steps have been taken in my country, by my government, to promote modular coordination as the government has taken in England -- without any reference, of course, to the metric system, because Sweden has been "metric" for many decades. The government has issued a regulation by which all buildings built for the government, or with government money, should be according to Swedish standards, and that means, among other things, being fully modular. If not, a very good economic reason must be given. Secondly, all the various government agencies which have the right to subsidize residential buildings, school buildings, etc., have the right to exercise the same sort of criteria regarding the design of those buildings. These regulations were issued this year (1967). All buildings are henceforth going to be modular, unless there is a good economic reason for their not being so. The reason for the issue of these regulations is precisely that the government saw no other opportunity to break that vicious circle I told you about this morning.

MR. KENT: Mr. Chairman, may I just pick up a few points here. One of the major problems in acquainting the complete building industry with modular coordination has been the lack of written information on the subject. I think I can simply say that one of the first publications on modular was that which two gentlemen prepared in 1945. This was in Sweden and written in Swedish, of course. The publication was then translated into English but I don't think any of you here have seen it. In other words, it did not have wide distribution outside Sweden. There was a publication in the U.S. called the A-62 Guide, which did have limited distribution. The first major publication which stated the modular principle clearly was not published until 1956, by the European Productivity Agency. A second report by the E.P.A. appeared in 1960. We have a Canadian publication appearing in 1961 on the subject of "modular", and quite a good American publication in 1963. This indicates that the modular idea is relatively new in the building industry of North America, which goes back 300 years. Industrialized building goes back perhaps 100 years. Again, it was only in 1956 that any organization in Canada became interested in promoting modular coordination. That was the Division of Building Research of the National Research Council.

MR. SHACK, INTERIOR DESIGNER: I am going to throw a new note in. I am not familiar with a lot of the building terms that you have used. We have heard today a number of things that involve manufacturing techniques, how buildings are going to be reduced in cost by automation and by providing a complete and integrated unit. But I do not think that the study as I see it, as an interior designer, has gone far enough. I think the system breaks down. All these things such as modular coordination are convenient, perhaps, to architects, and are convenient to contractors and manufacturers and no doubt, a number of points are very good and would have good results. But the one thing that has not been discussed the entire day is how the buildings are built for people. The module of four inches works fine, but unfortunately people are not built in four-inch increments, or two-inch increments. People are engineered individually. Now, if you take the imaginary grid which was explained to us this morning, the three-dimensional four-inch grid, many problems arise, I think, because of the inter-relationship of the interior with the exterior of the building. Working heights are 35 inches. Seating heights are 18 inches. Neither works out to four-inch modules. Table heights are generally 29-1/2 inches. So I ask, Mr. Chairman, for an expression of views on these matters.

MR. SUGIYAMA: That was rather a loaded question. I think we might start with Mr. Bergvall.

MR. BERGVALL: I can only hope that you, sir, will never be lodged in such narrow quarters that you feel whether the room you are in is a multiple of four inches or a multiple of two inches.

MR. DAVIDSON: There is no disputing whatsoever the fact that a human being sits on a chair of a certain height for his greater comfort. There is no disputing whatsoever that the worktop has such-and-such a height. There is no necessity, in any modular system, that these dimensions should change. The question stems, perhaps, from a misunderstanding, or a slight over-simplification that may have occurred in the discussions -- namely that the modular space within which you move in a modular building has this inescapable four-inch grid throughout, which you get hung up on every time you move. This is not the case. Modular coordination is an eminently practical matter and nothing more than that whatsoever. If, for example, we are talking about a chair, the eventual modular dimensions that might be concerned in the free standing chair is simply the plane of the legs upon which it stands. The fact that the top of the chair, the part that you and I sit on, happens to be 17-1/2, 18 or 20 inches is something that is decided for comfort reasons and has nothing whatsoever to do with fitting another building component into it. If, for example, the height for a kitchen sink or worktop is 35-1/2 inches and not the nearest modular equivalent which is 36 inches, it is perfectly possible to get out of the implied difficulty by having a backboard on the sink of 1/2 inch or 4-1/2 inches in height. Then the dimensions work out for tiling or for the next set of kitchen fittings from there up. I think that this sort of comment reveals a rather serious oversimplification in the understanding of the modular grid. I myself resist, as I say, the notion that space is filled with

the four-inch grid. This would be absolutely oppressive. Coordination only matters where things actually join each other. It only matters, for example, when setting out parquet tile floor. Considering the wall over there, coordination only matters when building the wall. Dado and ceiling heights etc. are important. It does not matter where the chairs are.

MR. BERGVALL: The four-inch grid has been mentioned, and when I introduced it this morning, you may recall that I talked about the important dimensions which give the building its form. These are the important dimensions that we are dealing with. The Danes and the Swedes refer to them as "decisive dimensions". So I think the dimensions to which the question referred are not the decisive dimensions in building; they are not the dimensions to which other components are going to be added. It is really this additive process of building that we are concerned with, and it is this additive process of building which creates many problems for us, especially if the addition is not correct.

THE FLOOR: My question is directed to Mr. Davidson. At the end of his talk he was about to speculate on the future, but he managed to escape. I would like to hear what he has to say about the future application of modular coordination in industrialized building.

MR. DAVIDSON: I am not the person to answer a question about modular coordination so much as the implications of industrialization in general on the future of the industry. I happen to be opinionated about this, but I would much rather that this came up at about five minutes to five so that I could escape quickly before it bounced back at me. I happen to feel that something really much more alarming is taking place in the building industry than, in fact, we realize. I myself become rather concerned when questions of architectural education come up, precisely because of what I am about to say in the next moment or two. To illustrate this: consider any industry in a state of change and looking outside of it we may see that a certain number of things are happening. If we look for example at the meat business, we think back a few years to the time when we had the local cattle grazer, the various neighborhood wholesalers, the corner retailer and various shops of that sort. We went and bought our meat conveniently at the corner store. Over the years, the meat business has changed completely. It has changed to being big business, with big ranches, freight trains carrying millions of head of cattle, central packing stations and super-markets. Of course, the only corner shop that has survived is the specialty shop, the kosher butcher for example, providing a specialty service. Now, there is nothing unusual about this, because when any industry changes, when any industry starts being exposed to the kind of competition for capital resources and for funds, which is typical of this particular day and age, we find that the participants in the building industry, as in any industry, look for new ways to behave. They look for new, comprehensive roles to play. I am suggesting that the only way the butcher could survive on a small scale is by being a specialty butcher.

Now, I am too close to the building industry to see what is going on, but I am afraid that the architects are going to end up by being "kosher" architects. I cannot comment on the role of the contractors and the manufacturers.

MRS. HUNT: I recall that about eight years ago, when I was employed by a large firm of architects in Winnipeg, they brought in people to advise us and demonstrate how to use the modular system. There was a big flurry, and we did a couple of jobs the modular way. I was fortunate enough to work in this system and I would ask Professor Kent what made the program stumble. Why did it fall down? It just petered away.

MR. KENT: Eight years ago? I am wondering if the office is one that I know very well. I am afraid that I cannot comment intelligently upon what happened, since I just have not followed up the activities of the particular office that I spoke to at that time. Perhaps some of the local architects would like to speak on this. It could have been, very simply, that they found that no sufficient modular components were available at that time, and so they just stopped using the system.

MR. BERGVALL: I am a little careful about giving advice in other countries, but generally speaking, if you want to promote modular coordination and are not content to sit waiting until it goes completely on its own, you must in some way break the vicious circle. One way is to emulate the Swedish in their actions of 20 years ago. Then of course, very few people had felt the wind of industrialization strongly enough to care much about modular coordination. Sweden consciously started out to see to it that the policy of the Building Standardization Institute of Sweden would be to issue modular standards through these 20 years. During this time, more and more modular products have appeared on the market in Sweden, and so a stock of modular components was built up. There was no excuse any longer for not using them systematically, and a campaign was commenced in this respect. This coincided with a degree of development within the Swedish building industry, that made it receptive to the idea of modular coordination. The process of industrialization and prefabrication had advanced far enough to make everyone aware of the necessity to do something about it. The conscious promotion was in the form of seminars all over the country, together with an industry which felt the need for change. The response on the part of industry was enthusiastic and gratifying.

THE FLOOR: Mr. Dunstone, would computer technology assist in perpetuating the necessary data and so on, to encourage more and wider use of modular coordination?

MR. DUNSTONE: If I get on to talking about the future of computers, we shall be here for the rest of the afternoon, but I think there will always be room, let us put it this way, for the man who constructs the computer. What will happen to the rest of us I cannot say. But undoubtedly, everything is moving towards computerization. This trend cannot be reversed. Standardization, industrialization, variety limitation, all these things are moving in every field in the same way. You can see it happening all around you all the time. I think this particular trend is inescapable. This is the world in which we live and are going to live, at a much faster pace than most people realize. I think modular coordination is a thing which we must grasp in order to use the benefit of the computer as soon as we possibly can.

THE FLOOR: Could you tell us of a few books which are, or may be available, on the four-inch module?

MR. SUGIYAMA: Many books have been written on this subject. Perhaps Professor Kent could elaborate further on this availability of books.

MR. KENT: Perhaps I should start off with the cheapest one, which is the Modular Drafting Manual, available from the National Research Council for one dollar. The next higher in price, I think, would be the one on Dimensional Coordination published by the R.I.B.A. A bibliography is included in the conference kits.

THE FLOOR: Thank you very much. I have one other question, involving the French housing. Do you recall the prefabricated wall thicknesses for this French housing. I think that it is something between 15 and 18 centimetres.

MR. BERGVALL: The particular French systems had non-modular dimensions throughout and what the wall thickness was, I frankly cannot remember. The building regulations in Great Britain are theoretically based on performance specifications. They give certain guidelines deemed to satisfy national specifications, as the easy way out, if you like. As for party walls in between dwellings of different occupancy, the density equivalent to seven inches of concrete is deemed to satisy the specification. Seven inches, of course, is a non-modular dimension. In the case of the concrete system that I showed earlier, a conscious decision was taken to make all the walls and all the floors eight inches thick because of the other advantages in terms of standardization, even though it is recognized that 15% of the concrete is not being utilized. Now there are other ways and means of making walls up to the nearest modular thickness, say, from seven inches up to eight inches, without increasing their weight. Usually these ways and means involve making such things as preparations in the concrete which may or may not be more expensive depending on how often the process is repeated, and what kind of equipment is used. But it may be that in a particular building situation the wall runs right through the building, including right through the outer skin, or perhaps related components form part of the party wall system, going right through the underside of the weatherproofing membrane, say, and from front to back of the dwellings. In that case, the modular dimensions run between the walls, probably in modular multiples. But if the building situation is such that, in fact, wall thickness is critical, because some modular component runs past the outer end of it, then someone must decide to go to an eight-inch wall and find the most economical way of doing it.

THE FLOOR: I was, for a moment, surprised to see this type of housing. Architecturally you can see the same type of housing in Germany, in France, and in England if it is prefabricated, and in Eastern European countries, such as Poland and Russia. It is interesting to see that they all have had the same type of experience.

MR. SUGIYAMA: For those who are interested in securing books, here are two of many good books available. One is by Professor S. R. Kent, the Modular Drafting Manual and the other is Modular Coordination and Buildings, put out by the European Productivity Agency. For those interested in seeing what sort of content these books have, they are available here.

I would now like to say something in answer to Mrs. Hunt's question about the continuance of an effort towards teaching and becoming accustomed to modular coordination. It is true that some years ago there was a similar campaign in Canada; Professor Kent was involved in it. And I think that because there were not six Professor Kents in Canada, the campaign seemed to peter out.

MR. DAWSON: It is not quite true that the campaign petered out. Professor Kent has been extremely busy in all parts of the country, and he has been responsible for tremendous gains in and around Toronto. In fact, most of Southern Ontario is acquainted with the modular concept. Now, I would like to say this, that given that we recognize that higher productivity is essential to higher standards of living in our country; and given that we recognize modular coordination is one means of increasing efficiency and productivity, then we as professionals, architects, engineers, manufacturers, contractors and teachers, in short everyone concerned with the building industry, has an obligation to do what he can to further this concept.

The Department of Industry is cognizant of the need for increased productivity in building. The matter has been discussed widely with representatives of the industry, especially the groups I have just mentioned. These discussions reinforced the decision to launch the BEAM Program, about which Mr. Hindson spoke to you this morning. This program is being implemented with the assistance of Industry Advisory Committees, which are made up of architects, engineers, contractors, manufacturers, teachers and labour union representatives. BEAM is a continuing program, one that will not go into decline unless the industry itself does not show the interest necessary to sustain it.

In Canada, unlike some countries, the government is not in a position to force the thing. We are in a position, however, with your co-operation, to provide some leadership and to create an environment which is conducive to the development of any worthwhile concept. It is important that industry agrees that it is worthwhile. A further step, which we may consider taking in the future, is to encourage the formation of a Modular Society in Canada, which will, if modelled after the Modular Societies of England, Ireland and Australia, enable the industry itself to guide its own move to modular coordination.

MR. A. NOBLE, C.M.H.C.: Let us step ahead in time a little, and consider that some general recognition in the building industry has been given to modular coordination. Do you believe that this coordination should ultimately be extended to include the overall physical environment -- roads, public services, etc., rather than to remain a system to be used in the consideration of the individual building, which is something of an anachronism in our increasingly complex society. Personally, I would say that probably too little authority is given to the relationship between buildings, spaces between buildings, etc. Maybe this applies particularly to downtown areas.

MR. DAVIDSON: I must admit that I am always a bit diffident about promoting the idea of a modular world in which to live, particularly if it is

based on a four-inch world; I think it might be a little bit embarrassing sometimes. Important also are the types of tolerances to which one works in setting out roads and drains and so on, which are probably more than four inches anyhow. But on the other hand this is perhaps taking an immotile and simplicist view of the thing because there are undoubtedly situations where the complexity of relationships between buildings is such that there would be effective reasons for making a modular relationship exist between them. I think that in the traditional subdivision of single family houses, separated by Mother Nature and a few roads and service lines, there probably is no need for a grid smaller than the 100-foot unit or so that is divided up at present on this continent. But on the other hand, I would accept that in downtown areas this is no longer the case. It may also be that, in fact, we no longer have links between them. If we start moving into a speculative frame of mind, which I think you asked us to do, you can imagine that the servicing of houses is done by total energy systems and such like. These have no links between them other than electricity power lines. And of course, the electricity power line is not in modules of one foot, but in modules of 100-yard reels of cable.

MR. BERGVALL: I could add an interesting example there, in connection with the switchover to right-hand traffic in my country. In my home town of Stockholm, a lot of the pavement tiles were made up of squares of concrete, happening, I would say, to be exactly three modules by three modules. But very often, I saw people standing there with a chisel and hammer in hand, adjusting one line of these tiles to be, say, half an inch less. Precisely, only because a man, sitting in his office, who had made the drawings for the pavement -- the traffic lanes -- the pavement on the other side had not recognized dimensional coordination. He knew only that a proper pavement should be such-and-such a width and a proper traffic lane should be a certain width. Well, it would not have changed the functions of that street at all if he had left the workers to make up the pavements in dimensions that would have used full courses of the 3 X 3 module squares. That is a little example of how the mere idea of dimensional coordination, whether modular or not, must penetrate through the whole business of building. I think our whole urban environments must be more or less dimensionally coordinated, but not necessarily to a four-inch module.

THE FLOOR: I, as a contractor, ask our visitors to our country, what steps have been taken to develop the skills and trades necessary to effectively install and develop the use of modular design on site. Has anything been done to educate the man on the job as to the methods of using modular design and the advantages, so that we in turn will not only install modular design components but also increase demand for it?

MR. DUNSTONE: I think that in traditional building, the worker does not notice modular construction. He is working to four-inch dimensions instead of the 1'8 3/8", and this is easier. If we are talking about industrialization, I think, then, that the situation I was describing this morning occurs. The tradesman then becomes the erector and I do agree entirely that training is necessary to handle this. The modular concept

has to be understood all the way down the line. I think it has to be understood even in traditional building; it works easier if it is. The use of modular coordination only simplifies the work on site; it never complicates it. The present setup of craftsmen knowing their work will be adequate to deal with modular coordination in traditional building. I do not think this can be confused with the different materials which are being used and which are coming into use for another reason. I think the pure dimensional side of modular coordination can only be simplified on site, can only be more simple to handle on site.

MR. KENT: There is a very definite need for carrying the educational process onto the building site. And I think that it has a value for any architect who is proposing to erect a building using the modular system, that he not only have his office fully aware of it, but all the contractors who have bid on the job and the successful contractor who is going to construct the work. I recall that on one building in Toronto, which the architect had designed in the modular way, the contractors did not bid it as a modular job. However, when the job was under construction the foreman looked at the plans for some time and noticed they were a little different, and then he came to the project architect and asked, "Bob, what's this modular all about? Will you come and tell us?" And at that time Bob realized that the foreman and his lead hands were going to be receptive to the idea. So he phoned me up and we went on the job and explained to the general foreman, the carpenter foreman, the lead hands and so on, just what was involved in the system. And so the job went ahead with all the advantages of a modular project. Now with regard to working with contractors in general, I might say that we find that they are the most receptive to the modular system. First of all, it does not involve any cost to them, it just simplifies their work. They complain, if you may call it a complaint, that they spend a little more time on laying out the project accurately. There is no getting away from the fact that the modular system does involve accuracy. But yet, once they have laid out the building accurately, they have reaped the benefits of this accurate layout toward the whole project. Another example I remember was on a job where a cabinet was not quite properly located. This involved the cutting of masonry above and below the cabinet. As the architect pointed this out to me, the tradesman came along and saw the architect pointing out to me, a visitor, that there was something wrong here. He asked what was wrong, so the architect explained to him, that if this had not happened, if a little more care had been exercised, then it would not have been necessary to cut the masonry. Immediately, the workman realized this as a bit of challenge for him in his future work to make things coordinate on the job.

MR. DAVIDSON: I would like to take up what I think is the second facet of your question, namely the union aspect, which relates more to the industrialization part of this whole subject. I have three comments to make. Firstly, anybody who gets into industrialization, and uses non-union labour in the factory is, from my experience, doing something that is really not worth the trouble. The amount of money that anybody saves in a factory

by using non-union labour instead of union labour, is not usually critical, and if it is critical, it means that he has not set up his production capability properly. This notwithstanding, I realize that, particularly in the United States, if you take a thing from one jurisdictional area to another, even if it is made with union labour, certain problems can arise. I would then switch my discussion with you for a moment to the second aspect. That is, that if you look at the work done in industrialized building in one country, it would be extremely unwise to transpose that, cold, to another country. For example in France, they have two unions for all workers. One happens to be left-wing and one happens to be religious -- I presume that can be called the right-wing. But anyhow, be this as it may, questions of demarcation do not arise. So therefore, in France, you can quite freely fabricate a panel which has a bit of cement finisher's operations in it, a bit of the electrician's work, and a bit of the steamfitter's, and so on. And you get no problems.

But if you were to transpose that experience to this country, it would be the first problem that you would be very wise to draw one's attention to. And indeed the technical answer that one would come up with would probably be quite different in order to avoid the demarcation. Which then brings me to the third point, which is that I am quite sure that a great many union problems could be avoided by decent communications between management, whatever one means by management for the moment, and the unions, however in fact they may be represented. I would like to illustrate this by quoting an experience from a seminar course I was giving in St. Louis, in the spring of this year. In the course of talking about these things, my students were constantly saying, "Ah, but you cannot do it because of the unions." And after they had said this to me about twenty times, I said, "We will get the unions in and see." We managed to get some people up from Carpenters' District Council of St. Louis, and it was the first time that union representatives had ever gone into the School of Architecture in St. Louis. I am willing to take a bet that there are no schools of architecture even in this great country that have union lectures as a regular part of their curriculum. And this I regard as a major calamity, and something that we should really do before we talk about anything else, since in the end, if we make ourselves more efficient it is fine for us, but there are more union members involved than there are people in this room, and people like us.

MR. BERGVALL: First, I would tell you that we have had rather little of that kind of problem in my country. But just to show the wisdom of the move that was suggested, I will tell you that 25 years ago, when building standardization was starting in Sweden, we invited the labour unions to have representatives on the board of the Building Standards Institute. This was the first official institute of its kind in our country to have people from labour on their board of directors. And that immediately created an atmosphere of mutual confidence, as you will understand, and made it possible to go further.

Finally, the whole question of labour is closely tied up with the question of education of labour for the industrial age as a whole. I agree with you that you could not copy our experience; it is only quoted as a piece of information which may have value for you. The Association of

Contractors, in co-operation with the unions, has seen to it that courses are given for the education of building labour. They must have their education in the same way as all other people, other specialists, in our country. A quite new type of building labour is now appearing, and these people should be educated jointly, according to this pattern, by the Association of Contractors and the labour unions; there is the proper place to teach modular coordination.

THE FLOOR: I would say it is one of the facts of life that, when the workmen have a better education, they want to have more money. I think it is wonderful that the man gets a better education, and that is important, but I think on the other hand that labour may become more expensive.

MR. DAVIDSON: It may be rather dangerous in this country at the moment to talk about something we do in France, but I would risk doing that, and saying, to my great shame as an Anglo-Saxon, that whenever people in France talk about industrialization they talk about improving the lot of the worker -- improving his quality as a consumer, improving his income. Now, whether you educate the man or not, you have got inflation on his side and against you. You might as well educate him so that you get proper value for money, if I can put it in these terms.

A CONSULTING ENGINEER: I want to ask a very simple question. How was the figure of four inches decided upon for the basic module? Was it an arbitrary choice? Does it have overwhelming advantages over any other figure, and what is the metric equivalent of the basic module?

MR. KENT: One of the requirements of industrialized building or the manufacturing process is to reduce the number of variables. On one hand we can reduce the number of variables so that we do not have sufficient flexibility. On the other hand we can state the number of variables to such an extent that they become an economic disaster. So, somewhere in between, we have to have sufficient flexibility, and yet on the other hand not too great a flexibility. I should really throw this back to Mr. Bergvall, who made a comprehensive study for the Swedish Manufacturers' Association when they came up with the 10-centimetre module. This begins to introduce the answer to the second part of your question.

MR. BERGVALL: I think we could go back to the four-inch module first, because that was the very first module, in the modern industrial sense of the word, that existed. It was invented in Boston by Alfred Bemis. Now the reason they chose four inches at that very early stage was probably just the result of subjective suggestion. It must on one hand be small enough to allow for flexibility, and on the other hand large enough to allow for any kind of limiting the number of variables. The example I gave you, about the architects not being able to discover whether their drawings had been adjusted to four inches or not, shows that this is probably the right choice. Now, as for the particular choice of 10 centimetres, the equivalent to four inches in the "metric" countries of Europe and particularly my own country. At the beginning, I must confess, we might have adopted the then

existing, and possibly existing even today, German system. In a "metric" country a lot of the already existing sizes will be multiples of 10 centimetres. Therefore the effect on costs of choosing 10 centimetres was definitely considered, as far as one could calculate such things. It seemed less if 10 centimetres was chosen than if 12 1/2 centimetres was chosen.

I think this is the reason why the idea of a 10-centimetre module took on so rapidly in all "metric" countries. So that with the exception of Germany, there is not one "metric" country in the world concerned about dimensional coordination which has adopted anything else but the basic module of 10 centimetres. Not one! Then the nearest inch-foot system equivalent to 10 centimetres is four inches. These are not identical but it is fortuitous, nevertheless, that the work on modular coordination, which during the war went on in Boston, U.S.A. and in several parts of Europe, in those countries who could devote some effort to it, proceeded principally along the same line. We came over here in 1946 and could compare in detail the work they had done in Boston and the A.S.A. 62 study on modular coordination. We found that, even with the difference between four inches and 10 centimetres, we had independently arrived in nearly every detail at the same solutions. It was most revealing and interesting. I think that answers your question.

MR. BRIAN AKINS GENERAL CONTRACTOR: I have a question that has not been brought up so far, and it is about the adaptation of our existing building codes to assist in the implementation of modular coordination. I would like, I think, to address this to Mr. Dawson, because his department could perhaps put pressure on other government departments. The National Building Code has been used as a prototype and guide in most of our communities, and we have an adaptation of it here in Metro Winnipeg. Because it is not accepted in its entirety, difficulties are created. To take a simple example -- exit doors and frames. A three-foot exit door with rabbeted door frame is non-modular to the outside of the door frame, which is the important measurement on the component. Also, masonry veneer, on a wood frame structure requiring a minimum six-inch size, creates difficulties in a modular sense. Is anything being done about this situation?

MR. DAWSON: We, in Canada, have a National Building Code, and we are very fortunate to have such a code, for not many countries are so favoured. However, the National Building Code has no legal status and is adopted in a community or municipality strictly on a voluntary basis. I hope that Professor Kent will carry on this discussion, because it is a most important one. Although I would rather give the National Building Code more credit for not being as restrictive on the subject of dimensional standardization as Mr. Akins suggests. Now, I have no doubt that the example you quoted is correct, and that being the case, then something of the nature of change must be implemented to allow the development of a modular concept. It has been recognized that the National Building Code may be restrictive in areas such as you have outlined, and in areas relating to the industrialization of building. For that reason, one section of the BEAM Program is addressed to an examination of codes and building standards; by that, I mean quality and performance standards

rather than dimensional standards.

I think it is true to say that due to pressure of other work, this aspect of the BEAM Program has not developed as rapidly as the aspect of information systems or the part on industrialization of building or that of modular coordination. We do recognize, however, that there is a difficulty in this area and I think that this matter will be dealt with, or at least work initiated in this area in the near future. The form that further work would take would include the appointment of a fourth industrial advisory committee. The make-up of this committee would be much the same as the others.

At the present time we have gone forward to the extent that certain members of the consulting engineering and architectural professions have asked to be considered for membership on that industrial advisory committee. We look forward to a great deal of interest from them, and a great deal of advice, so that if amendments are proposed to allow for adaptation to new techniques and systems such as modular coordination and the development of prefabricated building sections, such proposals will be made upon sound and factual grounds.

MR. KENT: I am certainly very pleased to have this question put before us. I must say it is the first time that I have known of the existence of details of the National Building Code which have hindered modular coordination. I see Stuart Frost down in the audience there, and I am reminded that when he was with the National Building Code, he and I were working out one phase which we hoped would cover all situations. Obviously Stuart, this has not happened. So, may I suggest that if at any time you find anything in the code which is restricting you in your use of modular coordination, you do inform the secretary of the National Building Code, so that he can bring it up before the Associate Committee. And I can assure you that the chairman and his staff will try to propose a solution to the problem, and try to get it adopted by the Associate Committee.

MR. BERGVALL: I might add a few words about how these problems are attacked in Europe. There is an increasing recognition of the fact that building codes must not only be nationally unified. They must at least be internationally harmonized. People are talking about the large market from a European point of view, and you might like to consider Canada and the United States a large market in the same sense. If you do not have the same codes there, how big is your market? The second point I want to make is that in these international discussions about building codes, it has clearly appeared as necessary that the building regulations be written as functional requirements' performance codes. But, our knowledge of performance standards is in many respects so piecemeal today that we can only describe this requirement in very general and very vague terms. This creates an opportunity for different interpretations in different local quarters which is something which must absolutely be avoided if industrial production is to be promoted. Therefore, one way out is to formulate codes as accurately as possible, based on performance specifications. Add to that a number of examples of construction which the local authorities should accept, and make it possible for anyone who comes up with anything new and unusual to have it accepted once and for all by a central, impartial authority.

The third point I want to make refers to what was said this morning about integration of the building process and the increasing importance of installations of equipment etc. This means that it is not enough to see to it that local building authorities do not have any odd local ideas about spacing of studs etc.; but also that no local plumbing, electrical work, or other regulations exist to the detriment of the nationally accepted standard. This is a requirement for the industrialization of building. Of course, this goes rather far, but I think it is proper, when you have brought up the matter of building regulations, to show what kind of building regulations systems are needed if you really want to promote industrialization of your building industry.

MR. BOWMAN, MANITOBA DEVELOPMENT AUTHORITY: I am an electrical engineer, and as such I have no criticism of the building industry endeavouring to achieve some standardization. But as an individual, I would like to put forward a plea for some simplicity in the language used. I can think of very few more clumsy expressions for what you are trying to achieve than "modular coordination", if all you really mean is standard units. Can you not get a little bit closer to that type of simplicity? The very word "module" seems to me to have some connotation of volume, or at least area, when in fact you seem to be using the expression as purely linear, a single dimension.

If your unit is to be used today as the brick has been used for hundreds of years, why not just call it the new brick? Or if you want to use the module, call it the "four-inch unit" or "sub-unit". There already is a four-inch unit in the language. It is used for measuring horses and it is called the hand. Is there not some justification for talking of a new brick of three or five or eight hands rather than some coordinated module? It has this additional advantage, that the word in French would allow you to use the same symbol "M" against 3M, 5M or 8M size.

MR. DAVIDSON: I have every sympathy for the point you just raised, because since we landed on the East Coast here, we have been interviewed by television and radio reporters who start all their conversations with us by asking "To the man who listens over his lunch pail, what is modular coordination?" And of course, there is a ghastly pause.

MR. DUNSTONE: I think this raises the greater problem though, that of nomenclature as a whole. And I think that as we move into this computer field more and more, we are going to need a definition of terms, and these terms have got to be fairly simple. I agree entirely that "modular coordination" is a clumsy term. It has come down to us from somewhere. No doubt Mr. Bergvall could elaborate on this, but it does pinpoint the necessity to have these terms defined and used in their proper context.

MR. BERGVALL: We found the necessity for exact definitions several years ago in international modular work, so that the term module, basic module, multi-modular, modulation, etc. could mean exactly the same in France, England, Germany, Russia, etc., with the proper translations. So we made up a document called the Basic Principles of Modular Coordination, which has until recently

been the basic foundation in our work.

At the I.M.G. Conference in Paris the week before I left for Canada, we made some additions to that, to catch up with the development in later years. And that will very soon be published in one way or other and made available to various sources. One channel from which it will be distributed is the Economic Commission for Europe of the U.N. There, for instance, the terms are defined and the whole concept of modular coordination described rather shortly, but on the whole, accurately.

MR. KENT: Since the word module has come up, perhaps I should put it in its historical context. That is, in the orders of architecture, where the module was the diameter of a column at its base. We happen to have a column over there beside that window, and if we take the diameter of that column, this then becomes the module. In other words it is a repeated unit of which all other parts of the architectural order become a fraction or a multiple. It can be of any dimension, depending on what scale the column happens to be. And I fully agree with the questioner that this has created a great deal of difficulty in our whole problem of dimensional coordination, because of its inflexibility of size. So we try to bring it down by calling it a standard module, a basic module, or something like that. I fully agree that perhaps a hand or something else would have been a much better term.

MR. V. SHUDULA, CHIEF ESTIMATOR, SMITH BROS. & WILSON, REGINA: It has been very interesting to listen to all this discussion about modular coordination. I am amazed at the lack of knowledge that some people have of its advantages. I think half the people today do not seem to realize that they are using modular coordination every time they design a building. The concrete block and joint is 16 inches long, and the brick and joint is eight inches. The members of the panel here have given us a very good discussion today. They are trying to educate everybody to the fact that in designing a wall, instead of making it four feet, 10 inches, it is a lot easier to have it five feet. I think everybody here has seen window openings at three feet five inches. It would be a lot easier to have them three feet, four inches without having to cut a lot of masonry. In brick heights also, this is just as easy. As a cost estimator I can see nothing but decided advantages in costs in modular construction.

MR. SUGIYAMA: From the foregoing discussions and the talks presented today, it is evident that the problem of increasing productivity and efficiency in the construction industry is really a complex one that will not yield a simple solution. It is a big challenge to the construction team, consisting of architects, engineers, contractors, manufacturers, suppliers and so on. Each will have his own peculiar sort of problems, and each will have to solve them individually, but there is very definitely a need for communication between these various people. I think that this is the area in which we all seem to fall down. We know what we're doing ourselves, but we very seldom know what the others are doing. Much work has been done to establish a module and, as Professor Kent put it, the four-inch module is just right. It is neither too small nor too big, and the metric people have adopted 10 centimetres (or 100 millimetres). These seem to work quite well. The Department of Industry

is organizing these clinics, which are open to all people interested. There will be a large number of these clinics conducted across the country.

In closing, I would like to compliment the audience for showing such a keen interest in these discussions and providing the necessary questions. I think the Department of Industry required this audience's participation to evaluate the success of the conference. I would also, on behalf of the audience, like to thank the members of the panel and add my own personal thanks for providing so much information and for providing answers to the questions which you put to them.

PANEL DISCUSSION

at

THE MACDONALD HOTEL, EDMONTON

on

OCTOBER 26, 1967

PANELISTS:	L. K. Bergvall C. H. Davidson P. H. Dunstone S. R. Kent
MODERATOR:	Kenneth Bruce
CONFERENCE CHAIRMAN:	Ronald Clarke

Mr. K. Bruce introduced the panel and then suggested that questions from the floor, directed to members of the panel were called for.

MR. FRED MINSOS, EDMONTON: We were getting pretty close to prefabrication this afternoon and I was wondering how the encroachment of the different trades would affect your system. In Swedish magazines I have seen complete bathrooms with precast walls, plumbing, fixtures, everything included and put into place, and I was wondering what effect trade unions would have on savings, because with these precast members it would be very simple to assemble and if the trade unions are as particular as they are here, it might offset the saving.

MR. S. R. KENT: The question here is one of trade union involvement, and I think Mr. Bergvall might be the one to answer this - You are referring to electricians, plumbers, etc?

MR. L. BERGVALL: First, I think I must draw your attention to the fact that it is very dangerous to draw conclusions as far as unions are concerned from one country under certain conditions, to another country under other conditions. To answer the question more specifically as to how this new development was influenced by the unions our unions have taken precisely the attitude towards industrialization which in my speech I have asked you to take -- that you do not try to escape the inevitable. We must face it and make it work.

MR. P. H. DUNSTONE: Trade unions in Britain hardly come into this problem yet. I think when they do they will be looking more at the overall picture of union labour. Union labour would work in the factory and on the site. The tendency would be for craftsmen to disappear and become erectors, and as long as they are picking up the money the men themselves do not mind. I think this attitude has simply got to be solved by the unions in some way.

MR. KENT: I think I should make some comment here -- I think what is going to happen here is that there will be a very large block placed in front of us that has to be removed initially. However, I think given time and a little patience, this block can be moved. Recently, in the United States, there were two very important decisions made in the Supreme Court. One was relative to a pre-made door and one was relative to insulation, prefabricated insulation on the building site. Unions objected to this and the Supreme Court upheld the decisions. I think these are temporary things, but certainly as part of the systems approach, one has to consider this as a major item.

MR. C. H. DAVIDSON: I would like to add something to the discussion so far about the unions. I think that this is very much a communications problem. Many times during my seminar courses in St. Louis, last spring, many of the American students would say, "But you cannot do that here because of the union." I strongly disagreed, and said, "We will get the unions in and ask them." So we got the unions, and for the first time in that School of Architecture, and, I am willing to bet, for the first time in a great many schools of architecture, people, from the Carpenters' District Council in St. Louis in this case, came and talked to the architect students and we found that in fact the unions had sensible things to say, and, had it been in fact adopted as a policy to discuss these problems with the unions at a very early stage, we might arrive at solutions better than the ones we were thinking of ourselves. These would, moreover, have the value of being agreed to by all parties.

MR. DUNSTONE: Because of good communication between labour and employers, agreement can be secured on these points. For instance, representatives of the Building Labour Union have been on the Board of Building Standardization ever since that institution started twenty-five years ago.

MR. BRUCE: Since this discussion is involving industrialized building, I think it would be wise to just mention that in the BEAM program there is an Industry Advisory Committee on Industrialized Building and on this Committee there are representatives of both the major unions in Canada for the very purpose of improving communications.

MR. MICHAEL PALMER, DIAMOND, CLARK AND ASSOCIATES, EDMONTON: Is not the key in industrial building jointing techniques? If you have a number of competing companies developing different jointing techniques you get waste being built into the whole concept. Because of this the economic advantages of industrialized building are lost. Unless you develop some uniform jointing techniques you eliminate some of the advantages of industrialization.

MR. DAVIDSON: You are absolutely correct. I am in fact involved at the moment, in England, in a project under contract for the Building Research Station to see if it is possible to produce standards. We have a number of school systems in England which grew up independently, and I believe I am correct in saying that the only standard interchangeable components in these school building systems are the doormats. I am finding from my experience on jointing, that this is not only a technical question but also one of the ways decisions are made - who makes the decisions. The decision on the job is usually the last of a whole lot of decisions starting with manufacturers way back who decided to use certain materials in certain ways and so on. I cannot say that this answers this problem. I must say that I think this is where modular coordination gets us to, and we have to get on from that.

MR. BERGVALL: This is precisely why international modular groups, having agreed upon the measurements, etc., have now taken on the study of international conventions on jobs. So you touched a very important subject.

MR. J. SISSONS, VICE-PRESIDENT, MEDICINE HAT BRICK & TILE LTD.: The question was raised a few minutes ago by Mr. Minsos with regard to the unions and their place in this unfolding trend, and I think it could also be asked regarding trade contractors. I think that they have similar definite interests in their present position and I would like to ask that same question but using trade contractors. What will be their position and what is the experience of the panel in that regard?

MR. DAVIDSON: This is a new type of question for me, and I think a very valid one. I think it is inescapable in any new method of building that new kinds of organizations are set up. I think it is inescapable that the specialists (trade contractors, sub-contractors) have to establish some kind of relationship with some other group of people in the building industry. This may mean that you get a consortium of trade contractors, not within one trade, but spreading across trade barriers. This, I think, might be one solution, or you may get special relationships between certain trade contractors and certain general contractors, I really do not know. I do not think it matters what the organization is, as long as it is more integrated than this organizational situation which exists at present.

MR. DUNSTONE: I think you have two situations here, one where you use modular coordination in a traditional sense, and here you have the initial situation where your trade contractor worries about it and it probably goes easier. On the other hand, you have this change to industrialization, where the trade craft skills tend to disappear and the erectors take their place. This is another thing altogether; it is a trend of the industry, a trend in which we are all bound up. The only fear of change arises insofar as there would be this change from lots of trades putting building materials together, as they have in the past, to industrialization rather than modular coordination; and in the industrialized sense, of course, the individual trades will tend to disappear.

MR. V. DELANE, CALGARY: I would like to ask Mr. Bergvall - he mentioned, in his talk, multi-modular scale, and in there he included the 15M unit in a bracket - Is there some doubt about the inclusion of this?

MR BERGVALL: You obviously understand that the more flexibility in design required for certain types of buildings, the smaller multi-modules must be. Now say, for instance, that certain systems for residential districts in Edmonton operate, some of them, on a 3M basis, and some on a 6M basis. Now it is very important that 3M and 6M, one a multiple of the other, are chosen, because in that case all of the

components could very often be interchangeable. It is this requirement of interchangeability that has led us to the establishment of the fact that each multi-module should be a low multiple of the next lower multi-module. This is why you find 3,6, and 12. Now 30 and 60 again are not directly multiples of 12, but that does not matter because they are for quite another type of building than those for which 3M, 6M and 12M components were foreseen. Now, in the international agreements, sometimes you have to make deviations from the pure scientific findings and be a little diplomatic. Also, the fact remains that in all European countries they make extensive use of 15M components. Therefore this was accepted in the international agreement, but only in brackets, thereby making it understood that these should have less preference than the others.

MR. R. CLIVER, EDMONTON: There has been much written and discussed on the changing role of the architect to be compatible with the demands of today's society. What change, if any, do you envisage in the role of the architect if modular coordination eventually becomes an accomplished fact?

MR. KENT: We are assuming that we are going to be working with more and more standardized components. One of the problems that we are facing is that the architect has not concerned himself with the standardized components that are available to the building industry. I suggest there is going to be a new role for the architect when modular coordination becomes an established fact, as we are going to be working with more and more standardized components, and working directly with the manufacturers in developing these standard components. These are going to be of the desirable qualities and the type of performance that can be used with degrees of variety, which is really what we are striving for.

MR. BRUCE: I think the question was more in terms of the role of the architect within the present building organization.

MR. BERGVALL: I must say that the mere introduction of modular coordination as such could not interfere with the role of the architect in the building industry. It would only simplify his work if modular coordination were the only change that was to take place. I do not think that the clients, represented by the architects, should direct the development of new products. Because usually they do so for specific projects, and that results in products that are only suitable for that project, and thus are probably to be produced on a comparatively small scale. I think that the manufacturers of components must copy the development of new products from other industries, discuss technical ideas, sort them, assess their value, assess what gains can be obtained from them. The next step is to put these things in your drawing office or laboratory and subject them to a number of tests. You can finally build a house where that product is integrated in the way it is supposed to be integrated when it appears on the market. Then you increase your production a bit, so you can get the

market's reaction to it, and after having done that, you have the various production techniques for the various stages of production, and then, finally, you are ready to say yes or no. This is, in very short terms, the method of development of products.

MR. BRUCE: I think the role of the architect is still in debate.

MR. DAVIDSON: In any wide industrial spectrum the various roles that people play are constantly changing. The change can happen in many ways - some people expand their roles up to include the activities previously done by other people, or you can get people to introduce themselves into this complete sequence because they have thought up some new specialty service. I tend to think that in the building industry, if architects go on behaving the way they used to, we will end up being specialists. I suspect there are a whole lot of new roles that the architects can play which are well worth playing, and if played, the architects will have a tremendous leverage in the building industry.

MR. BERGVALL: Talking about new roles may draw our attention a little too much to organigrams. What use will there be for the architect in the future society? What kind of work will be performed? In a wide sense, is the architect a specialist? We will always have a need for him, you can call him a landscaping architect, a building architect or an industrial designer. There is one trend in the building industry which deserves to be emphasized, which is that this new industrial evolution can direct the architect to create the things he has a specific talent for creating. Even within this new organization of the building industry the architect has a great opportunity to play a very important part.

MR. KENT: I am thinking of a panel in which I took part a few months ago, on school design. In this case the problem was to standardize school plans or standardize components for schools. I think we all recognize the way in which the client becomes short-changed in the standardized plan. Standardized plans do not serve the purpose which they might. On the other hand, where we are working with a series of components which are standardized and are modulated, the architect then has the opportunity of providing a complete range of flexible plans to meet the varying needs of, in this case, schools. At the same time, the owner is benefiting from a standardization of the building process. In this case the architect, working with a series of modulated components, is working with a different form of freedom than he had before and yet it is a different role than that to which he had been accustomed.

MR. BUTLER, EDMONTON: My question is directed to Mr. Kent and Mr. Dunstone. I would be interested in knowing the status in England of the acceptance of the metric system and also what the present status here in Canada is.

MR. DUNSTONE: The situation of "metric" in the U.K. is that for many years the whole of British Industry has been lobbying with successive Governments to change to "metric". The Government yielded eventually to this pressure and agreed that the U.K. should go "metric". The construction industry was one of the first to change and the British Standards Institution became the focal point of this change. A program has been agreed on by all sections of the construction industry for the change, which has already begun, and as of the end of 1968 all contract documentation and drawings are due to begin to change to the metric system. They are due to be completely in metric by the end of 1972. The change is without the pressure of law, and most people think the industry will bear the cost, but of course it will not; the taxpayer will The taxpayer will be paying for less revenue gathered from the industry as a whole and for the tax release in the form of new machines and this sort of thing. There will be no compensation at all to any members of the construction industry. If the implication of that question is: "Should Canada go metric before going modular?" the answer is "No". By all means go modular as soon as you possibly can and leave the change to metric to the politicians when and where it happens to come up.

MR. KENT: This question was brought before the Department of Industry prior to this Conference, because we recognized that people would want to know why we would make two changes if we are going to go "metric" in the future. From the survey that was made by the Department it was determined that "metric" would not be introduced in the near future and that there would be ample time to cash in on the benefits, as Mr. Dunstone has said, of going modular in the immediate future, and then when the S.I. units come along we will introduce those. I attended a meeting in Montreal recently and it was agreed there that "metric" would only be introduced into Canada when the economic situation forced it. In other words, it would not be done on a voluntary basis simply for the ease of communication, it would be done on an economic basis. Many of us are thinking that this economic basis will not occur until there is activity in the United States. As we look at the activity in the United States we find that the American Society for Testing and Materials has now prepared all its standards with inclusion of metric units. We find that there is a U.S. Congressional committee with a budget of nearly $5 million to make a study on the introduction of metric and the A.S.T.M. is also preparing a guide on the change to "metric". Ford Motor Company has prepared quite elaborate brochures on the change to metric. So the general conclusion of the meeting was that "metric" is coming and may be coming faster than we think.

MR. DUNSTONE: There is a story going around Britain that the Ford Motor Company of U.S.A. has spent more on a feasibility study on the metric system than the whole amount Britain is going to spend in going "metric".

MR. MCLENNAN, OTTAWA: I would like to direct this question to Mr. Kent. I am curious about the schools of architecture with respect to teaching drafting techniques. I know you are taught to draft in the

School of Architecture in Toronto and I wonder whether training is given in modular drafting and if not, why not? And do the schools of engineering in Canada do anything about it? It seems to me that surely one of the most difficult things to introduce would be a knowledge of drafting techniques in the modular context.

MR. KENT: To answer the easy part of that question first, I know of no school of engineering where the subject is being introduced. In the School of Architecture in Toronto - I'll begin with that one - we have had great difficulty - those of us who are actually concerned with the building of buildings as opposed to those who design buildings. We recognize the need for modular, but it has not been until the last couple of years, when industrialized building has become the "in" thing for architects, that the students have recognized the need for coordination of the dimensions of the industrialized building. At the School of Architecture in Toronto, the students are instructed in modular drafting. In true academic fashion they are not forced to do modular work but I find they are coming around to accepting it as a recognized industrialized building process. In other schools of architecture they are being instructed in the advantages of the modular system but as design philosophies vary in different schools of architecture I'm afraid the acceptance of modular systems also varies in different schools of architecture. Perhaps the situation will improve, as we are training some of the staff members of the schools of architecture to assist in the follow-up programs to this series of conferences - a series of modular clinics. I would say that the staff members of schools of architecture are becoming more familiar with the subject, although the literature on modular has not been too readily available until two or three years ago.

MR. J.A. DAWSON: I would like to follow through with the clinic aspect, as this question has come up at every one of these conferences. The Department of Industry, in co-operation with the Industry Advisory Committee on Modular Coordination, decided upon holding a series of clinics to communicate the modular concept in a way that Professor Kent had established and had been carrying out individually for a long period of time. The Industry Advisory Committee recognized Professor Kent's work in this field and it was therefore proposed that we hold a series of clinics on modular practice. We hope to initiate these across Canada very soon. In this connection we have enlisted the services of a number of architects who are in practice and in the teaching profession in Canada. We have held two orientation seminars under the direction of Professor Kent, to acquaint the architects with the publications on modular coordination and ways of instructing at the clinics - in short, so that they will all be speaking in the same general terms right across the country. The clinics will result in a broadening of the knowledge of the modular concept across Canada very rapidly. You people are very important in this program, and, given that we recognize the need for increasing productivity and efficiency in building, and that we recognize that modular coordination is one means to this end, I think you will wish to help us all you can. I certainly look forward to receiving your support and co-operation in this matter.

THE FLOOR: I would like to hear something on this same subject from the United Kingdom and Sweden - what they are doing in their architectural schools on teaching modular coordination.

MR. BERGVALL: First, I think it is necessary to make distinction here between the dissemination of information on modular coordination to people already educated for their proper roles in the building industry, and education. The latter means people who are being educated for various roles in the building industry. Both are equally important, but the situation is, of course, a little different in both cases. What is important is that neither information nor education stop at that very nice level which you are talking about - architects and draftsmen - but should penetrate all through the building industry, right down to the people on the building site. The Swedish Organization of Building Standardization has started very much like you have done in Canada, with a number of courses and conferences where they have tried to bring people together and inform them. You must train properly in the modern way of building, and on that program the labour unions and employers can join together to see that labour is properly educated for industrial-type buildings - and there modular coordination will come into it.

MR. DAVIDSON: I do not think we are doing as much as we could in the U.K. towards training people in modular coordination, but there are one or two things happening that are significant. The Modular Society has initiated a program of training procedures whereby a visiting team of people or body of information is sent around to schools of architecture which have requested the training program. A number of schools of architecture, in any case, are dabbling in modular coordination in their curricula. As is often the case, they find themselves in this almost inevitable collision between the design studio type of thing and the technical courses, so to speak, so that modular coordination is not getting the time it deserves in the schools of architecture. There is one thing, however, which is not absolutely relevant to modular coordination, but I think is very important, that is beginning to happen in the United Kingdom. It is the use of mid-career courses on subjects such as building management and modular coordination for people who are in the prime of their professional life and who go back for a fortnight or a week and learn some of the things that have happened in industry since they left school.

MR. DUNSTONE: I would like to add one or two things. These are: First, that the Modular Society is carrying out one-day seminars throughout the country to deal with this question of modular coordination. These are drawing board exercises, where a set exercise is given and it is entirely a practical day. The other is that, of course, the Government does require that all buildings for it be modularly coordinated. This means that within Government service architects are getting a fair amount of experience in modular coordination, and those outside who work for the Government are also becoming experienced. Therefore, we are getting

a body of experience going, and I believe we will see far more training courses all the way down the line in Britain. I believe that this will increase as we change to metric. The Construction Industry Training Board has in fact prepared a very good program of learning on metric in which I have suggested they incorporate modular coordination.

MR. E. LOCK, EDMONTON: So far, I have the distinct feeling that when you are speaking of modular coordination and modular units. you are thinking in terms of masonry and possibly prefabricated steel. Has anything been done to press the lumber industry to become modular, particularly in the domestic market and the export market?

MR. BERGVALL: As a matter of fact, lumber is not a critical problem in this respect. You will remember that I drew your attention, in my lecture, to the fact that, for the conversion to modular coordination only certain dimensions had to be adjusted to modular dimensions, general coordinating dimensions of a certain product. Now with, say, a 2 X 4-inch piece of lumber, only rarely do these dimensions appear as general coordinating dimensions. It is usually intended to make up for a part of the similar structural element of the building, and that totally functional element must meet the rest of the building with modular dimensions. The way in which you build up your wall should provide typical coordinating dimensions. Furthermore, 2 X 4-inch sawn lumber is just a raw material; when it is dressed and planed you might have other than 2 X 4 inches which are only nominal dimensions. I think the same could be said for any number of other wood products. Plywood is still made into inch dimensions in Sweden because of our traditional export to England, but I hope that will change. The accuracy with which non-conventional building work is carried out in my country, and certainly in your country, is such that you will never ask them to treat these various products to fit, say the framework of timber that is erected on the building site. The difference between metric and inch dimensions has not caused much of a problem yet, but I can foresee the time will come when such things will have to be taken care of.

MR. DAVIDSON: You have put your finger on a problem here. The feeling is always, and it is a universal feeling, that the dimensional or modular coordination and its associated industrialization are nearly always linked with concrete materials and components. There is no reason for this, and today I deliberately changed my lecture and talked about timber panels, fitting the windows into timber openings, to try and get over this situation. It does apply equally to prefabricated or pre-formed timber panels as it does to concrete panels.

MR. BRUCE: The subject of the joints in building came up earlier and it seems it is the joints in building we are wanting to coordinate. In general, a 2 X 4 and its 2 X 4-inch dimension does not interfere with the joints of a building, but if coordination is taking place, it may be in the length of the units but not in this 2 X 4-inch dimension. We, of course, have the same thing in structural steel and to date structural steel I-beams and wide trans-sections in angle iron and so on have not interfered with modular systems at all because

these dimensions are not being added to, or being added to each other, neither are they being added to other components. Bear in mind that we are always thinking of building as an additive process.

MR. DAVIDSON: I think it is important to remember that we are not talking about the world divided into little imaginary 4-inch cubes. A question that might have been raised would relate to, say, the relation between anthropometric dimensions and the 4-inch discipline. It might be argued, for example, that the ideal worktop height for a kitchen is not 36 inches but,say,35 1/4 inches or something of that sort and it would be quite false to jump to any conclusions that because the dimensions in the modular world are rounded off to the nearest 4 inches all dimensions have to be rounded off to the nearest 4 inches. If 35 1/4 inches is the right height for a worktop, worktops must be 35 1/4 inches even in a modular world. What you do about it is recognize that when a modular kitchen fitting is put into a modular kitchen, the top of the worktop is not a critical dimension at which some assembly operation is to take place. Possibly, for example, the back of the splash panel is the one that matters,as it is going to meet the tiling of the wall. In which case, supposing then that 35 1/4 inches is the height for the worktop, the splash back should either be 3/4 inches or 4 3/4 inches unless there is some other way of getting around it.

MR. DAWSON: I think that we are coming to the point in Mr. Lock's question - what he's really talking about is the development of dimensional standards, not only for single planks of lumber but for lumber millwork components, such as window frames, door frames, etc. I think the panel should address themselves to that point. I believe there is a Mr. Hayward in the audience and possibly he might wish to participate in this discussion.

MR. HAYWARD: When we make windows for the normal stud wall - this brings out the point that you brought out - the distance, say, between three studs is 48 inches less 1 5/8 inches so that is the module we use to arrive at a modular window size. When it comes to concrete blocks and brick, at the present time that is custom work for us, and we make custom window frames to suit the openings. Stud walls are more of an average production.

MR. BERGVALL: That actually shows, I think, the need for modular coordination. Your production for 16-inch-apart stud construction has certain standardized conditions to which you could manufacture; but, of course, it is not an ideal situation that you have to produce one range of windows for wooden houses and another range of windows for brick houses and concrete block construction, etc. Behind this whole idea is the experience which could be learned from other industries, that if we want to rationalize our production we must provide for longer runs, continual production, etc. and this is what precisely can be done with modular coordination.

MR. DAVIDSON: The most interesting point that this brings up is that if the windows are going to be modulated onto a 4 inch module nominal size it might then mean that you have to change the wall construction as you no longer get studs always in 16-inch centres. Sometimes they are 16-inch faces, particularly when you get doors and windows in each of the walls. If you are to get to a situation where the window standardized on the 4-inch module is going to fit indiscriminately into a stud, block, or brick wall, this presupposes that some conventions are drawn up by someone somewhere regarding a means of keeping the water out of the joints between the window and the wall in which it fits. This detail should be worked out once and for all on a standardized basis for either of the three neighbouring materials. This problem, I suggest, is organizational coordination as well as just dimensional coordination.

MR. KENT: This brings up another problem which was brought up earlier, and that is that the stud walls are made up of multiples of 16-inch centres for the convenience of the carpenter, without realizing what he was doing to manufacturing. The sooner we look at building as a whole and see the effect of manufactured windows on the building and the ease with which we can change the centre of the stud spacing, then I think we are coming closer to solving the conomic problems.

MR. BERGVALL: I only want to point out that, regarding the joints of the window and the wall, these are just fundamental standardization techniques. You will meet a number of such questions once you start standardizing various building problems. It requires that you pay attention to all dimensional deviations that may occur or are allowed to occur. This is just plain commonsense.

THE FLOOR: If we adopt the modular system into the building components and the next stage following that is complete industrialization, might we not end up in the country with a large chain of contractors, as happened in the food industry, where we have large chain stores, and in the car industry where the large monopolies have finally taken over all the smaller companies. I am just wondering if this is not putting the foot in the door towards future expansion of large monopolies.

MR. KENT: The question I think was whether in fact modular coordination is leading to the development of large corporations and putting the small contractor out of business.

MR. DAVIDSON: There has been quite a lot of talk in England along similar lines. A number of directions seem to be emerging. One is that there does seem to be an inescapable economic phenomenon leading towards the larger contractors doing certain kinds of jobs, but there is also the possibility that the middle-sized contractor can, in fact, handle even the largest jobs or take advantage of even the largest potential market situations by forming into various consortia or other kinds of grouping - and indeed this is beginning to happen in England. We can

see some of the typical forces to which we may be exposed and we may find untypical solutions to meet these forces. I do not think it is necessarily a foregone conclusion that you should have or that you will have very large contractors. The whole point of the modular business is to suggest that higher levels of efficiency can be attained without getting into, for example, a mail order, Sears Roebuck business, where you can get standardized buildings. This is not at all an inescapable consequence; there are all kinds of other sorts of consequences you may obtain. I think that being aware of these things now, we can perhaps adopt a deliberate policy and shape the future in a more positive way.

MR. R. D. HINDSON, DEPT. OF INDUSTRY: I would like to refer to the question regarding the small contractor. I would like to begin my comment by quoting a passage from Omar Khayyam: "The moving finger writes and having writ moves on, nor all thy piety nor wit can cancel out a half a line, nor all thy tears wash out a word of it." I am suggesting that modular coordination will come in any event, as well as the industrialization of building. Now, if the small contractor, or the practicing architect thinks he can prevent these things from happening by opposing them, he will in fact be encouraging the establishment of the large complexes, the large firms that can contract throughout the country because they can, just by making corporate decisions, standardize and industrialize, and this is one of the reasons they are formed, and one of the reasons they are so successful. If the smaller operator can do this himself he might delay that happening. I feel confident that the small and medium-sized contractors can successfully meet the challenge.

MR. BRUCE: I would like to ask a question here on the relative value of modular coordination in traditional buildings. We seem to be always referring to industrialized buildings, but this may not be with us for some time, and we are still living with the traditional methods.

MR. KENT: You have used this word "traditional" building, which I think is really a misnomer, because we are doing industrialized building to a degree at the present time, and what we have been talking about is a second or third degree development of industrialized building. It has been pointed out earlier that we are working with industrial components at the present time, perhaps much more than we realize. For the immediate future, all we are suggesting is simply that these industrialized components, which are now being used, be coordinated dimensionally by the module. I might say this is something which we can do immediately with all the components we are using at the present time; then, as we develop our industrialized techniques further and the scale of building components increases, they too will become of modular dimension.

MR. DAVIDSON: I should like to add something here; I do not wish to leave an impression that there is a sort of mystique about modular coordination. Certainly my experience is that it is really quite easy, and if you have any skepticism I am sure you will be cured in one day by attending one of the clinics. You may learn the modular behaviour that quickly.

MR. KENT: I object to being called an expert in modular coordination, because an expert is not needed in the application of modular coordination, and the more you get into it the more you will wonder, as I do, why it has not been adopted long ago.

MR. CLARKE, CHAIRMAN: I feel I must close this portion of the program by saying that although the expert advice we have received today is excellent none of it will work unless all of you here are determined to take an active participation in moving forward in the concept of modular coordination, industrialization or standard dimensions or whatever you wish to call it.

PANEL DISCUSSION

at

THE BAYSHORE INN, VANCOUVER

on

OCTOBER 30, 1967

PANELISTS:	L. K. Bergvall C. H. Davidson P. H. Dunstone S. R. Kent
MODERATOR:	D. W. Thomson
CONFERENCE CHAIRMAN:	Warnett Kennedy

MR. D. B. SUTHERLAND: How well will the 20-inch module be adopted by the IRNES* project for school design in Montreal and how well will the 60-inch module reported adopted by the SEF* project in Toronto fit in with the concept of modular coordination?

MR. L. BERGVALL: In my opinion the 4-inch module fits well and is a wise choice as a basic module. I do not know the reasons why the particular planning modules to which you refer were adopted. I could not say in this specific case whether they were a wise choice but I could certainly say that they are not in line with what the rest of the world would be doing in similar cases.

MR. P. H. DUNSTONE: I would like to add something to this by referring to an example at the University of California. The people sponsoring the performance refinements adopted a 20-inch planning module because they felt it gave the degree of fineness appropriate to university residential building space but, of course, there are likely to be refinements in this sort of thing as soon as further developments take place. For example, a number of the structural parts that go into a structure are quite likely to be 2M, and to fit such components into a 60-inch or 20-inch space leads to all sorts of problems. There is no common factor between the wall thickness or column sizes referring equally as a multiple of 20 inches.

MR. BERGVALL: This is in a way a question of proportion. One expects to have functional dimensions with a certain approximation, enabling one to operate with very few variations.

MR. I. L. HAMILTON: Would you please advise us what form of administration was set up to coordinate modular construction between government, architectural and industrial bodies in Sweden (and elsewhere if you have time)? This would help us understand how such an organization might be structured in Canada.

MR. BERGVALL: Before I answer - I must advise that these things must be organized according to the existing pattern. Now, for instance, the architectural profession has never been so institutionalized in my country as it is in Great Britain and to a certain extent in Canada. The matter of modular coordination has always from the beginning of 1942 been in the hands of building researchers in Sweden.

* IRNES - Institut de Recherche et de Normalisation Economique et Scientifique, Inc.

* SEF - Study of Educational Facilities

In other words, it has often been the centre of research which has carried out the investigations and has been responsible for promotional work. For the time being the situation in my country is that everyone expects the building standardization organization to take a lead in this field. Denmark has a similar situation although there more is done through the Building Research Institute. In France, particularly, it is in the hands of the Building Research Institute. In Germany the situation is a little unclear because they were pioneers. They were the first country to go modular but unfortunately they did it on a 5-inch basis (12.5 centimetre) and now there is a battle going on within Germany as to whether they should abandon this or adopt the metric equivalent of 4 inches (10 centimetres).

MR. C. H. DAVIDSON: In the United Kingdom no administration of any kind was set up to coordinate the adoption of modular coordination. What really happened was that a modular society came into being in 1953. What then happened was that the government understood the advantages of the modular concept partly through the members of the profession who were in the modular society, and eventually the government decided that all government buildings would have to be on a modular basis. Now, of course, the government has incoporated the modular idea in its change over to metric. In fact, the answer to this question is really that the Modular Society is the only central body containing representatives of all professions and sectors of industry and was largely responsible for the adoption of modular coordination in Britain.

MR. D. W. THOMSON: Mr. Bergvall mentioned that in Sweden the Building Research Institute prepared a series of standards on modular conventions for building components. In Canada we prepared an outline standard (CSA 31) which simply gives the terminology and states the principle of modular coordination. It was hoped that subsequent to this standard other standards relating to dimensions of building materials and components would then emerge based upon the A31 standard. This has not happened. So, in Canada we have only quality standards and we do not have dimensional standards for building materials.

MR. PETER MEES: Would it not seem appropriate to adopt modular coordination in conjunction with adaptation to the metric system; the module would then be 10 centimetres.

MR. S.R. KENT: This question about adopting the metric system has come up from the beginning of our discussions on modular coordination. From the assessments we have made we cannot confirm that there will be any change to the metric system within perhaps the next five or 10 years at the earliest, although metric may be coming faster than we presently believe. The best plan would be to go "modular" now and when our politicians have made up their minds to go "metric", we can adopt the 10 centimetre

module with a minimum of adjustment. The switch to metric can only be made on the basis of a government decision. But our industry can go "modular" now and then move to the 10-centimetre module when the decision on the metric system has been made.

MR. BERGVALL: I am not trying to give you any advice on that point but I would like to add a few words which clarify the nature of the module. Whether you work to a 4-inch module or in the metric system to a 10 centimetre module, there will be no difference in the appearance of architectural drawings where these are drawings for the building site. Differences will only appear on detail drawings of components and in specifications. But there is no reason why in an inch country you should not be able to deal with floor components having a dimension equal to that of 36M as we are doing. This means that the dimension of the component is 36 X 10 cm and in the inch system it would be 36 X 4 inches. The fact that modular sizes can be very easily designated means that you must not necessarily abstain from modular coordination until the metric system is adopted.

MR. DAVIDSON: In Britain metric has come about because industry lobbied successive governments to change to metric and eventually the government yielded to this pressure and did something positive about it. The construction industry is changing first, apart from the pharmaceutical industry, but the point really about the change to metric is that the whole of industry is changing. It cannot just be the construction industry. There is no point in just one industry changing.

MR. J. R. SIMPSON: What steps are being taken to standardize lumber dimensions, for example 2" ; 4" net, etc.?

MR. BERGVALL: The question of lumber dimensions very often comes up in the discussion of modules. I would call your attention again to what I said in my lecture about distinguishing between general and special coordinating demensions. Now, the design of frame construction in Canada really shows that the lumber dimensions are special coordinating dimensions, the general coordinating dimensions of a wall being its thickness and its height. Therefore, the lumber dimensions have nothing directly to do with modular coordination. That, I think, is the case with most lumber dimensions. It brings up an erroneous image of modular coordination, in that a lot of us have the idea that all elements of a building have to be built to some module, whereas this is not the essence of the thing at all. The various elements that go to make up a component can be any dimension.

MR. D. M. COWIN: Were any representatives of the building operatives invited to attend and, if not, why not? Secondly, what work is being done in relation to the following: (a) Tolerances and dimensional stability of components; (b) Modular sizes for building lumber?

MR. J. A. DAWSON: I think I should answer the first part of that question. A great many of the building operatives have been invited. Union representatives have also been invited and are present. The objective of having representatives of both union and management here is to broaden the knowledge of what modular coordination may mean to each. In this way some pitfalls arising from jurisdictional disputes may be avoided.

MR THOMSON: Following from that, let us turn to Mr. Cowin's second question, "What work is being done in relation to the following: (a) Tolerances and dimensional stability of components."

MR. DUNSTONE: Work is to be done on tolerances and I think that when you have the clinics of modular practice here one of the things which I presume will be dealt with first and foremost is the whole question of the relationship between the nominal modular size of a building component and building, and the actual size and the actual position that it occupies. In various countries now there are standard modular guides. There is knowledge available in print on the various factors that go together to make the difference between the size you expect the element or component to have and its actual size. There is also knowledge relating to the likelihood of an extreme difference ever occuring. We are now moving into a stage of enlightenment in which components may no longer be adjusted and we find that we are having to cover a lot of ground very quickly.

MR. COWIN: This question was directed particularly to the manufacturing industry. If I ask people what 4 x 8 means they do not all say the same.

MR. DUNSTONE: This very question was brought up in Modular Society Committee relative to the plus and minus tolerances in dimension column. I asked the committee chairman about it at the time. You may see the paragraph which has been inserted to the effect that where there is a possibility of dimensional errors occurring one must check with the supplier to make certain that all parts are the same size.

MR. BERGVALL: I think the question also touched another problem - tolerances in relation to dimensional stability. This, of course, is most important for wood products. We have always let ourselves believe that a 4 foot panel is just four feet although it may not be. We must take into account the changes in dimensions with the changes in modular content. The essence of tolerances is that they should be kept within agreed limits. These agreed limits must then be related to specified moisture content and temperature. That is how it is done in the Swedish standard.

MR. DAVIDSON: I would add that while we are talking about tolerances, there is no virtue in fine tolerances per se. The question

of tolerances, as I mentioned, is a practical one. One of the consequences of this, for example, is that the person in charge of a closed system can decide how he is going to deal with any enquiry about tolerances. Another person working under a different central control might recognize that he is going to join his panels together by bolting, in which case he would then have an immediate concern in keeping tolerances under strict control.

MR. BERGVALL: In certain cases some people have been very worried if a wall which is supposed to be 4 inches in thickness was instead, say, 3-15/16 inches. But, as a matter of fact, with a distance between two walls of 30 modules or even more these fractions of an inch have no practical importance. That means, you should not try to carry coordination on the theoretical level any further than it can really be handled on the practical level. The two must go hand in hand all the time.

THE FLOOR: Have you any comment on modular application to building in schools today? I know Mr. Davidson teaches at university. With regard to Habitat at Expo, we have here a system of prefabrication and modular design which is uneconomic because it creates a fetish of expressing itself as modular design. I would like to hear your comments on this.

MR. BERGVALL: Regarding the application of the 4-inch module to school design, we asked two of our leading architects in the early 1940's, who together had designed a school, to submit drawings of that school to us. Then we had these drawings redrawn, one to represent exactly the drawings these architects actually had done and one adjusted to 4, 5 and 6-inch modules. We then invited them to take a look at the drawings and they were able to single out only one of their original drawings, the one redrawn to a 6-inch module. This illustrates that a 4-inch module imposes so slight a difference that even a trained, good architect's eye may not recognize it. It also answers the question of those who want to use other systems of modules.

The answer then is to choose what dimensions you like and then adjust them to the nearest 4-inch modular size.

THE FLOOR: I am still looking for somebody to answer my question on Habitat. I simply took a number of careful looks at Habitat and asked myself, what is it that is being represented and who is it who asked himself the question.

MR. KENT: Perhaps the questioner would like to know about the training of architects. There is the difficulty in introducing too many restrictions to the young student in developing a form of design.

As the student matures he begins to face the facts of life. He should then recognize that the production techniques and the materials he uses have to have some dimensional authenticity. How mature the student becomes depends on the degree with which he accepts the limitations of material. I may say that in the schools of architecture it has been very difficult to talk on modular coordination simply because the students were not aware of the evolution towards industrialized building techniques. Now that industrialized techniques are becoming the "in" thing, students are beginning to take a much greater interest in modular coordination.

MR. DUNSTONE: Not being an architect I would observe that with traditional materials we are to some degree already industrialized. This means that the architect of course is working under a disciplined angle with traditional materials. All he is doing is changing one for another on the module. I would suggest all this results in simplicity.

MR. KENT: Being an architect by vocation, it is of course encouraging to see how important you think the architects are, because always when this question of training has been brought up it has always started with the question of how to train the architect, and that is only one little part of the whole problem. If you really want modular coordination to proceed successfully you must have a training program, not only among the architects but in all sectors of the industries including the building trade unions. That is very important.

MR. DAVIDSON: In the more industrialized age of building in which we are now, there is close cooperation between the labour unions and the contractors' organizations. Those days are gone, I think, when you could just pick up anyone who was organized properly and use him in any kind of building work. The worker must be trained for the task of being a building labourer in the modern world, and one of the things he must have a knowledge of in that connection is modular coordination. It becomes a question of what education is available — the education of people to carry out their role in the building industry; but it is also a question of re-education, of informing all those people who have already got their basic education in the building industry, but need to learn about industrialization and modular coordination.

MR. J. A. DAWSON: Further to educational aspects of modular coordination: As you know, this is the fifth in a series of six conferences that have been held across Canada. These have been designed especially for leaders of the industry, for policy makers and for union management. The objective has been to present modular coordination as a means of increasing productivity and efficiency in building. To increase productivity and efficiency is the duty of each of us here.

The Industry Advisory Committee to the Department of Industry on modular coordination has recognized the need for a series of clinics on modular practice as a follow-up to these conferences. These will be given in all parts of the country at the request of your associations and your institutes and so on, and also at the request of individuals. The object of these clinics will be to acquaint architects, engineers, draftsmen, building site supervisors, management people from manufacturing and labour with sound modular practice. In this connection we have enlisted the help of a number of potential instructors from the architecural profession across the country, on the basis of personal expertise and regional representation. Two from the Vancouver area are with us today. Further in this connection, we have had two orientation meetings directed by Professor Kent at the University of Toronto, with another scheduled for next month. These meetings are designed to orient the potential instructors toward using the same terminology in the instruction techniques at the clinics. Now, if we have, say, 50 of these clinics with an attendance of 30 at each we stand a very good chance of increasing the knowledge of modular coordination very quickly. I think the key word is knowledge, the knowledge of modular practice.

THE FLOOR: In this preamble on modular coordination, cutting costs of building construction is the target, and I think you will agree that here in B.C. the contractors and the design professions have had the finger pointed at them because of the high cost of building. I would like to know if, in the countries that use modular coordination techniques, there has been any significant reduction in the cost of industrial and commercial buildings? Has there been any comparison made?

MR. DAVIDSON: Speaking for Britain alone, there has been an elimination of waste. But, as far as I know no direct comparison has been made because in effect it cannot be made. You hardly ever do one building in a modular way and the same building in a non-modular way, so a direct comparison is very difficult.

MR. DUNSTONE: I was in Washington a couple of years ago when this question was discussed. There was a general contractor at the meeting who gave an answer. He said that general contractors are in business to make money and when one comes across a modular design he is going to think how high can I put in my tender and still get this building? So until we get the whole industry familiar with the modular system and everybody is competing on the same basis, we are not going to get a really meaningful answer to the question.

MR. THOMSON: I am sure somebody could quote some figures from the United Kingdom.

MR. DUNSTONE: We are talking about the advantages of program production of buildings. I would not like there to be any-

one in this room who feels that all the buildings one talks about are necessarily modular. And, even if they are modular, the amount of cost advantage depends on all the things that Mr. Davidson mentioned, e.g., good management plus the size of the market for a given type of building system. Too often, the only thing that can be interchanged between many systems is, I believe, the door mats.

However, even if we do recognize that program building produces savings in cost, it is then very difficult to determine how much they are. The very fact of introducing mechanical aids ensures an increase in quality in a number of aspects. It is difficult to obtain an answer as to how much modular coordination saves but it does save quite a lot. Industrialization also results in significant savings.

THE FLOOR: I would like to enquire - we are talking about grid dimensions and general horizontal dimensions - has the same thing been applied to the vertical dimensions of buildings and to landscaping etc.?

MR. BERGVALL: There has always been some discussion as to whether modular coordination should apply to landscaping or not. I do not think that, so far, any particular production advantages from applying modular coordination to landscaping have been proved. The question of vertical dimensions has been discussed internationally and it is recognized that the most important vertical dimension is the floor-to-floor height. On the other hand, it is recognized that vertical dimensions, such as the height of a window sill, door heights and other dimensions which form a human point of view cannot be fixed using modules greater than four inches. Standards have been proposed for a number of limited internationally-agreed floor-to-floor heights and for a number of international room heights. That there must be a number of these heights depends on the fact that the traditions in different countries are so different. There has also been discussion about which dimension - the floor-to-ceiling height or the floor-to-floor height - is the most important one to be on a modular basis, as there are indications that you cannot have them both on this basis. Nevertheless, I can say that there is a certain clear predominance for the opinion that the floor-to-floor height is the height which is the most important one because there are so many components which are directly dependent upon the floor-to-floor height.

When Sweden changed to driving on the right-hand side of the road, a lot of the curves had to be re-made because of the different patterns of traffic. However, the concrete blocks of which the pavement covering was made happened to be 3 x 3 modules. At nearly every corner you could see people sitting measuring and chipping the blocks. Now, is there anyone who believes that it is of any importance if the curve had been so much wider and the traffic lane for the cars so much more. It simply showed that the people dealing with these things had no idea of dimensions whatsoever.

MR. QUENTIN LAKE: Not one of your example organigrams failed to leave some one or some minority "out in the cold". Also, the client was always one of these. What organization do you know now which leaves no one out in the cold? And, do you not believe that most clients can and should be knit into the organisation?

MR. DAVIDSON: First of all, not all of my organization diagrams showed the client being left out in the cold. In some cases it was the contractor primarily, and sometimes the manufacturer who was left out in the cold. Now, I do not know of any situation in a free Western market economy where everything is brought under one control. I do know of a number of examples from centrally planned economies. I do not think it is entirely necessary that everybody should be brought into a comprehensive organization though this might be desirable. The point is this: One must recognize that the building is initiated from a decision. One then has to recognize that technical decisions of a primary sort require some definitive stand to be taken on the organization that goes with them. This does not necessarily mean coordinating all of the people. It means taking some positive attitudes to the people who are not coordinated.

We can speculate for a moment about the meat packing industry. The meat packing business, as we know, has changed from the status of having the local producer and wholesalers and retailers. This industry like many industries, has gone through evolutions and has evolved into large, fully integrated companies. The building industry probably will evolve in a similar manner, although not necessarily into single fully comprehensive units.

If I may add something, comprehensiveness may not necessarily result in an economic advantage. In Britain where more people are integrated on the building organization, economies are sometimes not readily apparent. For example a local authority may design projects and hire the labour to build them. This often results in an absence of economy.

MR. LAKE: After the choice of a large multi-module for structural elements, in which small tolerances are often very necessary, the provision of smaller multi-modules for other purposes could surely be tolerated with minus tolerances only? A set of plus elements results in an intolerable tolerance. In fact, is it not the case that both the extent and nature of tolerance on the largest multi-module will govern the remainder?

MR. BERGVALL: The fact that for some components it is found advantageous to supply only some modular sizes instead of all modular sizes, which is the whole essence of multi-modules, does not imply that problems of tolerance for these components will be any different from those components made to meet other modular components. Now, the essence of tolerance in modular coordination could be said to be that the tolerance of each product should be negative with reference to nominal modular dimensions.

Otherwise problems arise when the manufacturers produce components that occupy a larger space than the modular space allotted to them. Generally speaking, components must always have negative tolerances, openings must always have positive tolerances. These two go very well together.

The second rule is that you must be careful when you erect your components to see that each component keeps its station so that the dimensional devices of a number of components built side by side do not add up to an intolerance either plus or minus. Now, this is not something which particularly arises with modular coordination but it is a problem with any type of industrial prefabrication, modular or non-modular. Now assume that the joint technique allows the variation in joint thickness to consume the dimensional deviation of the components; this means that the possible variations in joint thickness must be larger than the total plus tolerances of the adjoining components. This can, in most cases, be conveniently designed. But take the type of light wall element where the various components are side by side. There you have a situation where the joint widths may not be sufficient to absorb plus tolerances. Does that answer your question?

MR. HOLBEK: I represent the prefabrication industry and I cannot sit any longer and not comment on the question regarding Habitat.

The only thing at Habitat that was standard was the box size. The whole development of Habitat shows up a problem in our construction industry, and that is competitive bidding. As soon as Habitat was announced the precast industry made a representation to the EXPO management suggesting that it be developed on the basis of pooling all available knowledge. We were told that this was impossible because the project had to go out for competitive design.

We have found time and time again that government jobs in particular have to go out for tender. There is nothing wrong with that but if a project were to be designed according to modular design it would be that much more competitive.

I would like to ask the panel whether there are any positive steps which the government would take, other than what we have heard about from other countries, to implement modular design.

MR. DAWSON: The Department of Public Works in Ottawa now suggests the use of modular coordination but does not insist on it. I am sure there are people here today who, if the government did insist on it, would object. I think I mentioned this morning that modular coordination cannot be legislated in our Canadian economy. If you wish

the government to do something about the situation, all you have to do is get together through your associations and ask the government to institute it.

THE FLOOR: Would you comment on the mechanical systems and equipment going into these buildings? Will they be coordinated?

MR. THOMSON: This is a most interesting point. Frankly I find it difficult to see how mechanical systems fit into the modular concept except in respect to the terminal units. However, possibly some of these gentlemen on the panel who have had considerable experience might know how it has been applied in other parts of the world.

MR. BERGVALL: Let me cite an example of a building where all the water distribution, plumbing and sanitary installations were fully modular. We were quite aware that it was not sufficient for just the brick sizes to be modular. Of course, all these installations could be brought into the same dimensional pattern, but at that time it was necessary to see to it that the various parts, of which a certain piping system was one, should conform to the overall modular design. Now, when this was discussed on a wider European and world basis the manufacturers of such parts rejected the idea because they said that if you have a certain type of line which consists partly of various T - shapes, bends, etc., the most expensive parts are always these bends and T-shapes. The straight line is the cheapest part to purchase and to install. Therefore, you should make every component as small as possible for the sake of economy. On closer analysis we found that this did not necessarily hold true because if you think about it, the connections between these various parts are special coordinating dimensions which could carry the coordination. What is necessary is that this total system of parts does meet in a modular way so that it fits in a modular building and so that as large a part or section as possible of the system can be prefabricated. Therefore, I see no particular difficulty in including these mechanical systems in modular dimension. On the whole, I would say that mechanical appliances of various kinds offer an immense field for modular coordination hitherto more or less neglected.

I made a study of window sizes a few years ago and I found generally that the top or lintel of the window was fixed relative to the ceiling. In the investigation I was making I found that the sill height often was related to the height of the radiator which was underneath the window. So I would suggest that where you do have this type of outlet equipment the height does have a determining effect on either the window sill or the window height. This illustrates that vertical heights of equipment, windows, etc. are related. In my study I found great discrepancies in these vertical dimensions.

THE FLOOR: At the completion of one of our previous meetings we had a presentation on French industrialized building methods including both open and closed systems. My impression, and that of others

attending this presentation was of the monotony of the systems. Is this an inherent danger of a highly industrialized building system?

MR. KENT: In France, immediately after the war the government decided that they would not repeat tuberculosis, they would repeat buildings, It was imperative to have buildings, even if it meant taking short cuts. The fact that the buildings had certain characteristics which you describe as monotonous can, I think, be traced back to the fact that in asking the question and in answering it, a certain kind of person put up the answer. In France most of the building systems originated out of this. They did not have psychologists or sociologists on their staffs and French architects are not particularly interested in housing as a field. But a different country with a different housing problem with different kinds of people would come up with different answers. The best safeguard, in my opinion, to avoid or reduce the risk of monotony is in fact for architects to get involved in the systems coordination organization. Architects should have expert knowledge in dealing with this sort of thing.

MR. BERGVALL: Very often modular coordination is blamed for the monotony of a lot of industrially-produced buildings which have not made use of modular coordination. The purpose of modular coordination is precisely to allow design freedom and at the same time to utilize industrial production methods and to avoid monotony. What you said about the French building systems shows what happens when there are industrial production methods without the application of modular coordination.

MR. DAWSON: I would like to enlarge a little bit on the further aspects of the BEAM program as it relates to modular coordination. When we discussed this program at first with the Royal Architectural Institute of Canada, the architectural representatives at that meeting said that they would very much like to design to modular standards but that the manufacturing sector could not supply modular materials. When we spoke to certain manufacturing organizations they said they would welcome the economies of dimensionally standardized components, but the architectural profession would not support this. In order to counter this argument the Department of Industry is preparing to publish a directory of modular building equipment and materials currently manufactured in Canada. This will be a directory in the strict sense. It will include the name of the manufacturer, a short description of the material or component that the manufacturer produces and the nominal size of these. We look forward to putting out this directory as a service to your industry.

I would also like to say a word about a modular society in Canada. This is an area in which the Federal Government cannot function except to create environment in which a modular society can be formed. It is the prerogative of your industry to inititate such a society. We would give it our full support.

I would like to refer for a moment to the Industrial Advisory Committee on Industrialized Building Techniques and Systems. This committee has supported the idea of a national conference which will be held, in April 1968 in Ottawa. The theme will be "A Systems Approach to Building". It will examine such things as land assembly, financing of structures, modular coordination and, in short, every aspect of providing houses, institutional and commercial buildings, all of which are basic to our economy. I mention this because it will be a very important conference, the first of its kind in Canada. It will provide a great many of you with an opportunity of becoming thoroughly familiar with what the systems approach to construction really means.

Just one further thing that has occured to me. It arises from Mr. Davidson's remarks. We in the Department of Industry do not look forward to the days when architecture become a "kosher" profession. We believe that the professions of Canada stand at the threshold of an era of unparalleled challenge and that all of our combined efforts will be needed if we are to achieve as much as is possible and necessary. We look forward by means of modular coordination, by means of a systems approach to construction and by means of development of a whole range of management techniques to a broadening of the architect's sphere of influence in building and we hope, with all due respect, that the "kosher" architect will never be the rule in Canada.

THE FLOOR: I would just like to add a few words before the meeting adjourns. There is, I think, a tremendous educational program to be carried out. My experience in the past year and a half indicates to me that the general contractor and the builder must be educated to think along the lines that you gentlemen have been telling us. My firm is at the moment proposing to use some ideas that were developed by a well known architect/engineer in Germany. These ideas will save a lot of money and time but my reception from our Canadian industry has been this: "I am making a dollar doing what I am doing now, so why should I change?" I think that this is where a great deal of the education must be given in order that these systems and the ideas of modular coordination can develop.

PANEL DISCUSSION

at

THE BONAVENTURE HOTEL, MONTREAL

on

NOVEMBER 1, 1967

PANELISTS:	L.K. Bergvall C.H. Davidson P.H. Dunstone S.R. Kent
MODERATOR:	J.H. Dereme
CONFERENCE CHAIRMAN:	Andre Tessier

MR. J.H. DEROME: (Translating from French and repeating a question from the floor) What further steps does the Department of Industry contemplate with industry in continuing this program on modular coordination?

MR. J.A. DAWSON: You have asked what further steps the Department of Industry intends to take in co-operation with industry, to further this program for the acceptance of the modular concept in the building industry of Canada; and I rather think that, as a sort of preamble of answering, I should say that all of this program, this BEAM program and the modular coordination aspect of the BEAM Program, has been initiated with the specific purpose of increasing productivity and efficiency within the building industry.

Now, it has become generally recognized, (and I would say especially recognized among groups such as this) that increasing productivity and efficiency is an essential prerequisite to a higher standard of living in our country; therefore, it seems to me that each of us, as Canadians, should do what we can to increase productivity and efficiency within our own spheres of influence.

The modular concept is one way of doing this. It is one means of achieving increased efficiency. This is the last of six conferences held across the country, starting in Halifax about two weeks ago, continuing in Toronto, Winnipeg, Edmonton, Vancouver and back to Montreal, where groups such as this have heard the lecturers. Thus, an improved knowledge of modular coordination has been disseminated within very influential groups of people within a very short space of time. Knowledge of the modular concept has therefore been increased and, we hope, more appreciated as a result of these conferences.

We cannot, however, expect to let the matter rest here. The Department, acting upon the advice of the Advisory Committee on Modular Coordination, has taken steps to organize a series of Clinics of Modular Practice. These will also be held in all parts of Canada, beginning in about a month or so. The target is to hold about 50 or 60 such clinics before the end of this fiscal year. In this connection, about 14 architects from practices and from the teaching profession have agreed to assist with the task by directing the clinics. Professor Derome, moderator of this panel, is one of the people who will instruct at these Clinics of Modular Practice. Another architect-professor who will assist is Professor Z. Jarnuszkiewicz from Quebec. A third professor of architecture, from McGill University, Professor Stewart Wilson will also instruct. In preparation for these clinics, three consultation meetings for the 14 instructors have been held in Toronto under the direction of Professor S.R. Kent.

We hope to organize these clinics in co-operation with the various associations representing the construction industry, and the architectural component associations of the R.A.I.C. in each of the provinces. We have talked to the provincial presidents of the

architectural associations across the country and we see an indication of enthusiastic response. The construction associations in the provinces and officials of provincial governments and educational institutions have indicated that they will assist us in the organizing of these clinics. The clinics are aimed at a group of people such as junior architects, junior engineers, draftsmen and supervisors from manufacturing, construction and so on. We are relying greatly on your input as senior executives of the industry to request that such clinics be held in your area. Anything that you can do to assist us and to co-operate with us will be greatly appreciated.

Further to that, there is another aspect of the program, arising from the discussions which took place between the executive of the Royal Architects' Institute of Canada and the Department of Industry during the early days of the formulation of the program. At that time, the representatives of the architectural profession said that they had been hoping for something like this for a long time, and that they would like very much to design to modular standards, and to specify modular materials, but they had difficulty in getting manufacturers to produce the modular materials, but they had difficulty in getting manufacturers to produce the modular materials, especially to manufacture them at no penalty in cost. Now, in to manufacturers, we heard a different story. They said that they would like to utilize the economies afforded by modular standardization, but, that there was difficulty in finding architects to specify modular materials and components. The Industry Advisory Committee therefore recommended that a directory of modular building materials be compiled, and this will be done by early 1968. The manufacturers in the audience will be receiving some survey material on this subject. The directory will list the names of the manufacturers, their modular products and the nominal dimensions of these products.

Apart from that, we have been speaking of a modular society for Canada in rather vague terms. Here again, the influence of the industry is necessary, for without industry support very little will be done.

THE FLOOR: Before the module is applied here, I feel it is very closely related to the 10-centimetres of the metric system. The conversion of the present non-metric system to the metric system may interest the people concerned, and at a relatively low cost in comparison to the tremendous profits and savings in the end, but we have to look further than this. Eventually we have to convert to metric in North America and England. To convert from a four-inch module to a 10-centimetre module may involve a conversion of rather expensive machinery. This seems to be a kind of double process which may not quite warrant the expense. Should the metric system not be adopted first, and then the modular system?

MR.DEROME: I will ask Mr. Dunstone to reply to this question.

MR. P.H. DUNSTONE: May I say, first of all, that I sympathize with your question very much, and I would like to reinforce that by telling you what is happening in the United Kingdom. There, after long pressure by the Confederation of British Industries, the government eventually gave way to the idea of going metric. Now, this is an industry-wide changeover, not just by the construction industry, but by all industry in Britain. The construction industry is one of the first to change, after the pharmaceutical industry, which I think has already adopted metric standards, but construction is the first major industry to go over. The difficulty with the metric system, or the S.I. system as it should be properly designated, is a political one. I would turn it round the other way and say that the decision to go metric, whether it comes or not and when it comes, should not influence your decision to change over to modular coordination, because if we in Britain were already modularly coordinated, which we are not entirely, our change to metric (and I am speaking now of the construction industry itself) would be so much easier. I sympathize with your question, in that difficulties for manufacturers may be slightly increased, but you have got to think of the political and the industry-wide problems before that question can be answered.

MR. L. BERGVALL: Perhaps this is the right time to point out that the difference between the four-inch dimensions and the 10-centimetre is not to be disregarded. We have, for instance, met a problem with American dishwashers in Europe. It is a practice, both in America and Europe, to allot a space of six modules for the dishwasher, which is about the space that is necessary. Now, six American modules of four inches, unfortunately, are a little larger than six decimetric modules, and the consequence is that very often the American dishwasher on the European market cannot slip into that six-European-module space. The thing is made even worse by the fact that sometimes American manufacturers put up factories in Europe to serve the European market and, of course, they use inch dimensions. Another questioner talked about the enormous costs of the machinery. Well, I do not agree that they are enormous. You may think that the production of dishwashers, for instance, is complicated, seeing that they require expensive machinery and tooling; nevertheless, the manufacturers change their products every year to show up with a new model; they could as well, at a proper moment, go over from four-inch modular to metric modular.

MR. S.R. KENT: The question of metric was considered carefully by the Industry Advisory Committee on Modular Coordination to the Department of Industry at its first meeting, and as a result of this, a survey was made as to the likelihood of Canada going into metric in the near future. The conclusion was submitted to us that there would be no economic advantage in going metric in the near future.

Now, I say "economic advantage" because this is the only reason why a government would introduce a change. It would not be done on national

grounds at all. It would be done on economic grounds and so, if there is going to be any change to metric, it would have to be done (as Mr. Dunstone has indicated) by pressure from the manufacturers to the effect that there would be sufficient economic gain for them in changing to S.I. units. But there is no indication that this will happen in the immediate future in Canada, simply because we feel that we are tied quite closely to the work in the United States, and to the markets in the United States.

Now, with regard to timing, we thought that a change to the metric system might be a long way off simply because work in the United States is a long way off, and we thought it was going rather slowly; but there is a committee in the United States, a Congressional committee which has been set up to investigate the process of changing to metric. The American Society of Testing Materials is now publishing all its standards with the S.I. units beside the inch units, and so really the conclusion is that when the S.I. units are produced, the switch to the metric system will seem reasonably simple.

MR. DUNSTONE: There is an apocryphal story going around Britain that the Ford Motor Company of America has spent more on a feasibility study regarding a change to the metric system than we in Britain have spent on the change!

THE FLOOR: Regarding the "foreseeable future"; as far as I know, in the next few years they may change it around. Also, as far as I know, Ford is ready to switch at any time to the metric system, and they will do it. I do not know when it will be, but they are ready to switch right now.

MR. KENT: I am sorry that I cannot pursue this any further. I simply stated, from the knowledge I have through the Government of Canada, that there is no mass movement for the change to S.I. units, and even if we found that tomorrow there was a decision to be made, it would take at least five years, based on the British experience. We might say five years is an absolute minimum time in which a change to the metric system could be made.

MR. BERGVALL: Whether you adopt the metric system or not is, as Mr. Dunstone stated, a political question, but I want to point out that even if you go modular, within the framework of the foot-inch system, that need not necessarily prevent you from designating your modular components in the modular way. It is a very simple modular figure. It means, for example, that a component 20 feet long is simply designated 60 M, other components 36 M (12 feet), and others 72 M (24 feet) and so on, instead of the foot-inch dimensions. That is already a simplification as far as nominal dimensions are concerned. These are the dimensions that would go, for instance, on an erection drawing of components, but for the production drawings to be used in the workshops, or on the building site, where components are produced - for example in pouring concrete - then, of course, there will be broken dimensions, precisely as we in the metric countries use actual dimensions in such instances.

MR. WALKER: I am a manufacturer. Mr. Chairman, may I address this question to Mr. Davidson? From your comment concerning not seeing salesmen, you obviously have found another way of keeping up to date on products, product research and application and general products assistance. Please tell us how you do it, especially in regard to modular coordination.

MR. C.H. DAVIDSON: My theme, I think, is that we have to adopt some positive attitude to communicating with each other on problems large and small, and I think that the shortcomings of the present system are that they are not coordinated. Now, when I say they are not coordinated, I say so thinking of many aspects of it; firstly, that the information that I receive is not standard in its presentation, nor coordinated in its format, nor coordinated in its pre-classification. The visits that I receive are not coordinated with my comings and goings. It is precisely because of this kind of inconsistency that I put out a very strong plea for coordination of all sorts. I would not like to suggest that any manufacturer trying to promote any product necessarily has to form any kind of consortium with me in order to get the message through. Perhaps I cannot add anything to what I have just said; it must somehow be coordinated so that the information is meaningful to me when it does arrive.

MR. BERGVALL: A system for that type of coordination which you have advocated was fairly recently introduced in my country, Sweden - a system which we have called Declaration of Properties, by which an organization sponsored by the government, the Building Research Institute, assists the manufacturers in publishing data about their products in a coordinated manner, in a coordinated size, answering coordinated questions regarding that type of product, giving evidence that the figures they claim are really accurate, thus providing the designer with information on various products which is objective and comparable, the one with the other. This is a very simple system and has met with very great approval by the manufacturers.

MR. GEORGE SALICK: I am with a firm of installation coordinators. May I ask a direct question? It seems to me that in Canada, this movement is being generated and moved by governments or by governmental agencies. This meeting was convened by the Federal Department of Industry. Now, we all know how competitive the construction industry in Canada is. It seems to me that the main source of money for building in Canada rests with the Canadian Government; my question is this: "Could anybody from the panel or in the room tell me how much the Department of Industry is going to spend in the forthcoming year to promote modular coordination, and what form will this expenditure take?"

MR. DEROME: I would like to ask Mr. Hindson to answer that question.

MR. R.D. HINDSON: The Department of Industry, through its Industry Advisory Committee, expects to spend very little on promoting

modular coordination. I think Mr. Bergvall has some pertinent figures. The amount of money that we plan to spend on holding a conference like this is extremely small when you consider what can result. Mr. Dawson mentioned the publication of a modular directory. The cost of that would probably be no more than three thousand dollars, including distribution. As to the cost of holding these conferences, I think you people have been around long enough to know how small that is. The cost of the seminars is also very, very little, and involves only the cost and the expenses of the instructors.

MR. KENT: It might be of interest to you to know that about four years ago, the Canadian Joint Committee on Construction Materials, composed of representatives of the R.A.I.C., consulting engineers, manufacturers, contractors and the Division of Building Research, had the intention of promoting modular coordination throughout Canada. They encountered one snag - none of the associations in the Joint Committee was able to put up the money that was necessary in order to put on the program which the Joint Committee was recommending, and so it is only with the formation of the Department of Industry and its interest in this subject that modular coordination now has a chance of being accepted in Canada.

MR. DAVIDSON: I would like to add one thing to this discussion; I presume to add it because, although I see myself as the left wing of this table, you see me as the right; I must confess, from my personal experience in England, that it is extremely unwise to rush in and do something just because government says one should do so. There is a very good reason to do something as soon as the market starts to sort itself out, so that it becomes worthwhile and profitable to do so. I would have thought that a very useful follow-up by your industry in this country, which I can talk about in your terms, would be for the client's side of it to see that there is a great deal of coordination of all sorts, and modular coordination in particular, so that it then becomes worthwile for the industrial side of the building industry to invest in suitable responses.

MR. REED: I am a manufacturer. I certainly think that the thoughts presented today were very profitable. Even arguing against it is like arguing against the need for religion. I think we will see, as a result of this conference, that there is developing a better coordination in our industry; but it seems to me, after travelling in Europe, that there is a very great difference between construction in Europe and construction in America, and the fundamental difference is the way in which we regard the use of time. Now, time really has a dimension today. We have talked about low cost, the attainment of low cost, and again there is a little inconsistency because when you talk about cost, it means different things to different people. The cost of a project building for a government is quite different from the cost, say, of a commercial establishment to an owner who is always facing a problem of lost rental if he cannot get his project completed on time. This is a very important factor to be considered, and I would also like to throw in one more observation, which

that the lowest cost components may not necessarily be consistent with lowest cost of production. A lot of things have to be considered, and there is a whole series of equations that have to be summed up to really obtain the most economical method and to get the best value. I think maybe value is possibly what we are really striving for, rather than just low cost.

I noticed, too, that the involvement of government in Europe and the involvement of government in North America are two entirely different things. It came out this morning that the greatest advancement in modular coordination was in Russia, where it was simply decreed that that was the way it would be. I hope that because this method has been successful there, we don't just assume that it will be successful here, because our conditions are quite different.

I also have another observation to make. The relationship of architect and consulting engineer, (who was not mentioned this morning), general contractor, and manufacturer, is very different in America (and this was touched upon by one of the speakers) from that in Europe.

We wonder, with all these differences, whether considerable care should not be exercised before having Government get involved in decreeing that modular coordination is the answer to all of our construction problems. This is just an observation.

MR. DEROME: Thank you, Mr. Reed. I must say that some of the points you brought up have already been descussed in the various committees of the BEAM Program. I will ask Mr. Dunstone to reply to your comments. I am very pleased that you brought up the point of time-saving.

MR. DUNSTONE: I want to consider myself today as a constructor's champion, as it were. I could not agree with you more about value. I did make the point, I think, this morning, that the whole thing must result in value, firstly to the building owner, whoever he is (whether government or private) and this, in its train, brings value to the country, to Canada in this case.

The next point, of course, is that reduction in cost usually brings with it a saving in time. Most of the points which I mentioned this morning, the cutting down on site layout, the elimination of waste, the cutting down of site labour, all these things mean time on the site. Usually time, as you are well aware, does mean a saving in cost, and conversely.

If I may, on the government side of things, step in a little bit where angels fear to tread; it is all very easy when one is away from one's own country to be an expert. An expert, as you know, is one who is over 50 miles away from home. Now, if I may comment upon the situation in Britain,

modular coordination was begun, not by government at all; in fact, it took 15 years to impress it on the government, and make the government realize that there was something in it. Now, all government contracts have to be modularly coordinated, and in fact, as I said earlier, the metric change is being bound up with a modular coordination exercise as well. I hope that I have answered some of the questions, at any rate.

MR. DEROME: Mr. Bergvall would like to add something to this.

MR. BERGVALL: Yes. I just want to say that if it took 15 years in England to persuade the Government that this was something important, it took 25 years in Sweden; it only proves another point that I want to make, and that is, that in no country can you expect either the industry or the Government to take any substantial steps towards the realization of modular coordination before the degree of industrialization within the industry is ready for it.

Furthermore, I am much astonished to find this distinction between time and cost, because time is money; that is a slogan that was invented on this continent, I believe. If we regard modular coordination as a tool for industrialization, it is interesting to notice that the justification for the promotion in Europe of various programs of industrialization and prefabrication has been precisely the need to economize on labour because of a widespread labour shortage.

Now, that is time, because with the overheated economy that we had in most countries in Europe for the last 10 years or more, we could not allot more labour for building purposes than was available. In many of the European countries, one felt that too few residential buildings were erected, and I have a feeling that the same will begin to be felt here.

As for the reference that I made to the U.S.S.R., and the other Eastern European countries, there is no evidence whether modular coordination gave any economy there or not, because you cannot keep track of such things in those countries. I only mentioned this because, of course, they had no problem in implementing their modulation.

Furthermore, the fact that we have another and somewhat different pattern in Europe from here does not mean very much, because they will have to change in European countries anyway once industrialization comes.

MR. AUERBACH: We have been talking about modular coordination, and I address this question to Mr. Dunstone. It has always been part of the open type system, or a special prefabricated building, but in every context it has been part of a system. We are talking here about the application of modular coordination, and the situation where there is no system. This is an irrational industry, and I think, if you want to use modular coordination, which to me is a tool to assist in building and industrialization, we must start at the top and create a situation in which we need the tool.

There is no point in having a modular coordination system or trying to fabricate parts of the system where this system does not exist; and I would like to ask a specific question here: What are Mr. Dunstone's opinions on this aspect of the thing, and how do you start such a ball rolling?

MR. DUNSTONE: Well, I think the open system, as such, is not as you described. In other words, everything fits together as it does now in a haphazard sort of fashion with traditional components. All we are doing is rationalizing or suggesting that we do. But we rationalize the dimensions of those components so that the fitting together, the meshing together is better. We know of the advantages that flow from that; and also that this must save time in the erection. Those are some of the advantages; I think that is all.

MR. M. STEIN: I practice as a general contractor in Montreal. My question is prompted by the history of jurisdictional disputes, walkouts, illegal strikes and so on which in recent years have accompanied the development of materials and techniques in the construction industry. Obviously, modular coordination will require less and less of the skills, the traditional crafts which organized labour has practised and jealously guarded for a good many years. I want to ask the panelists from abroad what has been their experience along these lines. What is organized labour's reaction?

MR. BERGVALL: First, of course, it is worth mentioning that it is very dangerous to draw conclusions as far as labour unions are concerned, on their behaviour from one country to another. With this reservation, I may say that there have been no difficulties on this point in Sweden, but it might be that it was because we took the labour organizations into modular coordination and building standardization right from the beginning. When building standardization started in Sweden 25 years ago, we saw to it immediately that they got the representatives of the building labour unions on the advisory board of the institution and that was, as far as I know, the first time that any worker-labour representative had been invited to a purely technical committee of that kind. This created, from the beginning, an atmosphere of mutual trust. We then saw to it that we had an opportunity to address ourselves directly to the annual meetings of the Central Organization of Building Labour in my country, explaining modular coordination so that when it gradually became a reality, there was nothing that they were not familiar with.

The same goes, to a certain extent, for those experiences that we have had of more advanced systems of prefabrication. I think our unions recognize that industrialization is inevitable, and that it is better to be in on it from the beginning and make it work for you. As the labour unions would probably agree, rather than try to prevent something that cannot be prevented and end up with a lot of difficulties, it is better to

be able to steer it in a positive way that would be to the labour unions' advantage from the beginning and would not be detrimental to the labour movement.

MR. DAVIDSON: I could add two or three things to this, about our experience in the United Kingdom.

Firstly, the unions in the United Kingdom have often taken the line that provided the proportion of trades used in any prefabricating enterprise is the same as the proportion of trades that would have been used on the building site, then it is all right. I am thinking of a factory where complete room box-type dwellings are made in the north of England out of timber products. There one can actually see electricians doing carpentry work and carpenters putting wires through. It happens to be more convenient to work that way. But the point is that the actual balance of trades in the factory is the same balance as one would otherwise have had on the building site.

The second thing that I wish to say is that if any prefabricator has to use labour, non-union labour at below the union rate, he deserves to go bankrupt, because he cannot be using his labour very efficiently.

The third thing I would say is that last year, when I was teaching at the School of Architecture of Washington University in St. Louis, Missouri, my students were constantly interrupting my courses by saying, "Ah, but we cannot do this in America because of the unions." After they had said that about twenty times, my response was, "Like hell; get the unions in and ask them." Now, this required quite a bit of organizing, but my point in mentioning it now is that I discovered afterwards that this was the first time that union representatives had ever been in that school of architecture, and I am more than willing to bet that it was the first time that they had been in any school of architecture, certainly within a few thousand miles of St. Louis. We discovered a great many interesting things during the three quarters of an hour that these union men were with us. If architects, even in traditional building, knew these things, I suggest that a great many of the potentially dangerous dispute-type situations might be avoided.

MR. VANDERCRAFT: Mr. Dunstone rather briefly touched on the subject of coding information and the use of the computer, and yet the cure-all was the information he really wanted. Now, the whole point I am bringing up is, how do you feed into a computer? The magnificent achievement is there, the machine is there, except that none of us speak its language, certainly not in Canada in a global way or national way. We do not have a classification index system that is accepted by all of us, and I understand that most of the world has accepted a classification index system; I do not think Professor Kent quite agrees with the system, but I would like to know whether any system is preferable over another system, or whether Mr. Dunstone could elaborate on the system as such in general.

MR. DUNSTONE: We have no panacea in Britain for this type of thing. We are doing a simple, a relatively simple exercise with the computer, whereby we are feeding into it the details of a particular component, which might be a concrete wall panel, for example. This panel would have with it the bolts that fix it, the damp-proof membrane at the bottom, the joints at the side, the gasket at the top - these would all be put together on the sheet, and the whole lot would be fed to the computer once and only once. Then the computer would be triggered on subsequent occasions by the drawing number of that particular component, and it would, as it were, take off, measure the components with which it had been fed in the first place.

That is what we are really doing now. It may sound quite advanced, but, believe me, we will be looking back on that in five or ten years from now and laughing at it. The Ministry of Public Works, as I said, is conducting this exercise. We have not attempted any particular, overall universal code at the moment, but we are looking into this situation. It looks as if we are going to end up with an enormous code relating to all types of building products, materials, facets of the industry which will be embedded in an enormous computer somewhere. We will simply milk off the facets of that code that we require for the purposes of a job. We, as measurers, for example, might not need the K factor, so we would leave it where it is, in this enormous number cruncher. This is the way the computer would be used eventually; but there is a lot of work to do before we get to that situation, years of it, and we have no panacea at the moment to deal with this situation.

MR. KENT: Well, of course, the question is, why are we interested in coding? I have reached some conclusions of my own from my experience in England, but the important questions are: Why did I get interested in coding, and why my deep interest in modular coordination?

Well, the reason was very simple: I recognized that the building industry, if it is going to get into industrialized techniques, was going to have to standardize. Standardization of building components in that smaller way is a prerequisite to any coding system, no matter whether it is alpha, numerical, or whatever it may be. There have to be standardized parts, and then a coding system may be devised. So coding will follow once standardization of building parts is accomplished.

MR. STERMAN: In the absence of any particular discussion on the market in the U.S., I have two questions directed, I think, more particularly to the manufacturer. Firstly, how does changing to the modular system affect their thinking, how does this affect the existing or potential market in the U.S. for their products, particularly as it appears that the U.S. is not moving along at the rate at which we would like them to move along. Secondly, if this adversely affects their thinking (changing over to the modular system),

what role will the Government, or particularly, the public ministry play in respect of the U.S. Government or the bodies of the manufacturers?

MR. DEROME: Is there anybody on the panel who would like to answer, to handle this question, or should I ask the floor?

MR. KENT: Ask the floor first.

MR. DEROME: Well, is there anybody on the floor who could handle this question from the manufacturers end of it? Yes Mr. Hindson?

MR. HINDSON: The person who asked the question, I believe, referred to a part of the industry, and I think most of you realize that construction products and materials are largely from domestic sources. Export trade in construction products, because of the freight and charges, is relatively small. Therefore, going modular in Canada should not affect our position vis-a-vis the United States to any particular extent. The United States wants to go modular, the government would like to go modular, much of their industry, we understand, would like to go modular. It is not impossible that we might improve our trade with the United States, in construction products and materials if we go modular first. I don't see any problem vis-a-vis the United States. I can see only advantages.

MR. PHILIP BEN: I do not think that we have to be sold on coordination from modular applications. I think we are all sold on it, and have been for many years. As a matter of fact, in small and large companies, engineers and architects, to some extent, use some kind of modular coordination - so the question is, how do we go about it, to apply for a modular system?

Now, in our economy, which is a free economy, with all its advantages and its disadvantages, what determines primarily is cost, and we seem to be convinced here that a modular system will reduce cost, will reduce labour, and so on. Now, who is the one who is going to prove it? Who in the industry is not prepared to supply you with anything you demand? Or your client, who would like to use the cheapest possible method to get the most out of his dollar. Obviously, while an architect or an engineer conceives a building and so on, he is limited by what the industry is prepared to give him at a certain moment.

Therefore, either you have to start with some kind of a pilot program, or you have to find a client who is big enough, progressive enough, and is prepared to risk some of his capital on these things.

I suggest, therefore, that some of the work which the Department of Industry could do very effectively is to sell the other Departments in the Government (particularly the Department of Public Works) on applying a

modular system on one or several or many of their buildings. We would then have a pilot program, and the industry will see to what extent we really saved in our present and future conditions. School commissions, provincial governments and other such bodies are the clients who will really determine whether or not these items are of advantage or are not of advantage in our present conditions.

Having indirectly asked the question of the Department of Industry, I would like to ask the panel whether they have any ideas, based on their experience of Europe, and bearing in mind that the conditions in Europe are different from the conditions here, how to go about introducing a modular system. Incidentally, if my information is correct, it is the modular systems in Europe that have not only been introduced by manufacturers but, to a very great extent, by developers, general contractors and so on. Under the system which exists in Europe (let's say in France, which I am particularly familiar with, or in Belgium), this gives the contractor or the developer much more freedom than he has here.

MR. DEROME: Thank you, Mr. Ben.

I think that this is exactly the type of question that the Department of Industry had in mind when they arranged this type of conference. They want to know the reaction of the people, and they want to be able to suggest to the various departments of government what are the needs of the people or what are the questions that those people, the professionals will ask of them. I think that this is exactly one of the questions that they will really want to hear, the suggestion about the different ways in which they should handle the thing themselves in their Departments.

Could I have somebody on the panel now?

MR. KENT: The questioner is quite right; it does require a big client in order to start the ball rolling, simply because it does involve some capital outlay for any manufacturer to change to the modular system. Manufacturers have proven that they are quite willing to change if there is a sufficiently guaranteed market available to them. So it comes back, then, to the large client to indicate that there will be a guaranteed market. As Professor Derome has said, it is the Government, the Department of Public Works in particular which would enjoy, I am quite certain, the attitudes of the questioner here indicating that he would willingly accept the modular system.

Within the Department of Public Works, there are many architects and engineers who are familiar with the system. They are trying to encourage architects to use it, but as yet they have not said, "You must use it." With this sort of guidance, I am quite sure they could then become Canada's largest client using the modular system.

MR. ROUSSEAU: I have a question for Mr. Dunstone.

This morning, you stressed the importance of having independent inspection from project management. Would you care to elaborate on how this

work is carried out in Europe? Is the work handed to the fabricator, the contractor, or independent professional groups?

MR. DEROME: Mr. Dunstone, you have another question that might seem a bit off the beam! But I think you invited this type of question this morning in your talk.

MR. DUNSTONE: The question of instructions has been very much stressed to me by a number of contractors who operate modular systems in Britain, not only their own systems, but other buildings systems. I am referring mainly to closed systems where they say that the use of the inspector on their own staff, the contractor's staff, very much cuts down the amount of trouble they get into, and if they divorce this inspection from their site supervision (in other words, the site supervision does as well as it can and then overlying this is the inspectorate), they get very much better results. It is just a question of checking from above, and (I think this is the import of your question) the inspector comes from within the contractor's own organization, at least in the examples that I know of.

PROFESSOR BULHEISER: I am Professor Bulheiser from Sir George Williams University.

Firstly, I think we should consider ourselves fortunate to have here a representative from Sweden. According to the Finkinton Report of the D.I.C., Sweden is a country whose economy is comparable to that of Canada. The report suggests that we have a lot to learn from Sweden.

Secondly, about the initiative; who should take the initiative in getting this modular system to work, I think should depend mainly on the Government, because no institution or business will put up the initial amount of money to put this into practice even though we might realize that it might be profitable in the long run. I am sure that most of the architects here are familiar with the study carried out by the American Government on washrooms, and the conclusion was that we are fifty years behind in the design of washrooms. I saw Habitat and have concluded that it did not show any improvement on the present conditions.

I think that the modular system is not an ultimate goal in itself. The modular system is only part of an overall solution. The buildings should have more psychology to them. For example, if we need a hospital and we know the needs of one particular unit, we should make a study and come out with the ideal unit, and then we can mass-produce the unit itself.

For example, if we needed 500 units, we could assemble 500 units and we could ship these units to under-developed countries at a minimum price. I have seen that most prefabricated elements have been made out of concrete in demonstrations. I think that sandwich construction which is widely used in the aircraft industry, should be made use of in the building industry, and I think the universities have facilities to conduct valuable research along these lines.

Then, about the computers, I do not think that most people are familiar with the facility with which problems can be solved through the use of the computers - I think the Government spends a lot of money on computers, and most universities have very good facilities. I know that in Sir George Williams we have a very good computer staffed by twenty-four capable people, and they await the order from industry. I think it is very important for the building industry to contemplate the system where we could use the computer and save a lot of man hours. Thank you.

MR. BERGVALL: The discussion has shown that modular coordination could be promoted in several different ways. As a matter of fact, one of the ways to do so had a rather particular resemblance to the systems that, as I reported this morning, we have used in Sweden - only we called it a regulation. We could have given it other more acceptable names, but the fact was that the Government, as a large buyer of buildings, sees no reason in promoting modular coordination with the left hand and buying non-modular coordination with the right hand.

There is one point that I think is to be emphasized, and that is the very important role of building standardization. The National Building Standardization Institute (the organization may be a little different in the various countries) has to come into play here, because modular coordination as such is a way of thinking, a method of introducing a dimension order. It is most necessary to build up a stock, so to speak, of modularly standardized components, and there is no other body to carry this out than the building standardization organization of your country.

MR. DUNSTONE: May I pick two small bones over the carcass of that question?

Firstly, I do not think it is a question of the government spending money in the sense that it lays down a bag of gold, as it were. We have a parallel situation in Britain, linked with modular coordination in the change to metric, and there I have said many times (and I am sure that it is being accepted anyway) that all the Government has to do is to promote long-tern and fairly large projects as normal buildings only. If it does this, and at the same time it says that modular coordination has to be used with these products, even if they are in an experimental stage, the ball will start rolling and will break this chicken and egg problem that we have - the designer is being reluctant to specify until the products are there, and the projects are not being made until the designer specifies them.

The other point is that if there is a preponderance of concrete in the examples I showed this morning (and certain, I think, of those which our colleague Mr. Davidson showed), it is only because concrete is the material that we produce fairly happily in Britain. The aggregates and the cement are all there, and so we tend to use this rather than imported timber. You, of course, would tend to do the reverse; that is to say, you would tend to use timber rather than concrete.

MR. DAVIDSON: I want to take issue with you, in the first part of your exposé, because you began by saying that such and such should be done, and then you went on to ask a question.

I take issue with you, if I may, publicly, on these two "shoulds". If I understood correctly, it was that we should standardize on buildings - I forget if you said hospitals or something like that - and we should export them and so on. There is no easy answer to that sort of question. I was extremely careful, several times earlier this afternoon, to stress that people like you and I have a question which we must, I think, ask ourselves: "What is it that we are going to repeat?" I suggest that before you come up with an answer such as "We will repeat hospitals," a certain number of major considerations have to be taken into account first. It may not be that there is not a situation in which hospitals might be repeated, but you must not let yourself be seduced into the idea that complete buildings can be repeated too easily.

The second thing that I want to take issue with you about is this question of heavy materials and concrete, and I think you started to say that we should use foam plastics like the aircraft manufacturers, or something of that sort. It may be that in certain circumstances you can use new, so-called sophisticated materials, but the warning that I would like to make, and to start making publicly, is that the traditional building materials are far and away the cheapest, weight for weight and very often performance for performance, though not necessarily always.

If you are going to use a material that is a priori more expensive, I suggest very often that you are setting yourself more problems, even more problems to solve than the man who starts with the cheap traditional material.

PROFESSOR BULHEISER: What I meant is that maybe the engineers and the architects working on this example hospital, might miss many points. Another group, say in a different city, designing a similar facility, spending as much time, might well complement the first group. This calls for a systems approach to the problem of providing hospitals. Why not come out with a standard unit that has all the facilities and amenities required for the sick person and which might then be marketed not only to our own market, but the markets abroad. This is not something to be done today or tomorrow, but I think that it is time that it should be planned in a long-range program.

Now, we go to the example of schools. I have spent some three quarters of my life in schools. The present classrooms are just abominable, because everything interesting is found in the room except what is being spoken about. Why not spend some time studying in these areas and come up with functional units?

This was an example; and then I mentioned this question of construction. I am not doing away with concrete, but I think that there are more advanced materials that could do the job better than the standard materials. What I emphasize is the need for study, because I think that the building industry is technologically backward. It does not have to be tomorrow, but certainly a survey is needed so that the proper steps may be taken in correct sequence.

MR. DEROME: Thank you for this comment. I must say that many of these studies that you are suggesting are being done now in different types of buildings. They are being done for schools, they are being done for hospitals and for other types of buildings.

I am afraid, though, that this aspect of the problem is getting too much "off the beam" for this afternoon's discussion; I really wish to keep your suggestion on hand, that studies have to be made, and that we have got to start making them.

MR. KENT: This, in a sense, relates to the problem of prefabrication. There is one thing that we are against in advocating the modular system, and that is that we are trying to present a complete packaged house. It has been suggested that any aircraft is obsolete as soon as it is produced. In the same way, I am quite certain that any building, no mattter how it was surveyed, would be obsolete by the time that it got into production.

What we are advocating in the modular system is that we provide raw materials and equipment which are flexible enough to meet the changing needs of society. Granted, research has to be done as to how it is to be put together.

MR. BERGVALL: I want to say that I do not quite agree with Mr. Dunstone that the only thing to do, or the most important thing to do, is to provide large projects.

Industrialization can be brought about in many other ways. For instance, the Ford Company does not have to put all its cars in one place in order to be able to produce them industrially. That means that the industrial production of components can be very well foreseen even for small projects. I would rather say that one of the advantages of prefabrication is precisely that it will allow small projects to be carried out as easily as large projects, and that, I think, is rather important with a country of your distribution of population.

I do not know if you have noticed the way in which National Homes of the United States used to advertise their prefabricated project, but it went along these lines. They demonstrated to you how a small builder with a limited amount of capital could turn over his capital much more quickly and thereby make much more profit if he bought most of his package from, in that case, National Homes; but the same goes for any prefabricated project.

That is one point. Now, the other point that I want to make is that it is often said (and rightly so) that the type of standardization that you should have should be component standardization and not the other standardization. There have been enough speeches now for component standardization; we can combine them into any kind of building, and that is wonderful. But if you studied the various types of apartments that are actually being built in Sweden, you would find that they are so similar to each other that it could with justification be said that they have all the disadvantages that they would have had if they had really been standardized to a very limited number of types, but lack the advantages that they would have had if they had been standardized in a systematic way. That is a point that can apply in more than residential buildings, of course, and in a certain way it supports the question from the floor.

MR. PRATT: I am an architect here in Montreal.

We, as a firm, are involved outside of Canada. We are involved amongst the newly-emerging nations, and one comment that I would like to make, going back on to this question of conversion to metric, and its importance from the manufacturers' point of view, is that many of the newly-emerging nations are going to be converting to metric, or are doing so now. There was a recent article in Fortune which stated that if the United States and Canada do not convert now to metric, they may find themselves, or we may find ourselves in the situation where markets begin to dry up. Mr. Bergvall covered this point in the dishwasher example. It has been predicted that if the change to metric is left until 20 or 25 years from now, it could cost as much as twice the G.N.P. of the United States as it stands at the present moment. That is just one comment that I felt I should make, and that should be made, as far as the manufacturers are concerned, when they are considering both the application of modular coordination and also the country as a whole switching to metric.

I have one question which I would like to address to Mr. Bergvall. Is there, at present, any international group executing technology forecasts to determine guidelines for present research and development progress directly involved with modular coordination? That is, are we, in our current determinations, taking into account the technological developments which will be required 25 years hence, or are we following the historical precedent which will, hopefully, determine that technological development?

MR. BERGVALL: There is one international organization which devotes its efforts exclusively to the question of modular coordination. That is the International Modular Group, of which I happen to be the Chairman. This group is connected closely both to the C.I.D., the International Dealers' Organization, and also to the I.S.O., the International Standards Organization; it is also linked closely to the United Nations, and Economic Commission of Europe, because most of the countries studying these matters are European countries. Since the I.M.G. started in 1960, we have been working with a program in which we must all the time foresee what might be going to happen.

We do not try to be prophets, because prophets very often make wrong prophecies; but we are open to the fact that the building industry can take many ways in the future. The dimensional conventions that are made today may prove later on to be very important for the building industry, and therefore they should be made in such a way that they cover all possibilities.

For this reason, for example, we have not made any decision on whether to promote open or closed systems, small components or large components, and so on, but investigate jointly which are the scientific or even purely geometrical conditions to achieve a full dimensional coordination in such a way and in such terms that we should not block the way towards the future in any direction whatsoever. I can say that this trend began in 1955 when this work was started on a less than international scale through the E.T.A. organization, in which only a limited number of European governments took part. This organization now has representatives not only from European countries, but also from such remote countries (from a European point of view) as India, Japan, Canada and the United States. One of the members from Canada is Professor Kent.

MR. DUNSTONE: I cannot support the questioner, of course, in his plea for a change to "metric" or what I take it is a plea for a change to metric, because this brings me into the political and industrial field of Canada, about which I know nothing but I can make an observation to you about the length of time that it is taking us in the United Kingdom to effect a change to "metric" and that is around eight years. The thing was first put forward in 1965. In 1966 a questionnaire was sent out to the industry, and from that questionnaire came the agreed program for the change. The program incorporates a start to be made on contract documentation at the end of 1968, and the whole of contract documentation (that is, all new projects) are due to begin in metric - to be billed in metric, that is - by the end of 1972.

So you can see that there is an eight-year cycle there.

MR. BENNETT: I am a manufacturer. It seems to me that the subject that I want to bring up has been touched upon several times quite completely in this question period. I believe that the motivation for the adoption of modular systems already exists through the media of the state, and educational facilities being carried on in Montreal and Toronto at this time. Having looked at a few name tags around here today, I am aware that a lot of manufacturers that are represented here were also represented at the S.E.F. Orientation Studies. I understand that these people are developing performance specifications which really do not have too much to do with what we are talking about now, but they are also developing coordinated systems, and these systems are being developed on a modular concept.

Now, I know that several manufacturers have already indicated their willingness to participate with the groups in both Toronto and Montreal in

their school construction programming, and these school programs could indeed provide the large customers which have been referred to earlier this afternoon, so my question is a very simple one: Are these studies being coordinated with the BEAM program so that anything that we manufacture and we develop now can be developed and expanded into other construction?

MR. DAVIDSON: I will not answer the question on behalf of the BEAM program because there are BEAM people here who can do it for themselves; I would venture to say, however, that coordination is something which (as I have already said this afternoon) has to cover a great many more facets than the sizes that things actually have. I am familiar with the S.E.F. and the Montreal equivalent programs and I am also aware (and no doubt you are too) of a very large number of programs which are being talked about more or less actively in the United States as a result of the so-called success of the S.C.S.D. initiative.

The points that I would make are as follows: firstly, there is a great danger, which it might be wise to look at now (even though the results may not hit us for a long time) , if a large number of clients' bodies start to produce incompatible performance specifications. I am not implying that all the performance specifications have to be the same. I am implying that if there are differences, I can see very real industrial advantages in concentrating these differences in certain aspects of each range of performance characteristics so that somebody who produces a sub-system or range of components meeting one of the performance ranges may either get through completely in another case with the addition of some particular physical member, or by working in conjunction with some other people.

The other thing that I think it is wise to say in connection with these S.C.S.D. type initiatives in the field of coordination, and it is in the wide sense that I would like to use the word, is that they have coordinated a number of parties in the building industry. If you remember my illustration with the organigram that preceded my comments on the California schools, there are still some people out in the cold, the public architects notably, and the building contractor, and I would like to think that a new generation of performance-dominated, client-dominated initiatives would start in which some new procedures for getting the public architect involved at an early stage and some preliminary selection of contractors, at an early stage, could be thought up.

MR. DAWSON: We do know something about the schools studies in Montreal and Toronto. On the BEAM Committee on Industrialization, we have the Director of the Montreal Study and the Director of the Study of Education Facilities in Toronto as members.

I would like to say also, that we have representatives from the senior trade unions in Canada, the C.L.C., C.I.O. and the C.N.T.U. in the membership of the Industry Advisory Committee on Industrialized Building.

MR. KENNEDY: I am an engineer and manufacturer.

I would like to offer a few comments on this chicken and egg situation, and I would like to end up with a suggestion.

One of the speakers this morning mentioned the fact that there are three ways of deciding who should go modular first. It could be that the Federal Government could express an interest by pointing the finger in four directions as to who should go first. I think it is obvious that where there is a major capital investment involved, or even a major design development cost involved, industry must have some certainty that, if not a guaranteed market, there will at least be a reasonably profitable market before the investment is made.

Mr. Davidson, this morning, mentioned that out of 400 known so-called industrialized systems in Britain, only 40 are expected to survive, and I think that this illustrates the risk to the manufacturer when he goes into something in the hope of a market instead of some reasonable probability of a market.

If we look at the systems which have been successful in Europe, a great many of them, if not the majority, have been aimed at a specific consortium of clients or owners, i.e. a class of schools, certain hospital systems and systems of public housing. Even if developed by a manufacturer or a contractor, there has been a specific point or target in sight.

Of the various organization charts that Mr. Davidson showed, the client would seem to be a major participant, with a major building program. He would seem to be the driving force in three out of four classes, and in the fourth class where the manufacturers appeared to be the driving force - well, repeating myself, there must be, if not a guaranteed market at least a reasonably probable market before industry can be expected to make major investments.

This raises the question as to the order for certain things to happen. The speakers, making their remarks separately, have indicated that three things that I have identified are more or less independent. First of all, the modular dimensioning of architectural working drawings - Mr. Kent has indicated that this can be done largely independently of the method of construction that is actually employed in the field.

Second, the manufactured modular components; here again it is possible with different methods of field construction, and it requires a larger investment. The final stage will appear to be industrialized construction systems using such modular forms as are developed. Taking Professor Kent's remarks, I am sure than modular dimension work, actual drawings, could take place without capital investment (other than the training costs involved), and apparently at an almost immediate saving to the architectural firms involved.

The manufacture of modular components is something which obviously will follow, to a greater degree, with open system components, when

there are jobs to be bid involving such components; and as I say, finally, when there is such a large number of such components available, we will see systems of industrialized construction using such components.

So to sum up, it seems to me that the most logical order is; number one, the modular dimensioning of architectural drawings regardless of method of construction; number two, the manufacture of modular components; and number three, the rationalization of the site labour.

I was most interested in Mr. Bergvall's comments on the fact that the Swedish Government had regulated or legislated on modular coordination not only with regard to their own construction for the Government, but also for all buildings being subsidized.

I would like to tie this up with a suggestion that it seems to me that the Federal Department of Public Works is the largest single buyer of construction in the country, and the largest single buyer of architectural services in the country. It would seem quite logical that if the Federal Department of Public Works was to rule that architectural working drawings produced on their behalf would be to modular dimension practice - this is something which would not involve capital - the practice would soon spread to other private work of the architectural firms concerned and very soon manufacturers might find that there were so many modular practice drawings in existence that we could not do anything else but produce modular components; so my suggestion is that perhaps the place to start is with the architectural working drawings produced with the Federal Department of Public Works, and by extension with the provinical school authorities.

MR. DEROME: Thank you, Mr. Kennedy. I will ask Professor Kent and Mr. Dunstone to reply to your comments.

MR. KENT: Mr. Kennedy has put his points very clearly. I will just say that modular working drawings are far simpler to prepare if you have some modular components to work with. I do know that in this connection we have enough modular components on the market to get the ball rolling in any case.

MR. DEROME: Mr. Bergvall would like to say something.

MR. BERGVALL: I might not have quite expressed myself clearly this morning on the point of the initiative taken by my government.

It is true that it decided that all buildings paid for with the government's money should be modular. It entitled those governmental agencies subsidizing various types of building to apply the same sort of regulations if they found it advantageous to do so. This indicates that a certain flexibility in the application of the pattern in the beginning is foreseen.

Finally, I want to emphasize what I said this morning: many of the speakers here have pointed to the fact that the conversion to modular coordination could be easily carried out in a drawing office, but as for the industry, it would require fairly substantial capital outlays. That might be so in some cases, but in others (and that follows what I said this morning), it might not be the case at all. That is particularly true if you coordinate your conversion with other exchanges of moulds and machines, which has to take place in the course of normal replacements of parts and in model changes.

EPILOGUE

On behalf of my fellow guest speakers and myself, I want to express a few words of thanks. Although, of course, on a journey like this one is supposed to give some contribution to the conferences -- and indeed I hope we have done so -- we also learn a great deal. This we certainly did, both for ourselves and for our countries, and therefore we are grateful to the Department of Industry for having taken this initiative.

It is, of course, also a pleasure to visit Canada, the country with the great future. I cannot help envying you a little bit when I think about all the small European countries, most of them hardly the size of one of your provinces, desperately struggling for some kind of unification, or at least for large, unified market areas. You already have a territory stretching out from the Atlantic in the east to the Pacific in the west, and you are to be congratulated on all of this territory. We have seen part of your beautifuly country in travelling from Halifax to Vancouver and back.

As an old friend of your country, having visited Canada for the first time back in 1948, it has been slightly discouraging to witness how comparatively little Canada is known in Europe. I think I am in a better position to judge that than my British colleagues, because Britian has always had rather special relations with Canada. It has been rather encouraging, though, to notice that in later years your country has gained an international profile of its own. Maybe that is because you have at last become aware of the great future of your country, and this is possibly what creates such an inspiring atmosphere here.

For those of us who have spent much of our time during many years on modular coordination it has been most encouraging to see the positive manner in which the Department of Industry's initiative has been received. However, the belief that modular coordination is something that we have been trying to promote for its own purpose is not valid. We have done so only because it is a tool, or a means for the industrialization of the building industry. This again is not a thing we are pursuing just for its own sake, but because it is the only way to solve the dwelling problems of the people of the world. Millions of people, both in Europe and on this continent are living in dwellings which are a shame on all of us.

But, again on behalf of my fellow lecturers, I think that all of us lost a little bit of our hearts to Canada, this great country of yours.

Thank you.

L. Bergvall

Appendix 1

CONFERENCE CHAIRMEN AND PANEL MODERATORS

HALIFAX

Moderator: Mr. D. M. Blenkhorne, architect, Shore and Moffat and Partners, Toronto.

Chairman: Mr. L. E. Shaw, President, L. E. Shaw Limited, Halifax.

TORONTO

Moderator: Mr. D. C. Aird, Manager of Methods Study, Design and Construction Division, Ontario Hydro.

Chairman: Mr. John Cochran, Vice-President, Building Materials, Domtar Limited, Montreal.

WINNIPEG

Moderator: Mr. J. S. Sugiyama, Principal, Izumi, Arnott and Sugiyama, Regina.

Chairman: Dr. J. D. Wood, Vice-President, Engineering and Research, ATCO Industries Limited, Calgary.

EDMONTON

Moderator: Mr. Kenneth Bruce, Vice-President and General Manager, Prestressed Concrete Division, Francon (1966) Limited, Montreal.

Chairman: Mr. Ronald Clarke, architect, Diamond-Clarke and Associates, Architects and Engineers, Edmonton.

VANCOUVER

Moderator: Mr. D. W. Thomson, architect, D. W. Thomson and Company Limited, Consulting Engineers, Vancouver.

Chairman: Mr. Warnett Kennedy, Executive Director, The Architectural Centre, Vancouver.

MONTREAL

Moderator: Professor J. H. Derome, Secretary of the School of Architecture, University of Montreal.

Chairman: Mr. Andre Tessier, architect, Tessier, Bissonnette and Corriveau, Architects, Quebec City.

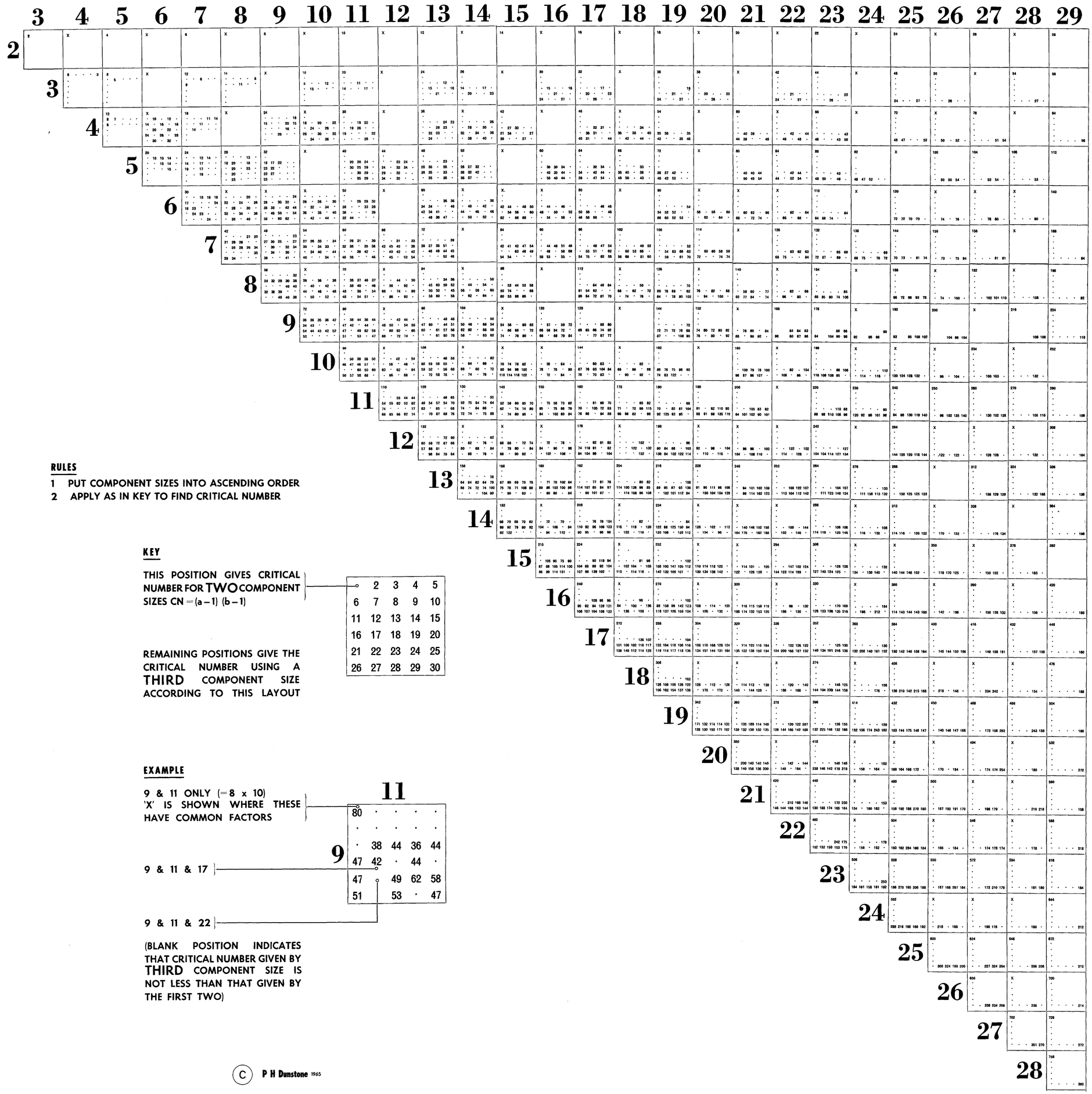
Appendix 2

ADVISORY COMMITTEE FOR MODULAR COORDINATION

NAME	TITLE	ADDRESS
Mr. C.M. Baker	Architect	Building Practice Section, Division Building Research, National Research Council, Montreal Rd., Ottawa, Ont.
Mr. D.M. Blenkhorne	Architect	Shore & Moffat & Partners, 100 University Avenue, Toronto, Ont.
Mr. Kenneth Bruce	Vice-President & General Manager, Prestressed Concrete Division	Francon (1966) Limited, 8300 Pie IX Blvd., Montreal 38, Que.
Mr. Ronald Clarke	Architect	Diamond-Clarke & Associates, Architects & Engineers, 1400 Royal Bank Bldg., Edmonton, Alta.
Mr. John Cochran	President	Domtar Construction Materials Ltd., Suite 2210, 1 Place Ville Marie, Montreal, Que.
Professor J.H. Derome	Secretary of School of Architecture	University of Montreal, 3450 St. Urbain, Montreal, Que.
Mr. R.J. Durrant	National Manager, Building Products	Westeel-Rosco Limited, 1 Atlantic Avenue, Toronto, Ont.
Mr. S.A. Gitterman	Adviser	Central Mortgage & Housing Corp., Head Office, Montreal Rd., Ottawa 7, Ont.
Mr. R.H. Grimm	Executive and Vice-President	Primeau Argo Block Co.Ltd., Belfield and Highway 27, Toronto, Ont.
Professor S.R. Kent	Professor of Architecture	56 King's Crescent, Ajax, Ont.

Mr. E.L. Mahoney	Assistant to the General Manager	Canadian Construction Association, Construction House, 151 O'Connor Street, Ottawa, Ont.
Mr. L.R. Shaw	President	L.E. Shaw Limited, 1 Sackville Place, Halifax, N.S.
Mr. K.E. Stubbs	Chief, Specification Division	Department of Public Works, Sir Charles Tupper Bldg., Riverside Drive, Ottawa, Ont.
Mr. James S. Sugiyama	Consulting Engineer	3043 Quinn Drive, Regina, Sask.
Mr. Andre Tessier	Architect	Tessier, Bissonnette & Corriveau, Architects, 880 Chemin Ste-Foy, Quebec 6, Que.
Mr. D.W. Thomson	Consulting Engineer	D.W. Thomson & Co.Ltd., Consulting Engineers, 1690 West Broadway, Vancouver 9, B.C.
Dr. John D. Wood	Vice-President	ATCO Industries Limited, 1243 - 48th Avenue N.E., Calgary, Alta.

THE TABLE OF CRITICAL NUMBERS (FOR 2 OR 3 COMPONENT SIZES)



RULES

1 PUT COMPONENT SIZES INTO ASCENDING ORDER
2 APPLY AS IN KEY TO FIND CRITICAL NUMBER

KEY

THIS POSITION GIVES CRITICAL NUMBER FOR TWO COMPONENT SIZES CN = (a – 1) (b – 1)

2	3	4	5	
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30

REMAINING POSITIONS GIVE THE CRITICAL NUMBER USING A THIRD COMPONENT SIZE ACCORDING TO THIS LAYOUT

EXAMPLE

9 & 11 ONLY (= 8 x 10)
'X' IS SHOWN WHERE THESE HAVE COMMON FACTORS

9 & 11 & 17

9 & 11 & 22

(BLANK POSITION INDICATES THAT CRITICAL NUMBER GIVEN BY THIRD COMPONENT SIZE IS NOT LESS THAN THAT GIVEN BY THE FIRST TWO)

11				
80	·	·	·	·
·	·	·	·	·
·	38	44	36	44
47	42	·	44	·
47	·	49	62	58
51	·	53	·	47

9