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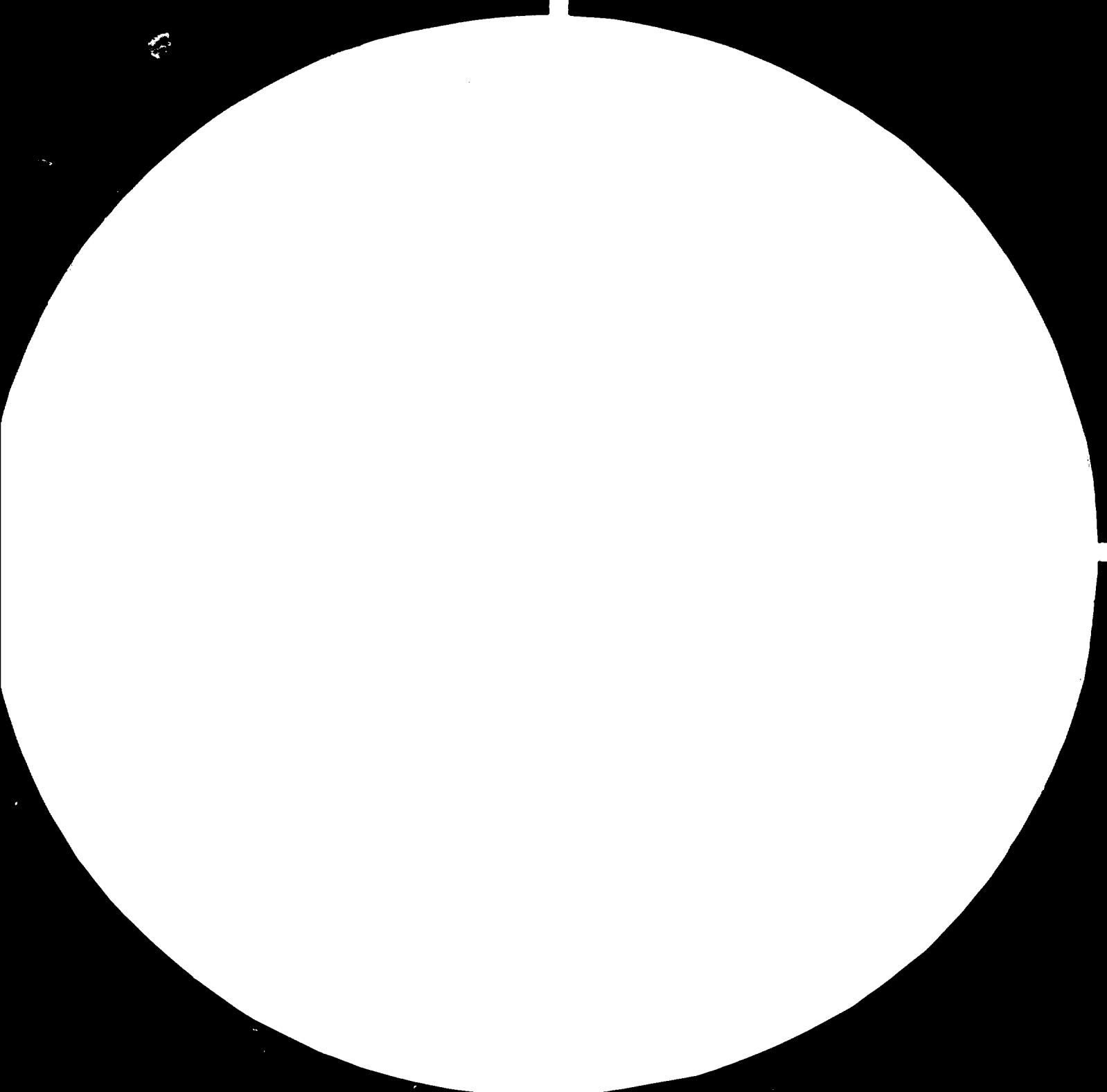
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Model No. 1170-631 1170-631 1170-631 1170-631

Resolution Test Chart

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January 1983  
English

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PROJECT FOR ASSISTANCE TO THE ALUMINIUM  
INDUSTRY IN THE PRODUCTION OF SEMI-FINISHED  
AND FINISHED PRODUCTS

A STUDY OF THE DESIGN AND PRODUCTION FACILITIES  
FOR WINDOW FRAME AND DOOR PRODUCTION AT THE  
KUWAIT ALUMINIUM COMPANY, KUWAIT

Report by W G Fancourt → Consultant to  
the Aluminium Window and Door Industry

for the

United Nations Industrial Development Organisation  
Vienna

422

This report has not been cleared with the United Nations Industrial  
Development Organisation which, therefore, does not necessarily  
share the views presented

3

I would like to record my appreciation of the help I received and express my thanks to the staff of the Kuwait Aluminium Company who assisted me to collect the background information for this study.

Bill Fancourt  
Shropshire, England, December 1982

CONTENTS

PAGE NO.

|     |   |    |
|-----|---|----|
| 1.  | INTRODUCTION                                | 1  |
| 2.  | COMMERCIAL CONSIDERATIONS                   | 2  |
| 3.  | NATIONAL STANDARDS                          | 3  |
| 4.  | COMPANY STANDARDS                           | 5  |
| 5.  | INSTALLATION METHODS                        | 7  |
| 6.  | MANUFACTURING FACILITIES                    | 9  |
| 7.  | PROPOSED PRODUCT STANDARD - 110 mm          | 11 |
| 8.  | PROPOSED PRODUCT STANDARD - LIGHT WINDOWS   | 13 |
| 9.  | PROPOSED PRODUCT STANDARD - ENTRANCE UNITS  | 14 |
| 10. | CONTROL SYSTEMS                             | 15 |
| 11. | PRODUCT STRENGTH - RESISTANCE TO WIND LOADS | 16 |
| 12. | WATER PENETRATION AND AIR INFILTRATION      | 17 |
| 13. | ACOUSTIC AND THERMAL PERFORMANCE            | 19 |
| 14. | CONCLUSIONS AND RECOMMENDATIONS             | 22 |

APPENDIX

LIST OF APPENDICES

PAGE NO.

|            |  |    |
|------------|--|----|
| Appendix 1 | EXAMPLES OF SPECIFICATIONS ISSUED<br>FOR PROJECTS  | 24 |
| Appendix 2 | MINISTRIES AND OTHER BODIES<br>CONTACTED   | 25 |
| Appendix 3 | LIST OF PROJECTS STUDIED   | 26 |
| Appendix 4 | ILLUSTRATION OF CLAMP MULLION DESIGN<br>TAKEN FROM THE "APOLLO" WINDOW<br>BROCHURE OF HEYWOOD WILLIAMS LIMITED,<br>CHESTER, UK | 27 |
| Appendix 5 | ILLUSTRATION OF POINTING DETAIL<br>TAKEN FROM THE "APOLLO" WINDOW<br>BROCHURE  | 28 |
| Appendix 6 | POINTING DETAIL AS USED IN KUWAIT  | 29 |
| Appendix 7 | LIST OF PUBLICATIONS SUPPLIED WITH<br>THE TOP COPY OF THIS REPORT  | 30 |

1. INTRODUCTION

This report gives the results of the study of the design and production facilities at the Kuwait Aluminium Company during the first part of Post TF/KUW/81/001/11-51/31.8.A.

A study of the billet casting, extrusion and anodising facilities at the Arabian Light Metals Company, Kuwait, was made by consultant Dr. Imre Molnar and is the subject of a separate report.

The two studies were made simultaneously and there was liaison between the two consultants. The reports were written separately but are to be discussed and evaluated together during a further mission to Kuwait by both consultants and a staff member of the backstopping substantive section of UNIDO.

The project is governed by the Agreement between the Kuwait Aluminium Company and Arabian Light Metals Company and UNIDO signed on 8/30 December, 1981.

The consultant (for the Kuwait Aluminium Company) started briefing in Vienna on 7 December, arrived Kuwait 11 December and travelled back to UK on 22 December 1982.

The Terms of Reference for the post were given as follows:

"To study the design and production facilities of window frame and door production with the purpose to carry out a detailed analysis of existing designs, equipment and technology as compared with other solutions in this specific industrial branch with the purpose of preparing well justified conclusions and recommendations on the subject of

- Possibility of general improvement of the performance of the plant in all its stages of technology and production.
- Testing facilities and equipment to be selected or already selected for the products concerning heat penetration, dust penetration and resistance to wind pressure; elaboration of specification/standard for the above mentioned and possible other parameters to be introduced on standard testing prescriptions
- Selection/elaboration of the functional design system of window frame and door construction best suited for the conditions of Kuwait; prepare an action programme on the elaboration and introduction of the system selected."

(UNIDO Job Description)



2. COMMERCIAL CONSIDERATIONS

The main objective of the study is technical, being concerned with product design and manufacture. However, the technical considerations can not be examined in total isolation from the commercial considerations since the products must meet the requirements of the customers in the market in which the Company trades, and within the general commercial framework of Kuwait.

The main commercial or semi-commercial aspects which are relevant to the product are:-

- (a) The absence of National Standards for aluminium windows and doors
- (b) The absence of Company standards or 'preferred' products
- (c) Contract conditions affecting installation on sites.

Each of these points is examined separately, as follows.

3. NATIONAL STANDARDS

In relation to the absence in Kuwait of any fixed and applied National Standards for the specification of aluminium alloy windows and doors the following facts need to be considered.

Firstly, the Company is faced with various demands for special profile sizes and variations in wall thickness up to 4 mm. Relatively fine design details are also subject to the approval of architects and building consultants. The Company commonly changes the 'normal' product offer in order to meet these demands.

Secondly, the consultant has seen on the site of the Sabah Al-Salem Housing Project windows made by another company to a very low standard of quality using mill finish extrusions (i.e. not anodised). Presumably the Company has to compete on price with such products on some occasions, especially for smaller projects.

In the opinion of the consultant both situations result from the absence of any agreed and applied standard specification for windows and doors. The consultant's experience in Western European countries and North America is that there is a national standard in each country. Specifiers usually refer only to the national standard and do not attempt normally to write a quality standard into the bill of materials by the specification of wall thickness, type of seals or other design details.

The use of the standards also eliminates low-cost, low-quality products as a source of competition in the majority of competitive situations.

In the existing situation the Company derives considerable benefit from its ability to produce special extrusions, primarily in the situations where high specification special products are required for 'luxury' buildings. However, the disadvantages which the Company suffers as a result of continuous changes of product design are considerable in that the factory is effectively mostly making 'prototypes' rather than having a regular and organised production of established products which can be further developed.

The consultant recommends that the Company should, as the leading manufacturer in the Country, exert the maximum possible pressure by way of submissions or pleas, or other appropriate advances. to the responsible Government Departments on a continuous basis. If other leading manufacturers and trade associations can be enlisted to help to attain the objective the case for the adoption of National Standards will be strengthened, and the industry as a whole will benefit. Perhaps an "Association" of manufacturers is possible.

As an example a copy of the British Standard Specification for Aluminium Alloy Windows, BS 4873, is submitted with the top copy of this report. The specification defines minimum standards for every aspect of window design. The consultant does not recommend that BS 4873 would be appropriate for Kuwait since the climatic conditions are very different in Kuwait and UK. However, the British Standard illustrates the scope which could be appropriate for a national design standard.

There may be a lesson to be learned from the experiences of manufacturers in Europe and North America who, before their standards were widely adopted, attempted to secure advantages over their competitors in times of low demand by down-grading window and door designs to reduce costs. The "reduced wall thickness race" was an expensive experience.

A small survey was made of the various specifications issued with individual projects as listed in Appendix 1. The specifications differ in almost every aspect of product design. For example:

- (a) Extrusion wall thicknesses given for the four specifications examined are 1.2 mm minimum, 1.6 mm, 3.0 mm, none specified for the fourth project.
- (b) The air infiltration requirements, where given on three of the four projects, vary from 3 m<sup>3</sup>/m/hr to 12 m<sup>3</sup>/m/hr at pressures which vary between 7.7 Kg/m<sup>2</sup> and 10 Kg/m<sup>2</sup>. The units used also vary.
- (c) American, British, French and German standards are referred to. It appears that the specifications are either ignored altogether or only loosely applied, according to the situation.

Discussions were held with various Ministries and other bodies as listed in Appendix 2. Additionally the opinions of the other extruder (Alexco, Mr. S. Samih Aktar) in Kuwait were sought. A different opinion on the present and potential future development of National Standards was obtained from each.

4. COMPANY STANDARDS

As an outsider the consultant gained the first impression that the objective of the Company was to sell extrusions and that the manufacture of windows, doors and other products was simply a means to that end. The literature presently used by the Company illustrates a huge range of extrusions which can be assembled to produce many different product variations.

It seems logical that the Company's customers, especially the newer ones, will also have that impression.

It is a matter of opinion whether the Company actually contributes by this means to the problem of an excessive mix of work within the factory. The production problems which result from the great variety of products is certainly a "text book case" of too many items in the catalogue.

The Company is already in the process of producing sales promotional literature based on finished products rather than extrusions. The consultant recommends that this work should be treated as most important and be considered very carefully.

It was not possible in the time available to the consultant to undertake any type of market survey, nor was it part of the terms of reference, but the Company should have, or should obtain, the necessary information. On the basis of first impressions gained from a detailed examination of the projects listed in Appendix 3, and from the opinions of the directors and staff, it appears that a reasonable product offer for the Company would be:

- (a) A system similar to the present 110 mm sliding window and fixed frame system with the 53 mm casement window and door system. Some modifications to the seals used in the casement system and other features are recommended in later sections of this report. This system to be offered primarily for Government contracts.
- (b) A lighter sliding window and casement system based on the same design principles as the 110 mm system. This system is to replace all the present lighter systems. This system to be offered primarily for lower cost buildings, multiple housing projects, etc.

- (c) A new system to be used for swing door and fixed framing applications to replace the multiple section assemblies offered at present. The swing doors have a poor resistance to dust penetration but have application in enclosed areas of high (pedestrian) traffic.
- (d) The other products, screens, partitions, handrails, etc. not forming part of this study.

More detailed recommendations for each of these proposed systems are given in later sections of this report.

The consultant recommends that the definition of such product offers be considered by the Company to be the "preferred" production in order to concentrate the bulk of the demand into a smaller range of products.

The formulation of these standards or preferred products need not conflict in any way with the Company's ability to take orders for special products for luxury or other buildings provided that the selling prices are appropriate to the additional work involved.

A slight modification to the Company's approach to marketing is involved to generate the desire, as far as possible, for specifiers, architects and building consultants to use an established, tried and tested product rather than to "design" windows and doors for themselves using available extrusions.

It is not suggested that this policy be applied in any way to existing orders but that the principle be promoted for new projects not yet designed. The principle can never be 100% effective in that there will always be requirements for special features but every case where a preferred product is specified will contribute towards rationalisation of the factory. The ultimate objective should be to generate a sufficient demand for the preferred products to allow conventional production lines to be established which will achieve the economies of scale.

5. INSTALLATION METHODS

A number of different sites were seen during the study, as listed in Appendix 3.

It is the common practice of the Company to measure the finished openings on sites and to manufacture the windows and doors to the exact sizes required. The consultant has seen an example in the factory where a window was being made to slightly different widths at head and cill, and slightly different heights at the left and right jambs.

This practice compounds the problems in the factory caused by the large number of design variations. In many cases where numbers of windows are nominally identical the minor size variations involved result in virtually every window being different.

The consultant accepts the statement that at this moment in time the Company must accept the demands of the main contractors to manufacture windows to site measurements. However, the consultant offers the following argument for discussion:

- (a) Window manufacturers in other countries do not generally have to manufacture windows to site measurements.
- (b) In Kuwait, both air conditioners (in some cases) and windows are fitted in holes in walls. The air conditioner manufacturers can not adjust the outside dimensions of their products and the main contractor can not impose size adjustment requirements on them.
- (c) The same applies for fitted furniture, baths, cooker extractors and many other building components.
- (d) The concept of a "co-ordinating dimension" works in other countries. The nominal opening size is treated as a minimum for the main contractor and a maximum for the component supplier. The component thus must always "fit the hole" and the gap at the edge is the only variable.
- (e) The mastic joint between the window and the wall is more durable if it fills a gap of 5-10 mm rather than close fitting edges. The mastic pointing is less likely to fail if it has sufficient bulk to be flexible.

- (f) In most cases the internal joint between window and wall is hidden by an architrave, either separately applied or integral with the window. Any "gap" is not seen from inside.
- (g) In many cases the external joint between window and wall, if pointed with mastic, can be covered by the external finish of the building and is not unsightly.

The consultant argues that these statements indicate that the Company should work actively to secure sub-contract conditions which will make site measurement unnecessary at some future date, even if that can not be achieved immediately.

Some action can also be taken with product design to reduce the effect of this problem, as outlined in section 7 of this report.

The consultant accepts that there will be cases, such as the luxury residence listed in Appendix 1, where the flush marble openings for the windows demand special manufacture. This example does not detract from the main argument since special conditions can always apply provided that the selling price covers the additional costs involved.

No doubt the Company can only press for standard and equitable sub-contract conditions on an industry wide basis, so as not to affect its own competitive position.

In other countries a standard form of sub-contract has been negotiated which covers such items as the allowable tolerances on opening sizes and the payment to sub-contractors in the event of unreasonable errors occurring. At the same time such items as fixed price contracts without time limit, "pay-when-paid" clauses, unreasonable delays, payments for variations and increased costs have at least been moderated or eliminated to reduce the "gamble" of the architectural aluminium business.

6. MANUFACTURING FACILITIES

The consultant has examined the existing manufacturing facilities. The first impression is that the productivity is much lower than European or American factories, but the situations are not directly comparable. The problems of great variety of both types and sizes of products as described in the previous sections of this report leave the production management with no alternative to a "jobbing-shop" arrangement. The consultant can see no way that more efficient line production can be introduced at least until a reasonable demand for the proposed "preferred" products has been generated.

The Company's own records of the rate of production achieved during the manufacturing run of substantial numbers of similar windows for the Sabah Al-Salem Housing Project show the scale of improvement in productivity which can be achieved.

The on-going need for special products could be satisfied in parallel with line production of regular products without any great difficulty in the future.

The standard of most of the machines and equipment in the factory appears to be appropriate and no general up-grading of the technology is considered to be necessary. However, three points are worth considering:

- (a) The standard of the double mitre saws is below that now in common use in other countries. It is recommended that the Company should consider the purchase of an electronically controlled double mitre saw with readout. Such a machine is ideally suited to the situation where many changes of cut length are necessary. The operator "keys" the size required into the machine which then automatically moves to the desired dimension and displays the length selected. Good machines are available from West Germany from EISELE, ELU, RAPID and others.
- (b) At present the carbide tipped blades used for saws are used for as long as possible and then discarded without re-sharpening. The purchase of a blade sharpening machine (not to include tip welding) would enable saw blades to be kept sharp and produce better quality cuts. A significant saving would be made in the cost of replacement blades.



- (c) The consultant agrees with the Company's tentative plan to purchase a press brake to replace the existing sheet metal folding machine, provided that the demand for formed sheet metal is expected to continue at a reasonable level. An electronic safety device to protect the operator is a sensible feature to include when ordering such a machine.

7. PROPOSED PRODUCT STANDARD - 110 mm

It appears that a system similar to that used for Government projects based on the 110 mm frame section (P126A) and the 53 mm casement window and door sections (P123A etc.) and the sliding window sections (P102-8 etc.) should be the standard system for Government and similar projects.

The following modifications to the existing designs are recommended:

- (a) The gasket presently used with the casement window and door designs is poor. If the existing design is tested on the new test rig the air infiltration and water penetration will be found to be unacceptable. A new soft neoprene gasket is required with an overall dimension of at least 10 mm. The corners of the gasket should be mitred and joined with cyanoacrylate adhesive (e.g. Loctite IS 414). The gasket should be positioned such that external pressure on the window acts to close the seal. With this modification the products should have an air infiltration performance of less than  $0.3 \text{ m}^3/\text{m joint}/\text{hour}$  at a test pressure of  $20 \text{ Kg}/\text{m}^2$ , and no water penetration at this pressure. This should also result in the windows being virtually totally dust proof. Mr. Karu has a sample of a suitable gasket.
- (b) The appearance of the product is very much a matter of individual taste but some may consider that the present casement and door moving frame would have a better appearance if the step on the inside face were to be eliminated. Possibly the degree of etching of extrusions should also be increased to produce a more matt finish.
- (c) A fundamental problem of the existing system seems to be the lack of a coupling system. Long ranges of windows and doors are drawn as a continuous product. The addition

of a clamp mullion system similar to that included in the "Apollo" window brochure (Appendix 4) would provide the following important advantages.

- 1) The products would be separated into manageable units.
- 2) The mullions provide a means of adjustment of the total width of the unit to suit the building opening size tolerance.
- 3) The mullions act as expansion joints on long ranges of windows.

An "equal leg" outer frame must be used in conjunction with the clamp mullion, something similar to section P082.

- (d) A "reverse leg" pointing detail could reduce the problems involved with site measurement of openings. Appendix 5 shows the pointing detail between the window and the building structure commonly used in the UK. Appendix 6 shows the detail used in Kuwait. It can be seen that the finished appearance of the two details is almost identical. The UK detail includes a sufficient bulk of mastic to allow for small movements without breaking the seal. More importantly the UK detail can accommodate an error of at least 10 mm in the opening size without difficulty.
- (e) The sliding window will leak water at the ... at an estimated test pressure of about  $14 \text{ Kg/m}^2$ . This would be unacceptable in UK but may well be satisfactory in Kuwait. The present sliding window design should have a good air infiltration performance by sliding window standards, perhaps about  $3 \text{ m}^3/\text{m/hr}$  at  $20 \text{ Kg/m}^2$ .

It is recommended that a standard system to this specification be designed with all the necessary ancillaries of flyscreens, architraves, fixing details, etc. for discussion at the project review meeting.

8. PROPOSED PRODUCT STANDARD - LIGHT WINDOWS

The existing sections catalogue contains a very large range of 'lighter' sliding and casement windows. It is recommended that a single overall dimension (presumably about 85 mm or less for the sliding window) be selected and windows designed to be competitive on lower cost projects. It is assumed that only single glazed sliding and casement windows are required for this product.

9. PROPOSED PRODUCT STANDARD - ENTRANCE UNITS

It appears from the projects studied that a reasonable demand exists for entrance units with swing doors. The Multi-Storey Car Park 2 for the Kuwait International Investment Company is an example. The doors which separate the first floor reception area from the staircase at the Company's offices are another example.

This type of product is used in many countries in situations where there is a high pedestrian traffic density. The doors have a poor resistance to air and water penetration by virtue of their design and so they are particularly applicable in internal situations. Normally the doors are used in conjunction with fixed glazed screens without ventilators.

It is recommended that a new product be considered specially to suit this application. The present arrangement which assembles a large number of separate extrusions has a high labour content and may be considered to be untidy in appearance.

The brochure for the UK "Slimline" system is enclosed as an example with the top copy of this report. There are many other similar systems.

10. CONTROL SYSTEMS

The documents presently used to control manufacture appear to be sensible, simple and effective. Since no problems were reported in this area, nor with stock control, no great amount of time was spent on the subject.

The main control system which the Company appears to lack is the allocation of the forward load on the factory. The principle of "shadow and firm" loading is commonly used in other countries and may be applicable in Kuwait. This subject is most important when penalties are applied for late delivery to sites caused by factory overloads.

The Company's computer systems are in their early stages of development but the systems are complicated by the product variety. The computer will be more readily applicable to the standard product offer and can be applied from costing right through to the production of works documents, glass orders, etc.

11. PRODUCT STRENGTH - RESISTANCE TO WIND LOADS

At present the Company makes no design calculations for the strength of its products and leaves this work to the building designers.

If the Company is to promote finished products as opposed to extrusions in the future then it is recommended that the standard product literature should be supported by maximum span and spacing information to enhance the image of the products.

The method of calculation of wind loads varies slightly from country to country. The UK method used by window manufacturers to calculate the strength requirements for their windows is given in the British Standards Institution publication DD4:1971, supplied with the top copy of this report. The calculations required are quite simple. They are a simplified version of the full calculation method specified in BS CP3 Chapter V:Part 2:1972 (not supplied with this report). It should be noted that DD4:1971 is referred to in the latest specification from The Ministry of Public Buildings and Works for the Kuwait Waterfront Project.

Loads transmitted to mullions and transoms are calculated by the "trapezoidal loading" method and the following limits are commonly applied:

- (a) Bars supporting glass should have a deflection which does not exceed the following fraction of the span

$$\frac{1}{125} \text{ for single glass}$$

$$\frac{1}{175} \text{ for double glazed units}$$

- (b) The permissible stress in bending of the aluminium should not be exceeded. This limit is not usually reached before the deflection limit but must be checked, especially on deep sections.

The glass strength needs to be determined separately from the frame strength. The normal method is to read the required glass thickness from graphs produced by the glass manufacturer.

12. WATER PENETRATION AND AIR INFILTRATION

The Company has purchased test equipment which the consultant agrees should cover all requirements for testing of the products. The equipment ordered will test for strength as well as water penetration and air infiltration. The equipment ordered will also test for resistance to pulsating loads, which is applied in some countries but not universally.

The UK method of testing is described in British Standard 4315: Part 1: 1968 which is enclosed with the top copy of this report.

While the method of testing could follow the British, or other similar method, the performance standards required of the product must be suitable for the climate of Kuwait.

Europe suffers many rainstorms which demand a high resistance to water penetration. This does not apply in Kuwait to the same degree.

The severe problem of dust infiltration found in Kuwait does not apply in Europe. In order to prevent dust infiltration, the air infiltration performance of the products must be higher than the European standards.

The following performance standards should be suitable for the climate in Kuwait and could be used to evaluate product tests and define the amount of product development necessary in advance of any National Standards being agreed.

Water Penetration : No gross leakage when tested by  
the method described in BS 4315:  
Part 1:1968 at a pressure of  
1" (10 mm of water)

Air Infiltration : leakage of 1 m<sup>3</sup>/m/hr at  
of 20 Kg/m<sup>2</sup>



With a change of design of the gaskets the existing casement window should meet these standards.

The sliding window should meet the water penetration standard but it is unlikely that it can be made to reach the air performance standard because of the unavoidable gap which must exist at the top and bottom of the meeting rails.

13. ACOUSTIC AND THERMAL PERFORMANCE

No consideration seems to have been given in Kuwait to the acoustic performance of windows and the control of noise entering buildings from outside. This is surprising when residences are built to a very high standard close to busy roads.

The recommended maximum noise levels for rooms in the UK is

|                 |       |
|-----------------|-------|
| Conference room | 30 dB |
| Bedroom         | 35 dB |
| Private office  | 50 dB |

Traffic noise is mainly low frequency at a pressure level of about 75-80 dB.

A window with 6 mm glass produces an insulation of 20-25 dB depending on frequency and is worse for frequencies of less than 200 Hz.

Provided that the window does not have an excessive air leakage the design of the frame will not affect the sound insulation since the noise comes through the glass.

The noise insulation of a single glazed window is not improved significantly by using a double glass unit if the air space between the two panes of glass is less than 50 mm.

Two separate single glazed windows fitted as a double window with an air space of 150-300 mm between them and with insulating material on the edges of the cavity will produce a sound insulation of 40-45 dB provided that the air performance of the individual windows is good.

A double window can be more effectively sealed against dust penetration since two lines of seals are involved.

A double window is also a "thermal break" window in that the internal and external aluminium frames are not connected.

Double windows thus have considerable advantages and it is recommended that the Company should be aware of their potential suitability for Kuwait.

It is usual in Europe to make the internal window of a double window as a horizontal sliding window with very light low cost frames and no lock. The "secondary windows" are thus very low cost windows not suitable for fitting as prime windows.

There has been considerable discussion of the possible use of thermal break extrusions for windows in Kuwait. These extrusions contain an integral plastic separator in the extrusions to reduce the thermal conductivity of the sections.

In cold countries thermal break windows are used mainly to prevent the condensation which otherwise occurs on cold frames. This problem does not exist in Kuwait.

The potential use of thermal break sections to reduce air conditioner power consumption is questionable since the area of window frames is very small compared to the total area of the building. Mr. Allison at The Kuwait Institute for Scientific Research is preparing to investigate this subject but has no firm views at the time of this report.

There is thus no means of knowing if there will be any real demand for thermal break windows in Kuwait. They will probably not be justified on economic grounds but may be specified anyway. One project has already been specified to use thermal break sections although the requirement was later cancelled.

Unfortunately the Company cannot finalise its longer term product design policy until the thermal break question is answered. It would not be sensible to complicate the design of the products and suffer the increased costs involved and invest in the relatively expensive plant and equipment required until the market requirement is known.

The case for using sealed double glazed units is clearer. A double glass unit with a 6 mm air space will transmit about 61% of the heat passing through single glass under normal shaded conditions. Increasing the air space from 6 mm to 12 mm will reduce the percentage to about 54%.

Solar control glass and external shades for windows both reduce the heat entering the building by the "greenhouse effect" of solar gain. It is up to the architect rather than the Company to specify these features, both of which are in use in some buildings in Kuwait.

Aluminium which is exposed to strong sunlight will reach a high surface temperature, especially if it is finished in a dark, matt colour. Care needs to be taken with the use of small plastic components which soften at fairly low temperatures in this situation. Similarly, provision must be made for expansion in long ranges of windows and a clamp mullion is particularly suited for this purpose.

The final aspect of the thermal performance of windows which needs to be considered is the air leakage of the windows causing increased air conditioner loads by allowing hot air to enter the building. The Kuwait Institute for Scientific Research are considering the recommendation of air control as low as one air change per hour. This would give preference to casement windows because of their inherently better air performance, or simply to reduce the proportion of the total windows in an air conditioned building which can be opened at all.

14. CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the Company take action on the following subjects, as detailed in the body of this report.

1. Exert the maximum possible pressure for the adoption of National Standards for the basic design features of aluminium windows and doors.
2. Conduct a proper market survey to establish, as far as possible, the precise requirements for:
  - a) A main 110 mm product
  - b) A lighter product for housing, etc.
3. Select and promote preferred products based on existing designs slightly modified. Produce sales promotional material based on finished products rather than extrusions.
4. Consider the need for swing doors and fixed entrance units as a separate product.
5. Attempt to negotiate installation conditions based on the co-ordinating line principle.
6. Consider a new pointing detail to increase the allowable tolerance on finished openings and reduce the need for site measurement.
7. Consider the incorporation of a clamp mullion system in the preferred product range to simplify installation, to sub-divide large products into manageable units and to provide allowance for thermal expansion.
8. Consider the purchase of a new electronically controlled double mitre saw from Germany.
9. Consider the purchase of a saw blade sharpening machine.

10. Look at improved methods of factory forward load control.
11. Decide performance standards to which the preferred products will be developed using the new test equipment.
12. Examine the possibilities for secondary windows for:
  - a) An alternative to thermal break
  - b) The up-grading of existing buildings
  - c) Dust penetration
  - d) Acoustic performance
13. Obtain more information on the requirements for thermal break extrusions before investing in capital equipment or complicating designs and increasing costs.
14. Try to form an association of manufacturers to tackle common problems on an industry wide basis.

APPENDIX 1

EXAMPLES OF SPECIFICATIONS ISSUED FOR PROJECTS

Shuaiba Harbour Facilities (Ministry of Defence Specification)

Refers to American specifications for aluminium and German specifications for glass.

1.6 mm extrusion wall thickness specified.

Thermal break specified but deleted later.

Test for air and water penetration at 40 Km/h (equivalent to 7.7 Kg/m<sup>2</sup>). Air infiltration 0.5 m<sup>3</sup>/m/min (equivalent to 30 m<sup>3</sup>/m/hr).

Augellah Housing Project (National Housing Authority Specification)

Refers to British specifications.

Site windspeed specified as 40 m/sec.

No test requirement specified but 40 m/s is equivalent to 12 m<sup>3</sup>/m/hr at 10 Kg/m<sup>2</sup> air leakage by British Standards (lowest BS category).

National Museum Project (Ministry of Public Buildings and Works Spec'n)

Refers to British Standards for aluminium (French for steel).

3 mm extrusion wall thickness specified.

No performance standard specified.

Kuwait Waterfront Project (Ministry of Public Buildings and Works (new) Spec'n)

Refers to British and American Standards.

Site windload given as 1112 N/m<sup>2</sup> (equivalent to 113 Kg/m<sup>2</sup>).

Air leakage per BS DD4 12 m<sup>3</sup>/m/hr at 10 Kg/m<sup>2</sup>.

Test certificates required to prove performance.

Construction per BS 4873:1972 (specifies 1.2 mm minimum wall thickness).

APPENDIX 2

MINISTRIES AND OTHER BODIES CONTACTED

Ministry of Public Works,  
Design Office for doors and windows  
Engineer Abduraheem Al-Khateeb

Ministry of Electricity and Water,  
Architectural Expert  
Engineer Fawzi Fouad

Kuwait Institute for Scientific Research,  
Energy Conservation Office  
Mr. Allison

The Kuwaiti Association For Construction Trade and Industry,  
General Director  
Mr. Ahmed M. Elsheikh  
(also for the monthly journal "Construction Kuwait")

Kuwaiti Engineer's Office  
Deputy Managing Director  
Mr. Fathi Al Badri



APPENDIX 3

LIST OF PROJECTS STUDIED

Sabah Al-Salem Housing Project

Al-Adan Hospital, Fahaheel

Residence for H.E. Sheikha Sheikha Al Ali Al Sabah

Multi Storey Car Park 2 for Kuwait International Investment Company

Sief Palace Area Building

- \* Schools Health Education Centre, Shamiya
- \* Harbour Buildings, Shuaiba
- \* Project for Abdul Aziz Al Rajab, Riyadh, Saudi Arabia (doors only)
- \* 15th Brigade Army Camp
- \* Doha East R.O. Pilot Plant
- Kuwait Towers (visit only)

In the time available for the study, some projects were examined in greater detail than others.

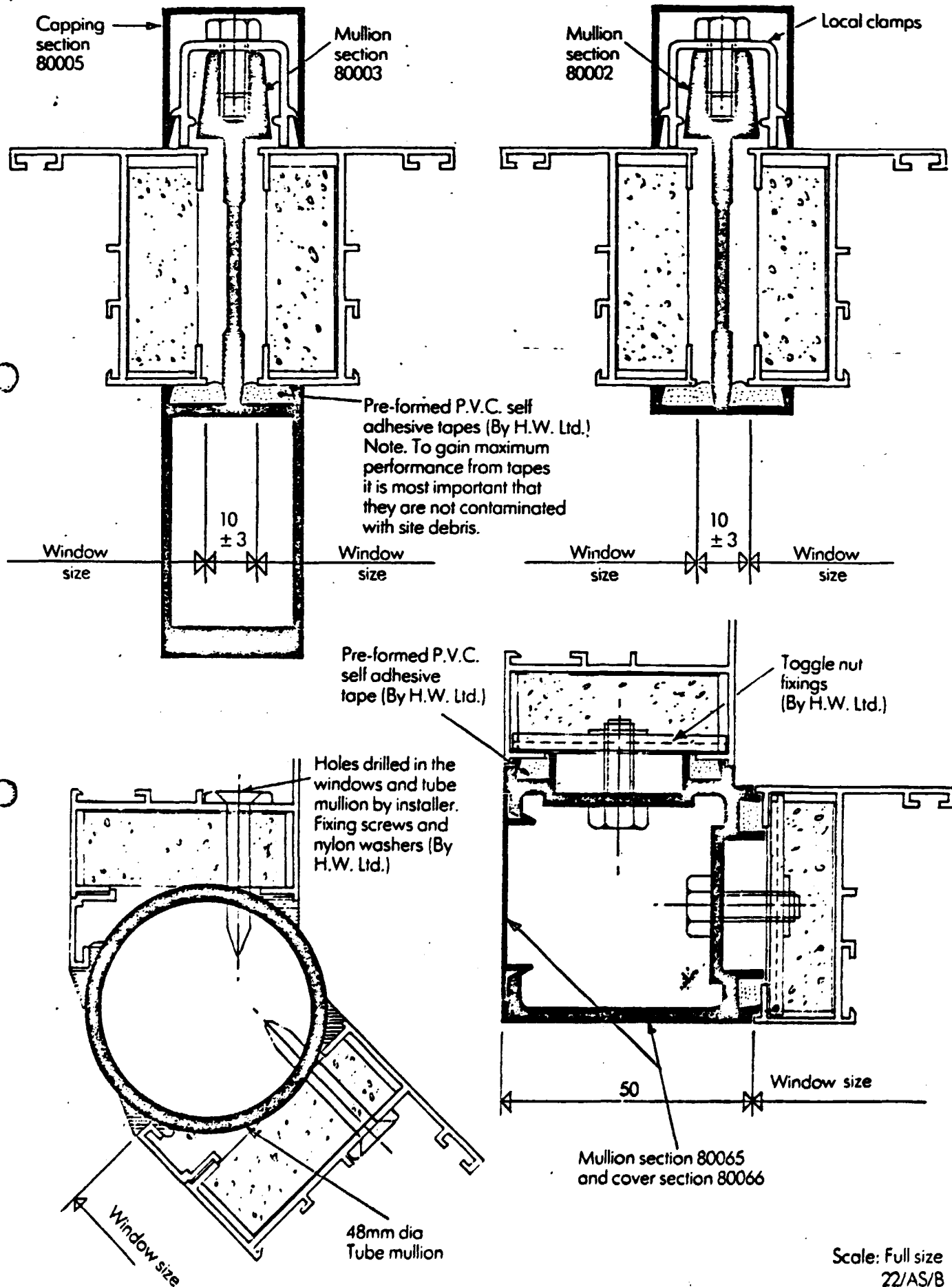
\* indicates examination of drawings only - no site visit

# Coupling Mullions for Site Assembly

apollo windows

APPENDIX 4

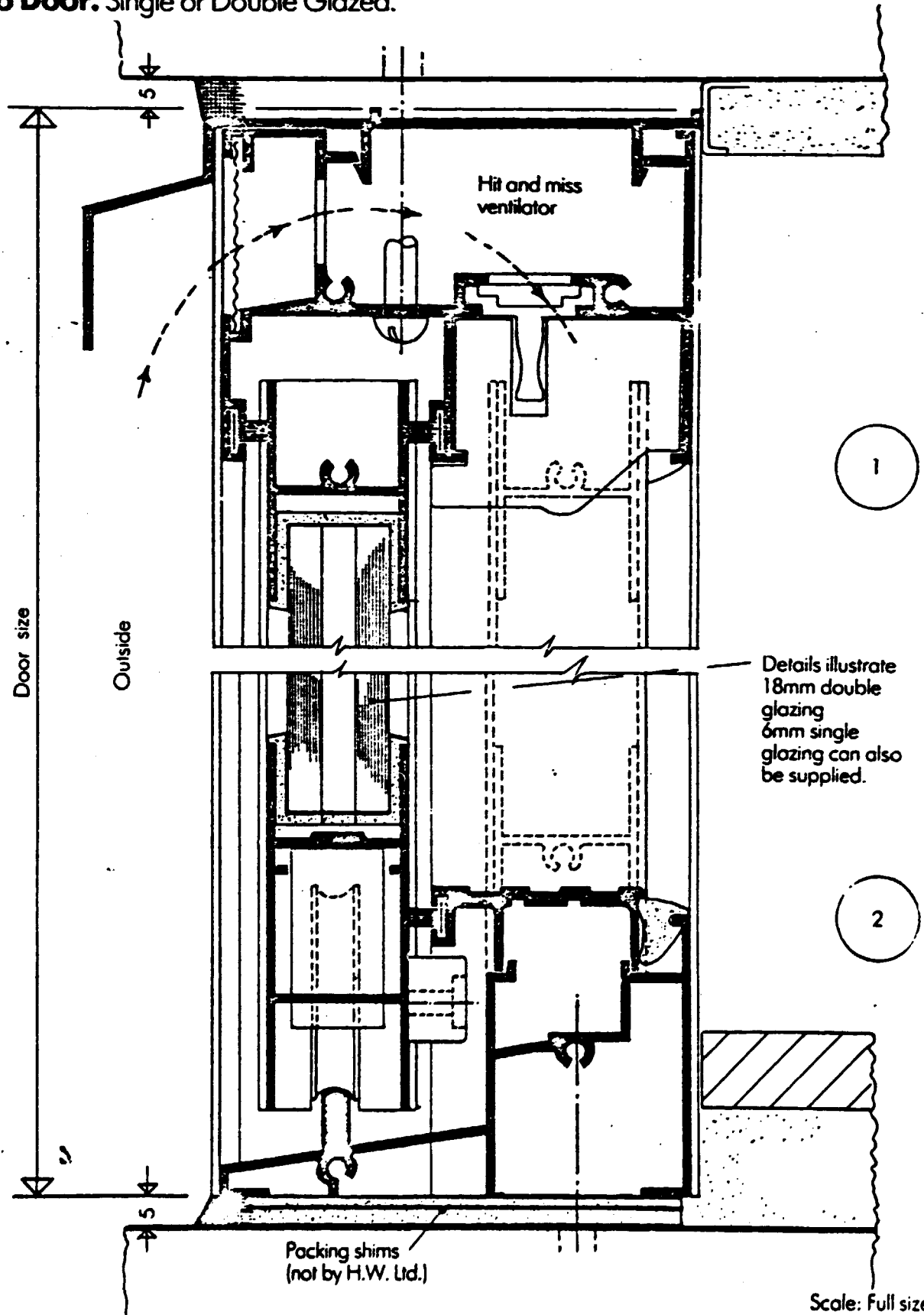
Inside.



Scale: Full size  
22/AS/B

# apollo windows Patio Doors

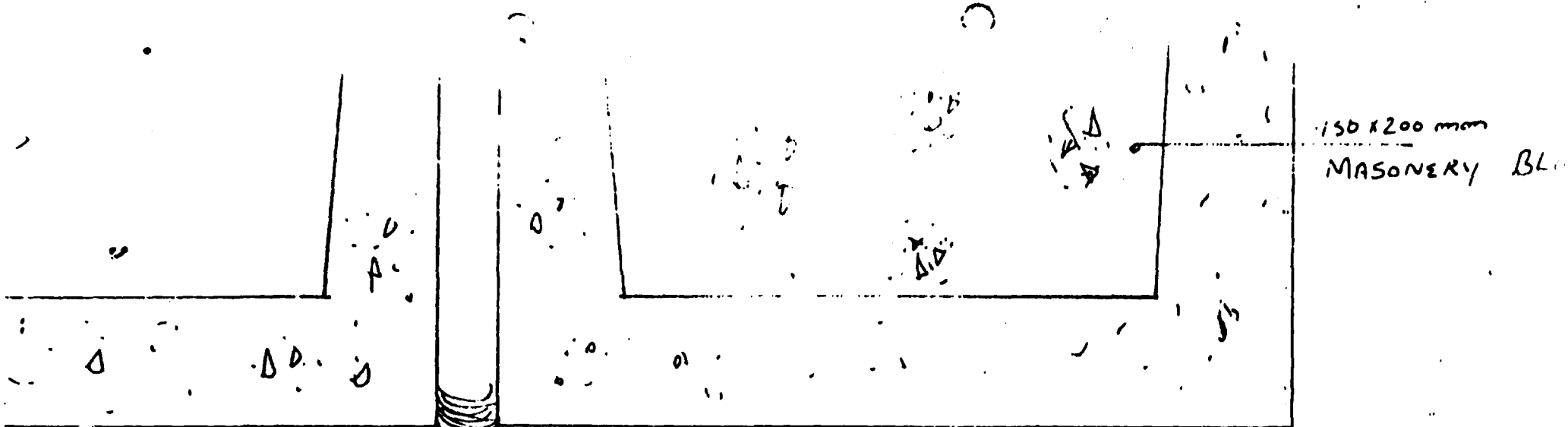
Patio Door. Single or Double Glazed.



Details illustrate  
18mm double  
glazing  
6mm single  
glazing can also  
be supplied.

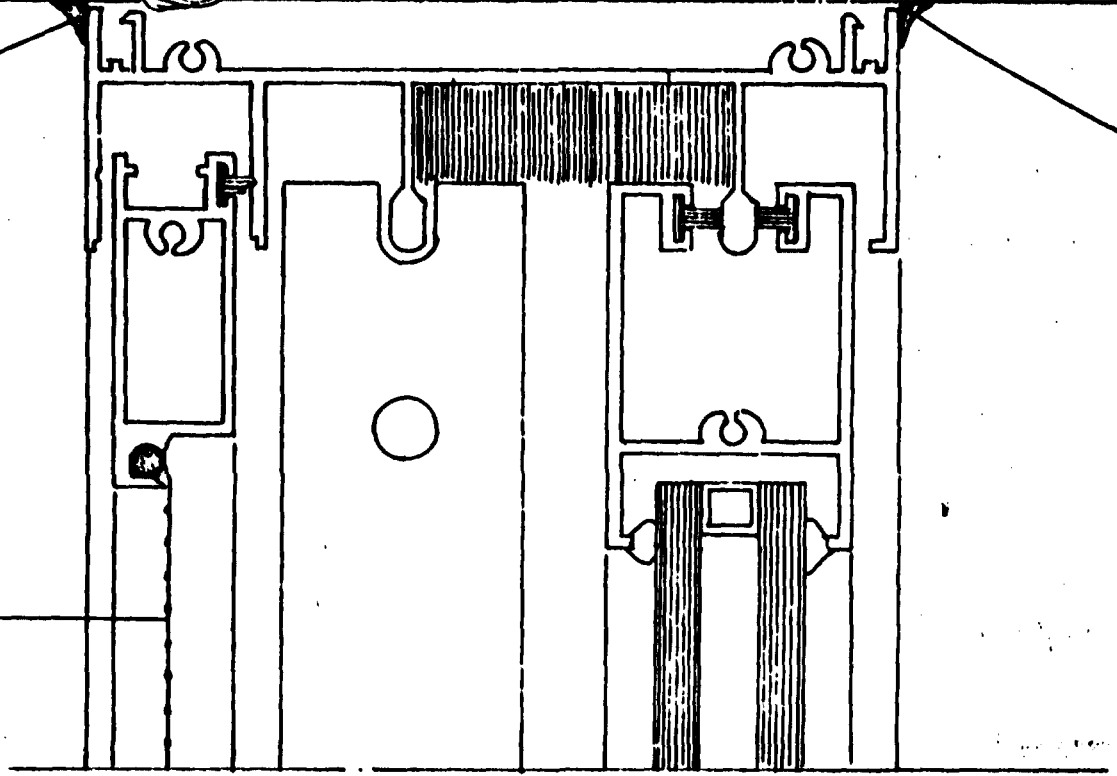
Packing shims  
(not by H.W. Ltd.)

Scale: Full size  
22/PD/A.



SEALANT.

SEALANT.



FLY SCREEN

HEAD DETAIL  
scale . 1:1

APPENDIX 7

LIST OF PUBLICATIONS SUPPLIED WITH THE TOP COPY OF THIS REPORT

British Standards Institution Specification for Aluminium Alloy Windows BS 4873:1972

British Standard 4315:Part 1:1968. Methods of Test for Resistance to Air and Water Penetration. Part 1. Windows and Gasket Glazing Systems.

British Standards Institution Draft for Development DD4:1971. Recommendations for the Grading of Windows. Resistance to Wind Loads, Air Infiltration and Water Penetration, and with Notes on Window Security.

Product Brochures for "Slimline" Doors, Screens and Shopfronts by James Gibbons Windows Limited, Wolverhampton, UK.



U  
NO. 173: 1972  
UDC 620.1: 659.715

Specification for  
Aluminium alloy  
windows

Presented with the compliments of the  
British Standards Institution

BRITISH STANDARD 4315 : Part 1 : 1968

UDC 69.028.29 : 698.3 : 620.193

METHODS OF TEST FOR  
RESISTANCE TO AIR  
AND WATER PENETRATION

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glazing systems

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