# A suggested computer system for package-deal building contracts

**by Alan Bond, BSc.**

*The following article was written by Alan Bond, a 1976 undergraduate student at Bristol Polytechnic who chose as the brief for his dissertation the use of computers in package deal contracting. His aim was to suggest a system suitable for all facets of the work of a package deal contractor. As part of his study he prepared pilot programs concerned with the representation and placing of the building on the site and the preparation of the site survey. His main argument that we should adapt our techniques to suit the potential of the computer rather than attempting to bend the machine to match our methods is one that we could all usefully consider. While he presents the optimistic view of computer use there is no doubt that the industry has been slow to take advantage of the possibilities it offers. Anyone wishing to enter into correspondence with Mr. Bond should write to him at 20 Lampeter Road, Westbury on Trym, Bristol, Avon.*

With the exception of the big contracting organisations, the building industry is badly fragmented. Normally each profession concerned with a particular contract is a completely independent organisation in its own right. Added to this, on the contracting side of the fence, are the sub-contractors.

Both the large capital outlay required and this breakdown of roles have in the past led to the development of specialist computer programs by the larger members of individual professions and contracting organisations.

As the cost of computer hardware continues to fall rapidly, the implementation of data processing by machine becomes more and more attractive but is still limited by this traditional professional specialisation. Until we arrive at a situation whereby the greater part of both the design and construction work is carried out by one unified organisation, efficient *large* scale use of computers cannot be made. In other words a full package-deal approach is required to make it work.

Without leading into the political and professional pros and cons of this idea it must be stated that this does not envisage the end of tendering but rather a higher level of competition encompassing the complete design. The whole point of computing is that it is faster. Whether this saves money is a symptom rather than a cause which is dependent on how it is used. At present, most contracting organisations would be hard pressed to design and tender for a project in the same time as they could prepare a tender for someone else's design.

Given a computer system which could design and prepare tenders in one go, the job could probably be done in a shorter time than it takes merely to price a bill of quantities for a normal tender.

It would be wasteful to use a computer for these pre-contract functions and leave it at that. Computers probably have more going for them in post-contract areas than anywhere else. Scheduling, ordering, critical path analysis, wage calculation, etc. are all tried and tested computer applications in other industries, and this may be the tip of the iceberg.

If the uses of a computer in pre and post contract periods were separated, limitations would be imposed, but putting the two into one system would allow a flow of information such that almost all of the post-contract data processing could be automated – variations; valuations; plant, material and labour allocation; transportation; etc.

The story need not end there, either. Disregarding the present economic climate, most contracting organisations would expect to have more than one contract in progress at any one time. Operational research techniques such as Critical Path Analysis, Queueing & Monte Carlo are well established but are usually applied to individual elements – one project on its own if at all! The only common denominator as far as any one construction organisation is concerned must be the whole firm's activities, not individual projects, so why not "optimise" taking all the jobs at once? Manually, this would be bordering on the impossible but if computerised the organisation might even be evaluated and redirected on a daily basis!

With a traditional construction firm, especially when using a large number of sub-contractors, this aspect would probably be relatively unimportant, but we shall now consider a system building organisation which designs, manufactures, markets and erects as a complete package.

This idea formed the basis of the thesis prepared at Bristol Polytechnic, the task being to explore the application of computer techniques with a view to the automation of as much of the design and management functions as possible in a practical construction environment. This intentionally reversed the normal procedure in trying to develop a system with a broad objective and letting the limitations of computing techniques decide how to achieve a result which is still relevant and practical, rather than starting with a fixed plan of attack and forcing the programming of the system to comply with each individual part of that plan. This may lead to a product which makes a more comprehensive and efficient use of the computer.

The starting point for the study was the client's provision of a site and the requirement for a building and the result envisaged was the design and construction management of that building.

The results of this exploration are summarised by fig 1, "The System Flowchart". This is divided into three broad columns – "Input/Output", "Computer Stage" and "Back-up system". The first is self-explanatory, being the data fed into the system and the results obtained from it. The second and third are the computer functions, "Computer stages" being the actual processing of data and "Back-up" the storage of information.

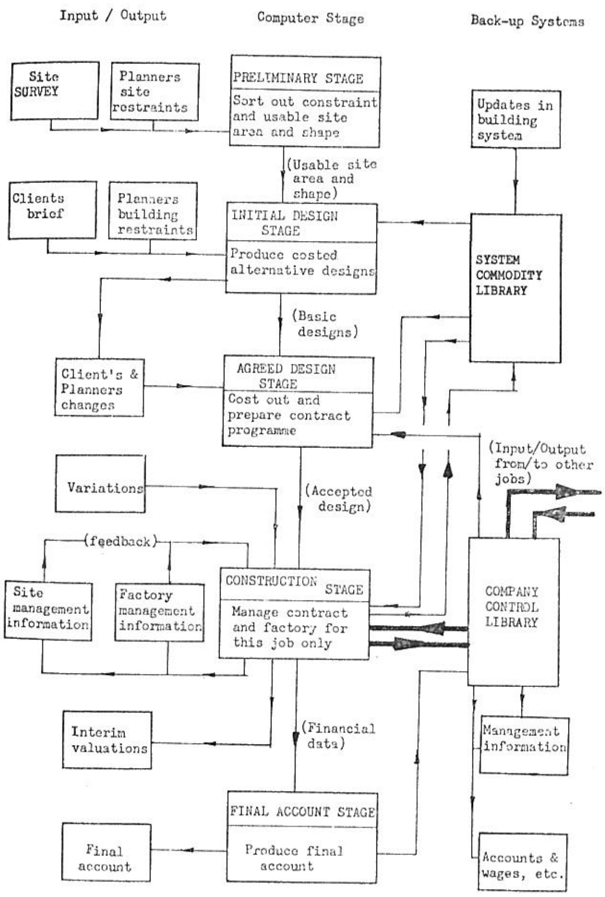


Figure 1

The system begins with an automated site survey capable of being carried out by one operative. The method uses electro-magnetic distance measuring equipment (E.D.M.) to define both the plan shape and levelling grid for the site using polar co-ordinates. This equipment, which already in use today, is capable of recording the information onto magnetic tape which can be used as direct input to a computer thus eliminating all booking, processing and plotting errors by the surveyor, to say nothing of the time saving in computer input.

At the same time details of any building lines, access restrictions, sewers, cables and such like, together with any areas which are to be reserved for purposes other than the proposed works (such as car parks to serve existing buildings, space for future development, etc.), are similarly entered.

The computer then undergoes the "Preliminary" stage which basically superimposes one on the other to categorise areas of the site into those which can or cannot be built on, and those which may be if some condition of the design is satisfied. A simple example of the latter would be the position of windows to habitable rooms defining the distance between some existing dwelling and the proposed building.

This defines the restrictions of the site in terms of conditional mathematical statements using polar co-ordinates from the site survey.

The next batch of input, namely "Client's Brief" and "Planners' Building Restraints", attempts to define the design parameters of the building itself. Alternative arrangements for gathering this information were investigated, ranging from mere discussions with the Client/Planner and subsequent computer input by a trained operative to direct communication between computer and Client via an interactive terminal. The latter formed a practical piece of research in the thesis.

The use of terminals requires further discussion. When fully developed the system envisages a travelling representative of the construction company with a portable computer terminal visiting Clients at their own offices and linking up to a central computer via an acoustic modem and the GPO telephone network. The computer would then pose questions to be answered by the Client. Substantial discussion was entered into to explore the use of "back-up" systems to assist the Client in his interrogation of the system. This would display examples of answers to and provide clarification of individual questions when the Client commanded it so to do. Further it would detect incorrectly presented answers, taking remedial action by reposing the question and simultaneously issuing directives explaining why the initial answer was incorrect.

As to the formulation of the brief, attention was focused on deriving methods whereby a prospective Client could be provided with quantitative measurements of various kinds for each design alternative presented to him by the computer both quickly and accurately. This outlined the contents of such a brief.

Cost is the ultimate criterion for measurement and this is normally initial cost. Little attention is usually paid to long term maintenance, running costs etc. Part of the reason may be that these are far less explicit than initial cost and therefore may appear to be less important. Another reason may be that Clients and Professionals are simply not used to talking quantitatively in such terms and therefore have no inbuilt sense of what is cheap or expensive, low or high. Say to a QS that such and such an office cost £40 a square foot and he would ask you why you didn't employ him, but tell him the running costs are 50p a square foot per annum and he's more likely to shrug his shoulders and grin intelligently (or otherwise!).

An argument was put forward in the dissertation for presenting such information in non-finite terms i.e. as indices. Methods of deriving long term cost indices, maintenance cost indices, running costs and an efficiency index were suggested. The efficiency index simply derives the costs of movement of articles and persons around a building over a given time scale and relates it to a standard figure. As a Client is presented with alternative designs he can quickly deduce which is the most efficient to operate, and be given some measure of how much better one is than the next.

With initial cost, a Client may wish to know the cost effects of using different types of finish in different areas of the building. The proposed system would allow this to be done with any building component, giving information stating the cost effect accurately and almost instantaneously. All this information must help the Client to decide the type of building he requires.

As a standard building system is envisaged, the selection of components by the Client can be made fairly straightforward. On a practical level the Client would merely be concerned with standards of finish. When asked which type of door is required in a particular area of the building, reference could be made to a catalogue which would show photographs and give broad costs of alternatives. If the effect of a given choice on the total cost of the building was required, such a request could be made and an instantaneous answer given. The computer would of course decide whether it had to be fire resisting, a double door or sound-proof, etc., from the functional criteria chosen.

The physical details and limitations on the positions of rooms are defined in three pieces of information (In the thesis these were expanded to six, but for brevity three have been used here.) These are:—

(a) Room specification,

(b) Functional Inter-relation matrices and,

(c) Group Synthesising matrix.

(a) is virtually self explanatory. The Client is asked for the sizes of the main rooms he requires in the building (i.e. excluding toilets, corridors, etc.). To this he may answer giving ranges or fixed dimensions for the length, breadth and height of each unit. A questionnaire routine then gathers information enabling the computer to determine room temperatures, air changes, fire rating, etc. Further questions are then asked to determine finishing standards for each room or group of rooms.

(b) is aimed at abstracting information concerning the arrangement of rooms. This is done in two ways, firstly by asking on a scale of —100 to +100 how important it is to have one room next to another (—100 being imperative *A* is *not* next to *B* – for reasons of noise or smell for example – zero meaning it doesn't really matter and +100 signifying that they must be), and whether they should be directly accessible (i.e. without use of a corridor). Secondly, the size of the communication channel, over and above a normal door opening, is asked for. This information thus defines the priorities and sets the parameters for communication channels within the building (i.e. corridors, stairs, doors, etc.).

The group synthesising matrix allows the Client to say roughly which rooms should be in the same area of the building. This irons out idiosyncracies in the other two. For example, the position of one room may be described as unimportant with regard to any of the others, in which case it may end up in the design in an utterly ridiculous position. However this information is not treated dogmatically, and if it contravenes anything in the other two it is ignored.

The two design stages are now encountered. At this point it must be stated that an "optimum cost design" is *not* being sought. If and when a clear and practical definition of such a design emerges – the system will be adapted to suit! What is being looked for is a building which is satisfactory to the Client and which, as far as possible, has been designed by him. The computer only enters the proceedings as a "prompter" and "censor". It "prompts" by suggesting reasonably workable and practical layouts for the building based on the information it has been given, it allows the Client to "tinker" with them while at the same time providing him with the financial results of this tinkering and then "censors" by not allowing him to contravene planning and building regulations. The principle of course is fine but a great deal of research would be required to achieve such an end. The following is a suggestion as to how it might be done.

Four basic processes are involved,

(a) an analysis of the Client's brief to define a "*skeleton layout*" to be used as basis for the selection of

(b) *outline shapes* generated on the basis of the net site as resulting from the Preliminary stage,

(c) the "*cost zoning*" of those shapes selected and

(d) the attempted *containment* of the "skeleton layout" within each shape selected to yield alternative reasonable solutions to the problem followed by cost information on each as previously discussed.

All this must, of course, be done mathematically. To alleviate the anxiety induced by the above use of "jargoneese" and to avoid the mathematical theory, consider the following analogy.

Each room in the proposed building can be compared to a half inflated rubber box which can be further inflated or compressed (within limits specified in the Client's brief) but the shape of which must always remain strictly rectilinear.

The "skeleton layout" is arrived at by arranging and inflating or compressing all the boxes such that they can be stuck firmly together in an order which optimises the information contained in the functional-interrelation matrix.

The "outline shapes" are wooden boxes whose shape (again rectilinear) and size, are derived by a random search within the constraints of the net site area.

The "containment" process is merely the squashing of the stuck mass of rubber boxes into each wooden one in turn. Some of the wooden boxes will not be big enough to allow this and are discarded. The remainder are made progressively smaller until as many of the individual rubber ones as possible are fully compressed. It may seem that the same design will always be arrived at but this is not so. No wooden box can be enlarged in any direction thus preventing them from always taking up the same final shape.

The thesis included an attempt to program a computer to generate the outline shapes (with reasonable success) but the real test would be the formulation of a mathematical model to represent the "skeleton layout". This was not possible in the time available.

"Cost-zoning" is a process which examines the levels inside the outline shape in order to derive an initial position of the skeleton layout which minimises the costs of excavation and site preparation. The progressive shrinkage of the outline shape is also related to these cost zones such that the final design takes up a position on the site which maintains the smallest ground works cost.

Having arrived at several initial designs, the Client is allowed to choose and amend at will, using an interactive terminal (with operator) for communication with the computer, until he is satisfied with what will become the final design. Once this has been achieved, the real boon of the system comes into play.

The Company Control Library (CCL), as shown in fig. 1, would be a comprehensive data base which would contain up to date detailed information on the state of all the jobs under construction by the company operating the system. A search programme would be used to determine the spare capacity in the firm for the introduction of the new job. A contract programme is simultaneously evaluated by computer and stored for future use.

Assuming the Client wishes to proceed (hopefully a more likely proposition after playing with the computer terminal!) the contract is signed on the basis of price and contract programme.

The last stage of the system proceeds, an explanation of which requires that all the jobs under construction are considered together. The idea is to use operational research techniques such as "Critical Path Analysis" (CPA), etc., in a two stage manner.

First, an attempt is made to keep each job on its originally evaluated contract programme in the normal way using CPA. Second, any gains made in respect of time on one job are used to supplement losses on others, again using CPA. There is, therefore, one CPA for each job where the events are actual construction processes and another master CPA where the events are the complete construction projects.

With the latter one, instead of recalculating the critical path at the end of each event in order to take corrective action, the event times are re-estimated using better information from the sub-analysis as the jobs proceed.

This approach is also applied to the CPA's for individual projects by collecting daily information direct from sites in order to predict better event times throughout the job. Similarly the master CPA is also amended daily.

To achieve this amount of control in the same manner by manual means would be extremely difficult, if not impossible. Using a computer to do the calculations would make it somewhat more practical but the large quantity of data required to be collected and the subsequent administration of corrective measures would still rule out the idea.

One method of overcoming this involves the use of automatic computer terminals (used by certain supermarket chains for stock control). These are similar to an ordinary terminal (and in appearance, to an electric typewriter) but have the useful facility of being able to store information typed into them while disconnected from the computer. This information can later be extracted by the computer. This has been automated to a point where the computer actually dials the telephone number of the terminal, switches it on, retrieves the stored data, and switches it off again. The reverse is also true, where the computer types information on the terminal which can be completely unattended at the time.

This can be used to advantage by wheeling a terminal into a hut on each site and connecting a small black box to the site telephone. Next add the same to a materials stock yard (and pre-casting factories in the case of system building outfits). Automated construction management is then well on its way.

The idea is to use the computer by day for design work as previously described and by night for job administration. Running through a theoretical day, starting at 6.00 a.m., the computer would telephone each terminal and type out instructions as to the work to be done for the day, the times of deliveries and any other information that may be necessary. From, say, 6.30 a.m. – 11.00 p.m. the computer is busy helping with design work while feedback information from sites, etc., is typed onto the terminals for local storage. At the end of the day this is read back through the terminal and checked. At midnight the computer "rings" around and gathers all the data from the terminals. From then until 6.00 am, it works out the instructions for the next day using the CPA principles previously described, whence the cycle is started again.

The success of this arrangement is likely to depend on the amount of feedback material coming from site. It is difficult to imagine any site manager spending all day sitting at a teletype thumping away. Many ways around this problem were suggested – all of which are, in part at least, used by other industries – e.g. punched cards, sensor pens, magnetic cards, etc.

The make up of this data could be almost limitless. Heuristic principles whereby the computer "learns" could possibly be employed. For example, if times of despatch and delivery are kept, some conclusion as to the best time of the day for such operations to take place can be drawn and used in the re-estimations of the CPA's. Similarly, fixing times for components could be fed back to allow an average to be evaluated by the computer. As the system was used it would "learn" in the sense that fixing times, etc., would tend to a more realistic mean. Moreover, this mean would be continually re-evaluated. A clocking in and out arrangement for men would make the calculations for wages almost automatic – the possibilities are endless. The more obvious feedback for the build up of interim valuations and final account needs is relatively straightforward.

Variations could receive the same sort of treatment. Advice to Clients as to the cost of such afterthoughts could be given with a speed and accuracy that would be impossible to match by manual means. Furthermore, additional information such as the effects on the efficiency index, maintenance costs and the likely effect on the contract programme could be given.

The Client could be given dates by which decisions on possible variations should be made if detrimental effects on any present contract programme were to be avoided. During this period the computer would direct the running of the project with the pending variation taken into account. Again, the beauty of the system is the inherent speed of data collection and processing which promotes tighter control on the job – avoiding abortive work and therefore cost to the Client.

Some will no doubt see this as a rather fanciful notion. Nevertheless, after studying the topic it is believed that such a system could be used in a practical building environment *NOW*. After all, the computer technology is by no means futuristic – all of it is in current use in some field.

Mention has been made of system building but it is felt that any form of building technology could be employed provided it conforms to some modular design method. The only limit is the amount of alternative building products that could reasonably be used in any one system. This is only really limited by the size of the computer's storage ability (i.e. the more products there are, the larger the "system commodity library") and the speed of processing.

As part of its conclusion to a report entitled "Computer Aided Building – a study of current trends", published in October 1973, the Computer Aided Design Centre made the following statement:—

"The decrease in the cost of hardware, dissemination of information on techniques pioneered in research and increasing expertise of those involved in software development set the scene for rapid growth.

Whether this growth is realised will depend on three main factors: the willingness of management in all sectors of the industry to seize the opportunities and make use of the available expertise; the ability of the professions to realise great change is under way and to adapt their attitudes to that change; and the co-ordination of sponsored research and development, directed to prevent duplication and misdirection. . . ."

Have our attitudes changed since 1973? Without wishing to "scaremonger", we are at the *start* of the age of "microelectronics" – a grossly underestimated technology. The sheer speed of its advancement makes it potentially more radical (as far as the possible effects on society are concerned) than anything of its kind this century. We are at the tip of an immense iceberg – the industrial revolution of the office perhaps.

There appears to be a blind disregard for computers in the building industry but beware the ides of the microprocessor! – the computer industry is lurking hungrily in the background sniffing around for yet another sales outlet – far better to use it now than become used by it later as just another sub-contractor.

# National Joint Council for the Building Industry

Details of the National Joint Council's pay settlement promulgated on 31st March 1977 are as follows:—

The parties to the National Joint Council for the Building Industry having received recommendations from the Building and Civil Engineering Joint Board which had been considering a claim by the Operative Parties for:

(a) an increase of 5% on total earnings;
(b) improvement in sick-pay entitlement; and
(c) an increase in holiday pay,

adopted the following terms of settlement:

Ratification of this decision having been declared by the Adherent Bodies as required by Rule 6.1.3.2. of the Rules and Regulations of the Council, the Management Committee hereby promulgate the terms of settlement to operate with effect from *Monday, 27th June 1977.*

1. *The 1977 Supplement:*

1.1. From 27th June 1977, operatives shall be entitled to a weekly supplement to be known as "the 1977 Supplement". This is to be 5% of each individual operative's total earnings, subject to the following:

1.1.1. Total earnings for the purpose shall be the figure of gross pay used for calculating National Insurance contributions (which includes sick pay), other than the 1977 Supplement itself.

1.1.2. The 1977 Supplement shall in no case exceed £4.00.

1.1.3. The 1977 Supplement shall not be less than £2.50 where an operative has been available for work during full normal working hours, except that the minimum for operatives whose wage rate is expressed as a proportion of the adult or craft rate shall be the corresponding proportion of £2.50.

1.1.4. The minimum 1977 Supplement, as defined in sub-para. 1.1.3. above, shall be reduced proportionately for any part of normal working hours for which the operative has not been available for work, in exactly the same way as the Joint Board Supplement.

1.1.5. The amount of the 1977 Supplement shall not be affected by the operative's absence on a day or days of public holiday for which there is entitlement to payment under the appropriate Working Rule.

1.2 Watchmen shall receive the 1977 Supplement on the above basis, with appropriate provision for proportionate reduction of the £2.50 minimum where fewer than five shifts are worked.

1.3. The 1977 Supplement is not to be added to payment for annual or winter holidays under the Building and Civil Engineering Industries Annual Holiday Agreement.

**2.** *Apprentices/Trainees*
From 27th June 1977, the following provisions shall apply to new entrants to the National Joint Training Scheme aged 16 or 17 years at entry:
2.1. Entitlement to Guaranteed Minimum Bonus shall begin from the commencement of the second year of training.
2.2. The Joint Board Supplement during the first year of training shall be:

| Age at entry | J.B.S. |
|---|---|
| 16 | £3.40 |
| 17 | £6.60 |

Apprentices/Trainees who were receiving the guaranteed minimum bonus payment before 27th June 1977, shall continue to receive it but their Joint Board Supplement shall not be altered until the commencement of the next year of training.

**3.** *Scaffolding Operatives:*
Negotiations shall continue in the Building and Civil Engineering Joint Board on a new training and pay structure for scaffolding operatives with the aim of introducing it from a date falling within the period of this settlement.

**4.** *Holiday Credits:*
Holiday credits for adults are to be increased by 15p per week (juveniles proportionately) with effect from 1st August 1977, with this amount being augmented by up to a further 5p per week from the funds of the Building and Civil Engineering Holidays Scheme Management Co. subject to discussion with the Board of that Company.

**5.** *Death Benefit:*
The amount of benefit payable under the Building and Civil Engineering Industries Death Benefit Scheme is to be increased to £2,500 where death occurs on or after 1st April 1977 and cover during unemployment under Rule 5.6. of the Scheme is to be increased from two weeks to four weeks with effect from the same date.

**6.** *Period of Settlement:*
The settlement shall be for 12 months and the Council shall not be required to consider any application or recommendation for a change in operatives' pay or for a change in conditions of a major character which would have effect before 26th June 1978.

# Correspondence

### Prices or Costs

Sir,

Reading Mr. Skoyle's article on "Prices or Costs", I regret to say, confused me. Perhaps being a Contractor's Surveyor has limited my way of thinking, as I always define costs as per I.C.E. 5th. edition clause 1(5) and JCT clause 11.

Both documents refer to prices and expenses, and the context in which these words arise, are themselves self-explanatory and do not contradict the term "Prime Cost" or "Costs" which appear elsewhere.

I am quite sure confusion does not occur at pre-tender stage and that the present situation has only arisen by the presence of many theoretical books published on the subject.

Yours faithfully,

D. Payne

Thaxted, Essex

### Scarves for Lady Members

Sir,

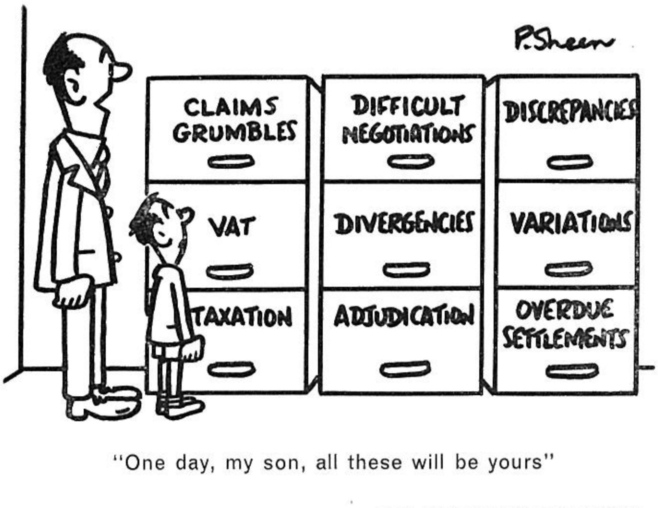
I refer to the Institute News item in the March issue of The Quantity Surveyor. I am concerned that it appears that the proposed Institute scarves are intended for lady members only. Apart from the fact that I do not acknowledge that any distinctions should be accorded to or demanded by lady members of the Institute (if one was being very cynical one might say that a quantity surveyor couldn't be a lady, or a gentleman, in any case), the use of scarves as an item of neckwear is *not* confined to women. Also by implying this the project could well be a "non-starter" by lack of demand. Obviously the wider the market the more viable the proposition will be, and hopefully the cheaper the product.

I should be grateful therefore if it could be made clear that scarves will be equally available to men.

Yours faithfully,

Beryl Foote (Associate)

Surbiton, Surrey




"One day, my son, all these will be yours"