

KEY TO ILLUSTRATIONS

THE SAME NUMBERS AND INDEXES ARE USED IN ALL FIGURES THROUGHOUT THIS HANDBOOK

H = Vertical distance between cladding grid lines; H1 = Height of finished panel
L = Horizontal distance between cladding grid lines; L1 = Width of finished panel
h = Distance between horizontal scorings = H1 - 4 mm
l = Distance between vertical scorings = L1 - 4 mm

- 1) Thickness of Mirawall sheet
- 2) Residual thickness after scoring
- 3) Vertical side folds
- 4) Horizontal lower fold
- 5) Horizontal upper fold
- 6) Horizontal upper 2nd fold
- 7) Cut off step at lower end of vertical folds (to permit overlapping)
- 8) Extra width of vertical fold beyond horizontal fold
- 9) Top hook
- 10) Bottom hook. This bottom hooking should not bear on its pin but should have a 2-mm clearance. Conversely, the top hook should fit tightly onto its pin, to resist stress and vibration.
- 11) Mullion bar of the load bearing structure. Normally, 6060 alloy U-shaped extrusion, 40≈50 X 40≈50 X 2≈4 mm
- 12) Panel joint width (gridlines)
- 13) Overlapping of upper panel on lower panel
- 14) Panel axis (for architectural grid line scheme)
- 15) Clearance between vertical mullion bar and insulating panels (for plane alignment)
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10 mm wide slots against the wall, for horizontal alignment. Twin slots (8 mm wide, ≈60 mm long) on protruding wing for depth alignment (perpendicular to the wall).
Material: steel, hot galvanized after cutting and working.
Bolts (fig. 9a) should be stainless TAM8 (Fischer) for concrete and masonry. Stainless FB can be used as an alternative on concrete. 8MA thread should be used with TAM 8.
 - 17b) L-anchor mm 60X40X5X100 (height) with 6 MA threaded holes for blocking of depth alignment, with twin slots on the longer wing for the second horizontal alignment to be carried out when fixing the mullions.
Through these slots pass the 6 MA screws for fixing the mullion and setting the vertical alignment.
Material: steel, hot galvanized after cutting and working (the threads need rethreading after galvanizing).
2 threaded 6 MA bolts with split washers. 2 stainless 6 MA screws with tab washers and stainless nuts on back.
 - 17c) Insulating gasket to prevent electrochemical corrosion between steel (17b) and aluminium mullion (11), with horizontal slots as (17b). Plastic material.
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INTRODUCTION

The ventilated wall is the most effective energy-saving design of the building envelope. An airspace between the cladding (see left) provides improved thermal insulation both in summer (above) and in winter (below). Insulation against the primary wall improves the performance if required.

A great number of ventilated wall systems have been proposed, some of them quite sophisticated.

The simplest and most time-honoured system uses aluminium sheet as the external cladding in the shape of "cassette" or "tray" panels, simply hung to mullions on the wall (described within).

Powder Coil Coated thick aluminium (Mirawall) is the simplest and most effective material for this basic cladding design.

This handbook has been produced by Otefal, the world leader in powder coil coating, as a first guidance to the use of this new exciting material in ventilated walls for new buildings or for renovation.

Those experienced in rainscreen and curtainwall techniques may use Mirawall in many other ways, but newcomers may take advantage of the information compiled in this document from experienced sources.

MIRASYSTEM

BASIC SYSTEM FOR VENTILATED FACADE CLADDING WITH MIRAWALL SOLID ALUMINIUM PANELS

1 SCOPE

This document presents the suggested manufacturing and installation procedures for exterior wall cladding using the "Mirasystem"A" technology. The main feature of Mirasystem"A" is the use of Mirawall, a special grade of thick, solid aluminium sheet finished by the PCC (Powder Coil Coating) process developed by Otefal.

1.1 Mirawall as an exterior cladding material

Mirasystem"A" is probably the simplest among the many systems available today for rain-screens and ventilated claddings in the building trade.

Most positive features of Mirasystem"A" arise from the use of Mirawall sheet, which has the following advantages:

- Panels fabricated from the precoated sheet are immediately ready for installation;
- Panel fabrication is easier and less expensive than with composite materials (e.g. Aluco-bond);
- Extra thickness of the coating (60-80 µm) ensures full protection of worked surfaces;
- A wide range of weather-resistant colours is available.

1.2. The Hung Cassette ("Tray") Principle

The basic components of a Mirasystem"A" cladding (**Fig. 3**) are "cassette" or "tray" panels fabricated from thick (2-3 mm) Mirawall sheet.

The Mirawall panels are carried by U-section mullions anchored to a masonry or concrete "primary wall".

A 20-70 mm wide air space between the exterior cladding and the primary wall is characteristic of the ventilated wall principle. This is most frequently partially filled by a layer of insulation (not shown in **Fig. 3**) fastened to the primary wall.

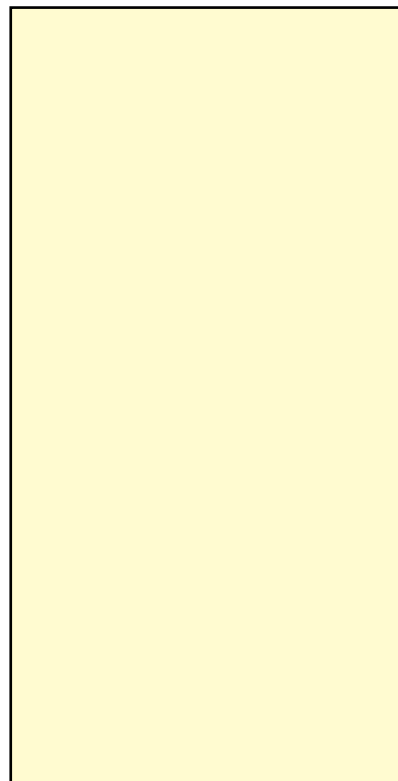


Fig. 1 - The FIM Tower in Warsaw (left) and the basic section of the hung panel system (Per-masteelisa) using "granite" colour Mirawall cladding sheet

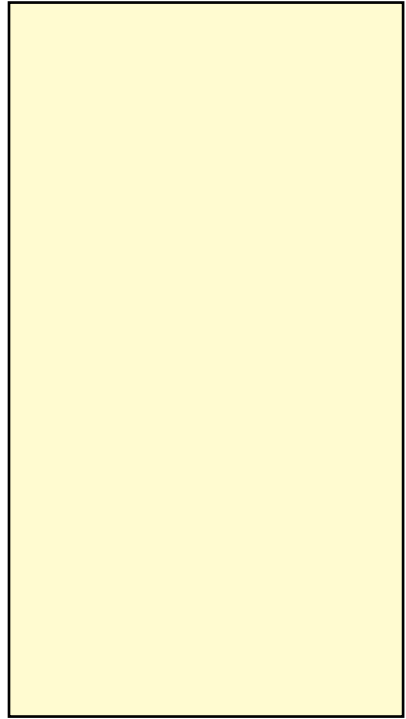
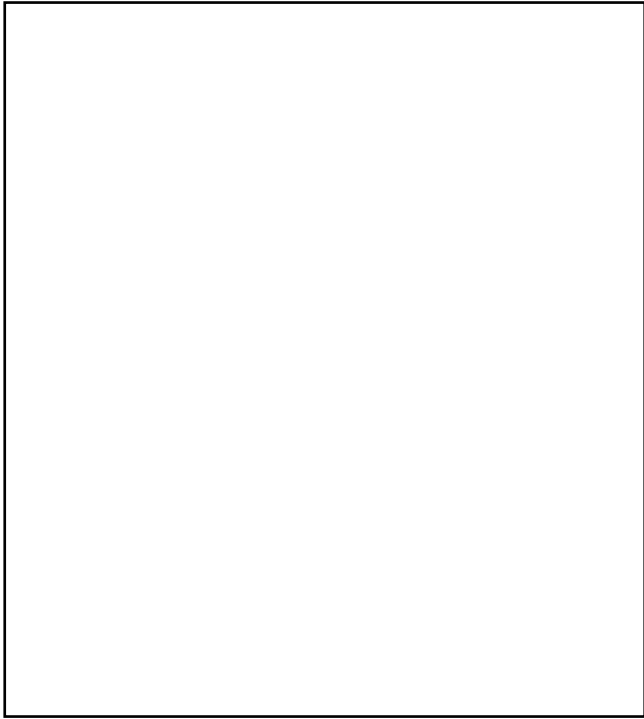


Fig. 2 - A simple "Hung Cassette" Mirawall cladding on a shopping mall facade (left) and its vertical section design (Tecnoalmet).
1 = Mirawall cassette panel (Rainscreen);
2 = Mullion;
3 = Wall anchor

The panels are connected to the mullions by hook-shaped slots, blanked from the side folds of the cassette shape.

Mirasystem "A", in its basic version, is not a totally air and watertight cladding. Absolute tightness is not essential for rainscreen and ventilation functions, provided that any small amount

of infiltrated water can be collected, drained away, or evaporated, as is normally the case for Mirasystem "A" in non-extreme environments.

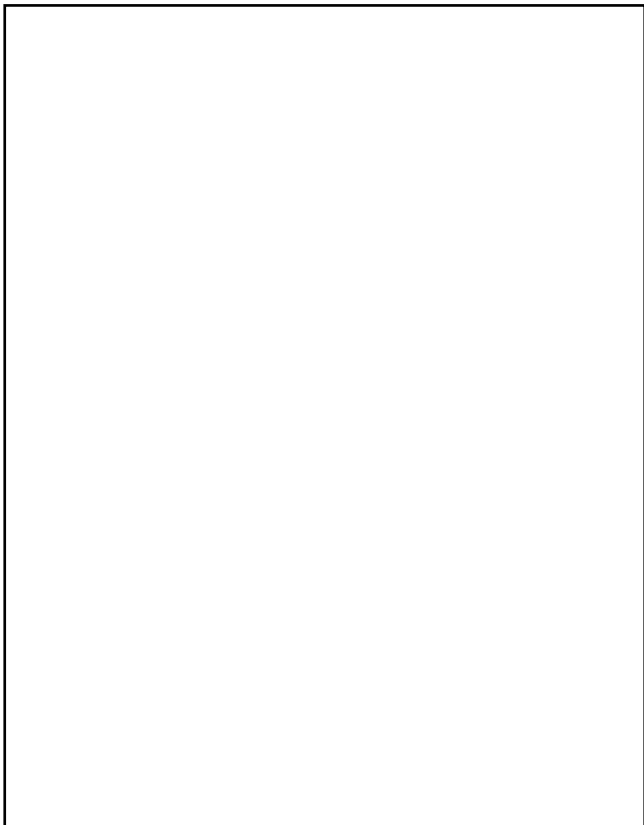


Fig. 3 - Basic design of Mirasystem "A" (without insulating panels)

2 BASIC SCHEMES OF MIRASYSTEM "A"

2.1. The panel

The basic component of Mirasystem "A" is the panel fabricated from Mirawall thick aluminium sheet.

Fig. 4 shows the main features of a 1000 X 1200 mm panel made from 3 mm sheet, and its fabrication sequence by the most elementary process of hand folding. Details of this and other folding processes are in Chapter 5.

In short, folding must be preceded by cutting or blanking of the corners as required for any "box" shape (Chapter 5.1.). For very thick metal as in the example, folding by hand or by a folding machine also requires scoring, routing or milling on the

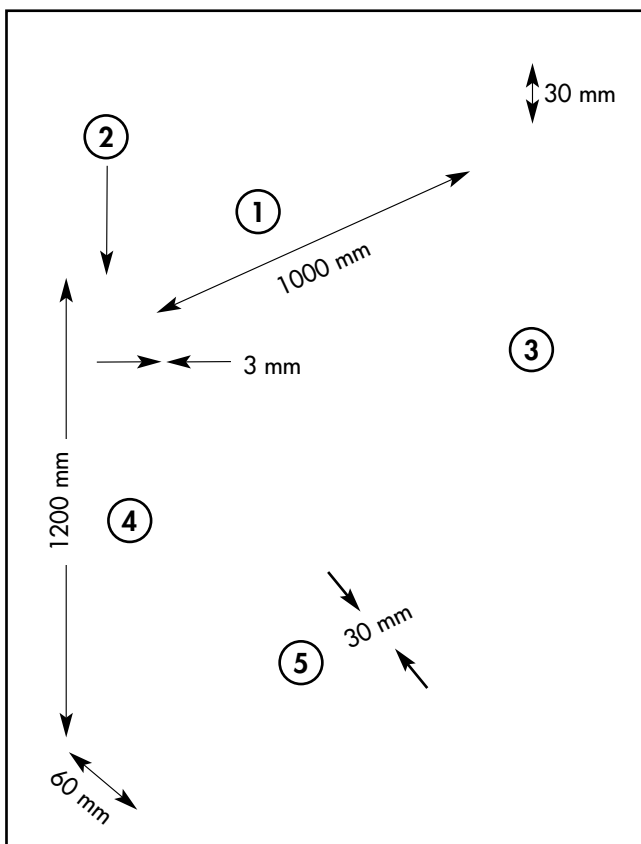
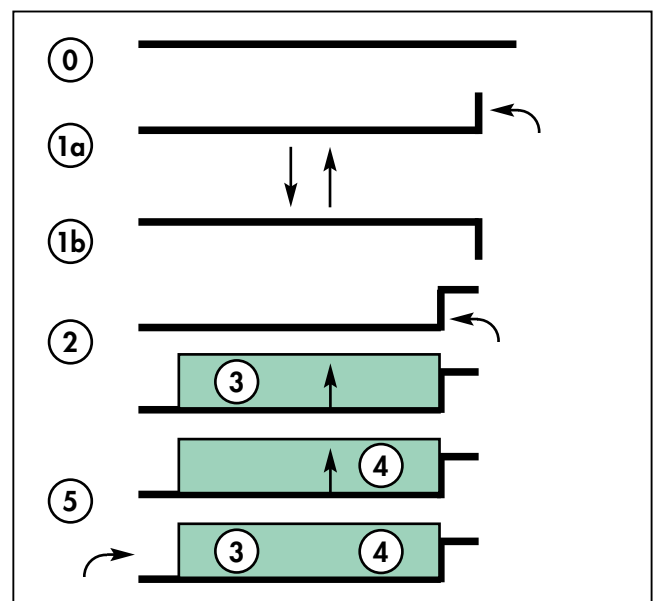


Fig. 4) - Hand folding sequence of Mirasystem panels (see Chap. 5)

back along the folding lines, so causing thickness to be locally reduced to 1,2 - 1,5 mm. This permits straight sharp-radiused folds to be produced and makes hand folding possible with the help of simple leverage equipment (Chapter 5.2.1)

Bending in a hydraulic brake press is also possible, and in such a case the back scoring may be omitted as discussed in Chapter 5.2.3.



Folding steps:

0 = Original Mirawall 30 sheet,
1060 X 1320 X 3 mm, pre-punched
and back-scored, exterior face
downwards

1a = First bend of shorter top side

1b = The sheet is reversed, exterior face
upwards

2 = Second bend of top side

3 = Bend of first longer side

4 = Bend of second longer side

5 = Bend of bottom side

2.2. Connection to the primary wall

The Mirawall panels are connected to the mullions supported by adjustable anchors fastened to the wall. Details in **Figs. 6 to 12**, and **Fig. 5** are schematic views of a cladding with outside and inside corners.

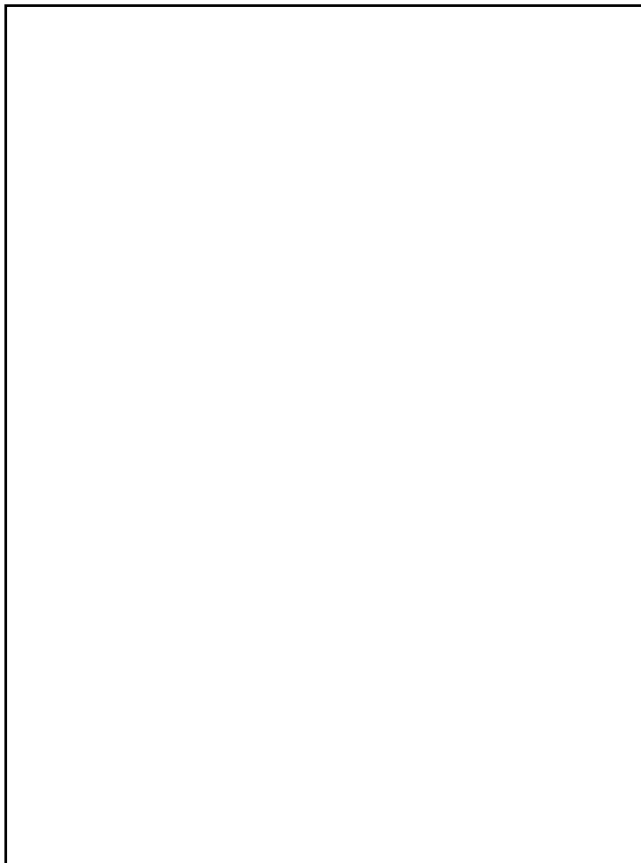


Fig. 5 - Mirasystem "A" cladding with inside and outside corners

A complete Mirasystem "A" cladding will normally include the layer of insulation panels fastened to the primary wall: this insulation layer, in combination with the ventilated airspace, causes a very remarkable improvement in thermal efficiency (lowering of the K heat transmission coefficient), in addition to the aesthetical renovation of the building.

2.3. System features

The basic features of Mirasystem "A" are presented in **Figs. 6 to 9**. Details and components are numbered in sequence, and the same numbers are used for the same items throughout this handbook.

NOTE: A comprehensive list of full items descriptions can be found on the cover flaps.

The main subjects to be dealt with in the case of Mirasystem "A" (as for any system in general) are the following:

- The basic design (Chap. 2.3.1.)
- Top closure (connection to the roofing Chap. 2.3.2.)
- Bottom closure (Chap. 2.3.3.)
- Side closure (Chap. 2.3.4.)
- Inside and outside corners (Chap. 2.3.5., 2.3.6.)
- Rounded claddings (Chap. 2.3.7.)

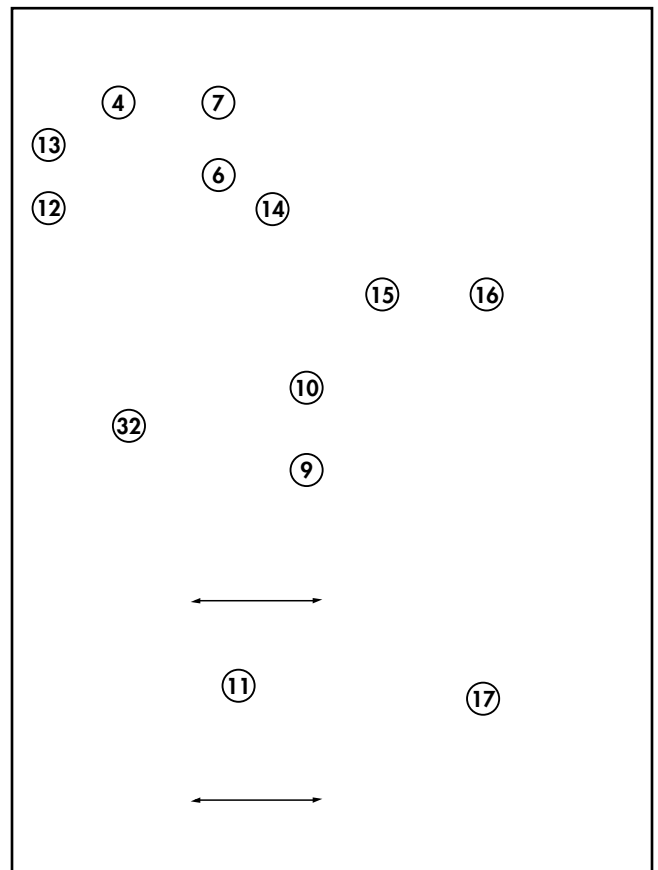


Fig. 6 - Vertical section of Mirasystem "A"

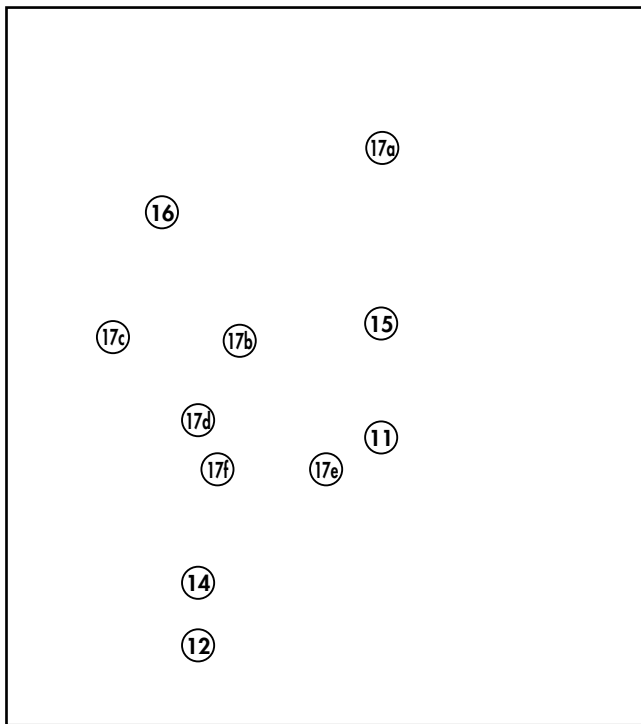


Fig. 7 - Horizontal section of Mirasystem "A" assembly

- Window incorporation (Chap. 3.)
- Components (Chap. 4.)
- Mechanical working (Chap. 5.)
- Installation (Chap. 6.)
- Alignment of the facade (Chap. 6.1.)
- Other subjects, such as behaviour in time, static - dynamic dimensioning, expansion, and water flushing, are not dealt in detail in this description of the basic system and should be considered separately with expert designer advice.

2.3.1. The Basic Design

The Mirasystem "A" cladding is composed of vertical ranges of overlapping panels. Observing **Figs. 6 to 9**, its main features to be considered are as follows:

- the shape of the panels (Chap. 4.4.6.)
- the bearing structure Chap. 2.3.1.)
- the architectural grid pattern (Chap. 3.1.)
- the air space (Chap. 2.3.)
- the insulation panels against the wall (Chap. 4.3.)
- the 3-dimensional alignment devices (Chap. 2.3.1., 4.)

The "cassette" or "tray" panels have vertical folds (3) -**Fig. 8**- wider than horizontal folds (4, 5), so that the hooks 9, 10 (blacked out of the vertical folds) can be hung onto the horizontal pins (17e) positioned on the load bearing mullions (11).

By using wider vertical folds, there is no need to cut the mullions to accommodate the horizontal folds. This is considered a simpler and stronger solution compared to alternative designs with protruding hooks riveted to the panel sides (see 4.4.6.). The different ways in which the panels can be made (metal thickness, corner joints, bending techniques) are presented in Chapter 4.

Panels may have extra hooks between those at the top and the bottom, for improved mechanical resistance, depending on the panel size and local conditions as set out in chapters 4.4.1, 4.4.2. Hook dimensions (9), (10) in **Figs. 6 to 9** usually are as shown in the sketch on the next page. High wind forces require wider hooks, and may be calculated for each case.

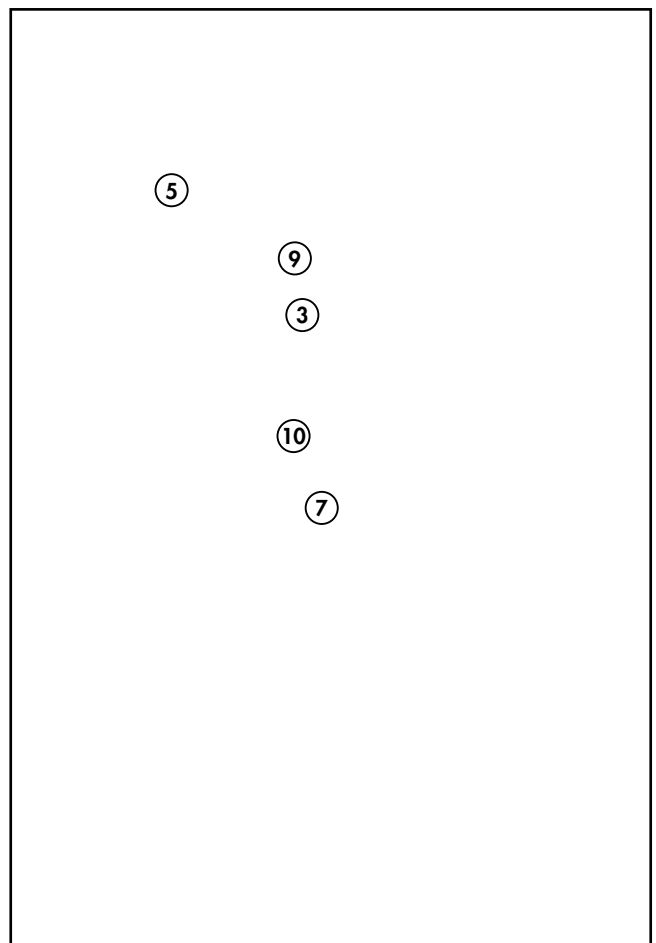


Fig. 8 - Prospect view of Mirasystem "A" assembly

The top hook is 1 ~ 2 mm wider than the diameter of the pin-gasket assembly. Such side clearance is suggested to facilitate installation of the panels. However, no clearance should be allowed between hook top and pin, so that the head of the hook bears firmly on its support.

In contrast to the top hook, the bottom hook should not have its head tightly pressed against its pin, but a 2 mm clearance should be allowed in order to permit thermal expansion.

Detail 7 in **Figs. 8 and 9** shows how the bottoms of the vertical folds of the panel are cut off in order to permit overlapping of the panels.

The bearing structure is composed of the vertical U-shaped mullions (detail 11), the stainless steel pins (17e, 17f), and the adjustable anchors (17a, 17b) that fix the cladding to the wall.

The width of the joint between panels (detail 12) obviously depends on panel dimensions and distance between the mullions. These are generally designed to cause the same width of the vertical and horizontal joints to be obtained.

Narrow joints may be required where there is a need to apply a sealant or weatherstripping for watertightness, but this feature will not be discussed in this basic scheme. Some hints are given in Chapter 7.

The width of the joints and the panel dimensions influence the architectural grid line pattern (details H, L in **Figs. 12, 16**) and are obviously to be defined at the design stage on the grounds of aesthetical considerations.

The airspace (11 + 15 in **Fig. 7**) is the characteristic feature of the ventilated wall. Its width is ≈ 50 mm for cladding heights up to 12 m; for taller claddings up to 20 m it should be increased up to 70 mm.

For very high-rise buildings, when the ventilated wall becomes a most relevant factor in the thermodynamic balance, air circulation in this space should be calculated and engineered to ensure smooth and efficient air flow all over the inner wall surface. (e.g. too narrow a space may cause heating of the air, or one too wide cause turbulence).

The airspace is actually the sum of two spaces: space 15 (**Fig. 7**) has as its main purpose to

allow some clearance for alignment of the panels on the same plane by moving them nearer or farther from the primary wall; space 11 (same **Fig. 7**) makes up the rest of the ventilation space.

The insulation panels (detail 16 in **Figs. 6,7,9**) are normally 40-50 mm thick, depending on the width of the air space and insulation requirements. 40 mm would generally be enough for buildings up to 12 metres high. Fiberglass is normally used, and a 40 mm layer in a ventilated wall with an aluminium rainscreen would be expected to improve the wall insulation by lowering the K coefficient from 2 to 0,63. High-rise buildings or special insulation requirements may need thicker insulation, and in such cases the wing of the L anchor should be longer in or-

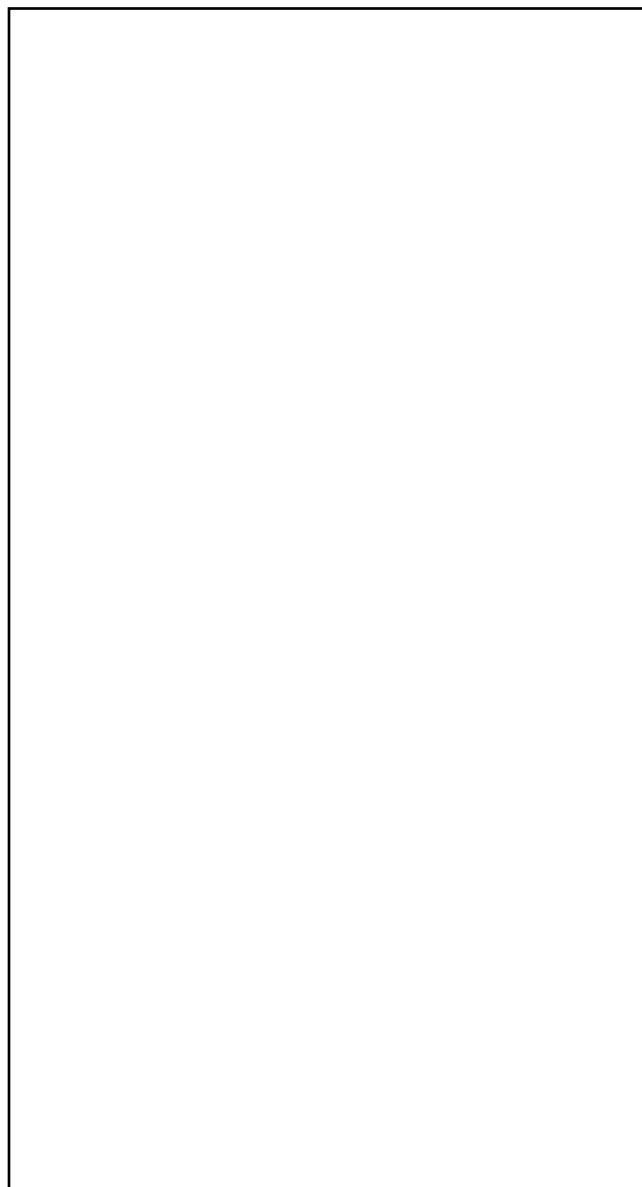




Fig. 9 - Exploded view of Mirasystem "A" assembly

der to maintain the clearance (space 15) needed for mullion alignment.

More details about the insulating layer can be found in Chapter 4.3.

Alignment of the panels to obtain a regular flat cladding is extremely important for the aesthetical result and is thoroughly discussed in Chapter 6. Mirasystem "A" is conceived as a simple basic product, trimmed down to a minimum number of components, and its on-site alignment is entirely obtained by adjusting the mullions in the three spacial dimensions, as allowed by the slots in the anchoring system before tightening the screws, bolts and nuts into their definitive position.

2.3.2. Top closure

The top closure (**Fig. 10**) is a critical feature of the rainscreen (or ventilated facade), as it must perform a number of essential functions:

- a) Stop water leaking from the roofing;
- b) Permit air circulation in the ventilated space;
- c) Ensure connection to the roof waterproofing;
- d) Provide an aesthetically suitable top finish to the panelled surface.

In order to perform these functions, the top closure features a folded sheet flashing (18), connecting and enclosing the different elements that come up to the top of the facade, namely:

- "Cassette" rainscreen panels (32)
- Mullions (11)
- Insulating panels layer (16) on the masonry walls
- Top finishing wall (31)
- Terrace or roof waterproofing (30)
- Roof insulation (if any)

The top closure flashings (18, external, connecting with the facade), (19, internal, connecting with the roof) have the shape of U-channel covers and run all along the facade perimeter. They are made up by joining a series of 3-5 m long elements fabricated by folding aluminium sheet. Joints (20) of the external flashing (18) are hidden under the sheet as they are on the visible part of the facade, whilst those (21) of the internal flashing (19) are not in view and there-

fore do not need concealing. For the same reason, a less expensive material can be used for the inner flashing (19).

Two alternative versions of the external top closure (18) are shown in **Figure 10 a)**: version (18 a) is flush with the rainscreen facade, and version 18 b) is protruding out of the facade. Either version may be adopted depending on aesthetical reasons, or prevailing winds and rain considerations.

Joints (20) and (21) require particular care because of expansion problems that may impair watertightness. **Figure 10 d)** presents some "do's and don't's" about these joints.

Details (20a), (20b) and (20c) show a correct design for the interior joint (20) featuring adhesive bonding on two sides and a spongy lining on the bottom applied before bonding the sides. Details (20d), (20e) show "don't's" about the same joint, demonstrating that 3-side adhesion will cause breaking of the joint as an effect of thermal expansion.

Similar problems arise for the concealed external joints (21). Besides the "sealed" versions (20a), (21a), an "open" version can be adopted for both exterior and internal joints, and the exterior case is shown in (21b).

The top closure flashings (18), (19) are fixed by stainless steel screws (25) to brackets (22), supported by the bearing mullions (11) of the rainscreen structure.

Oval holes must be provided in the flashings for screws (25) in order to accommodate thermal expansion.

Installation of the top closure flashings does not involve any operation on the top finishing wall (31), the insulating panel layer (16), or the roof waterproofing (30), except for a few aluminium L-brackets (27) that are fastened to the interior side of the top finishing wall (31) before applying the insulating panels.

The borders of the top closure flashings must be firmly secured, and this is ensured for the inner flashing (19) by hooking its border onto the L-profile (28) that runs all along the facade perimeter and is supported by the above mentioned inner brackets (27).

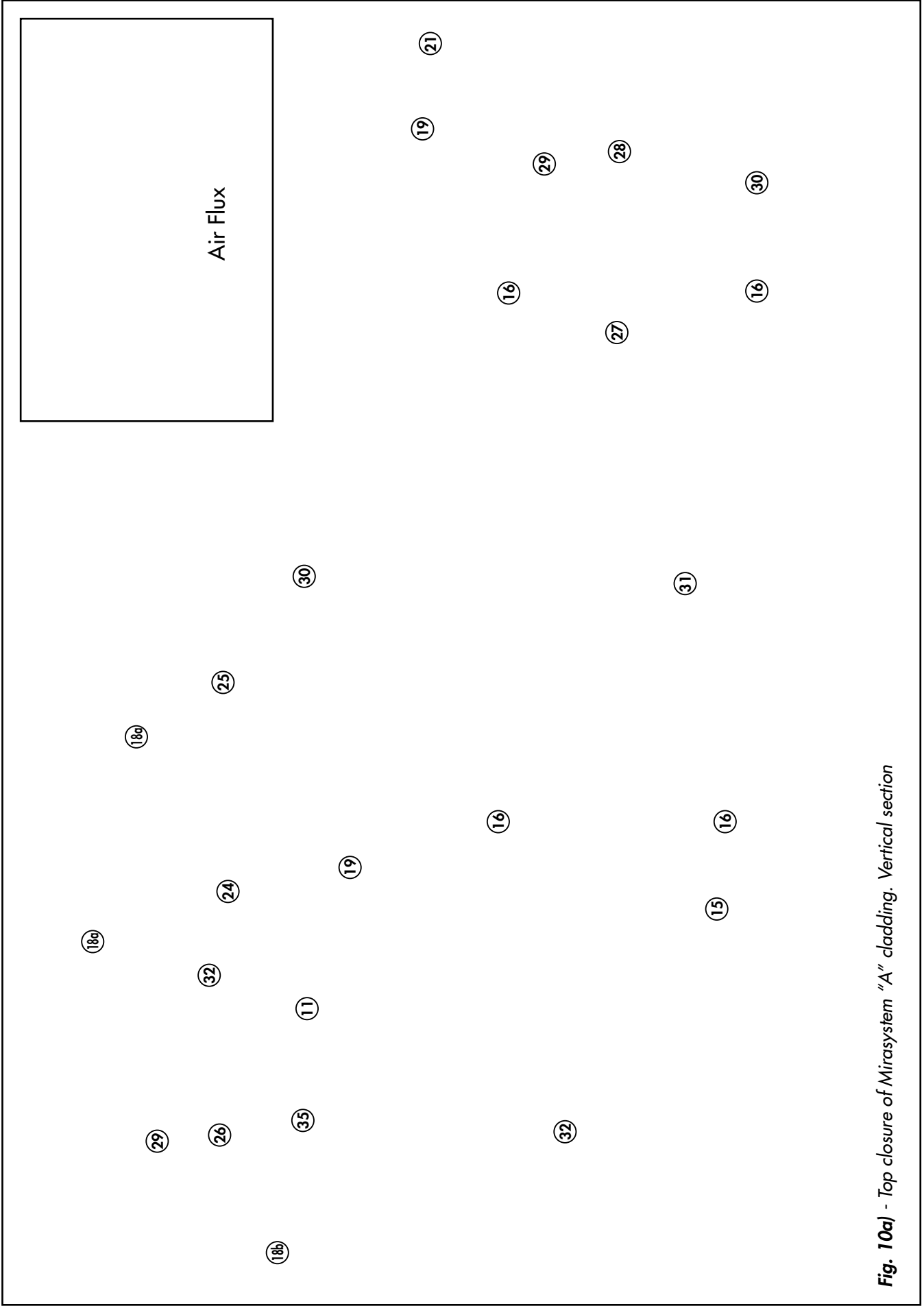


Fig. 10a) - Top closure of Mirasystem "A" cladding. Vertical section

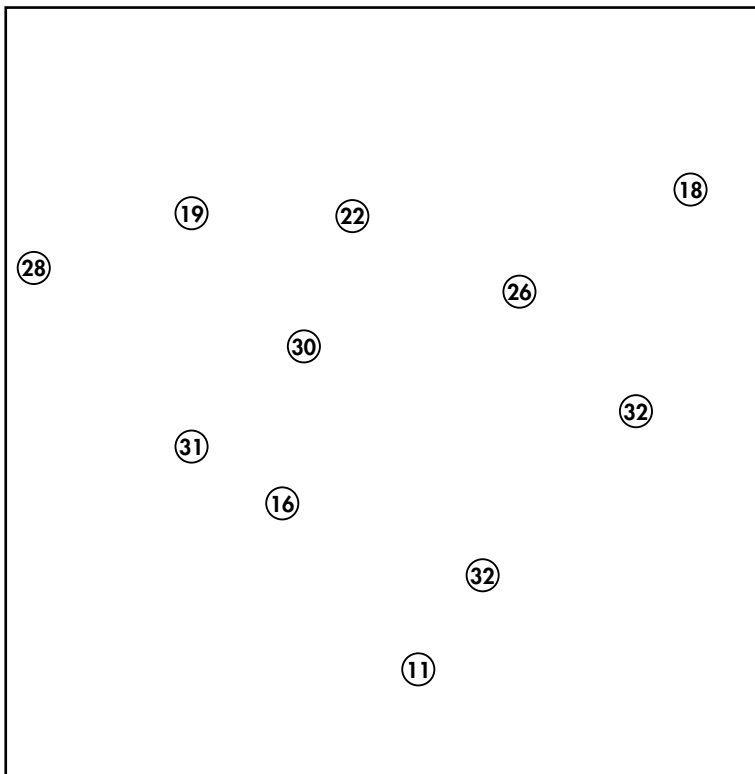


Fig. 10 b) - Top closure of Mirasystem "A" cladding. Prospect

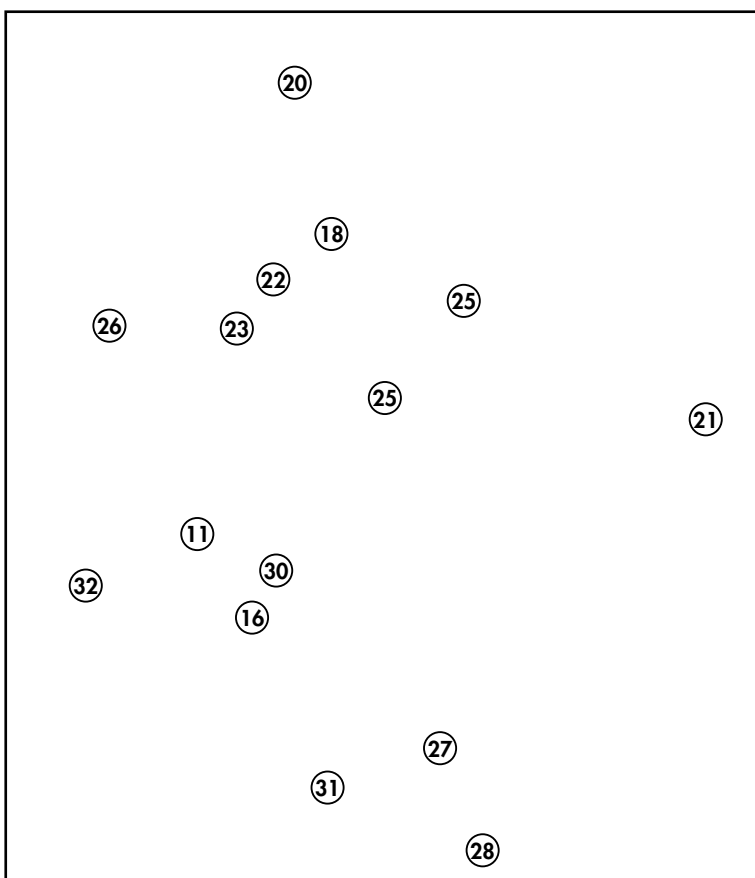
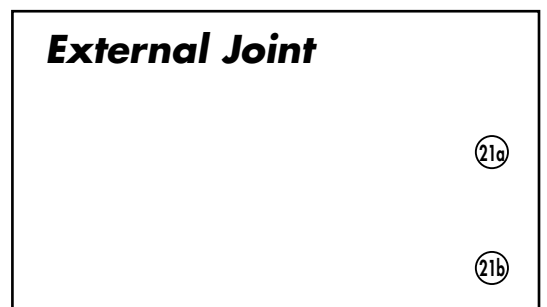
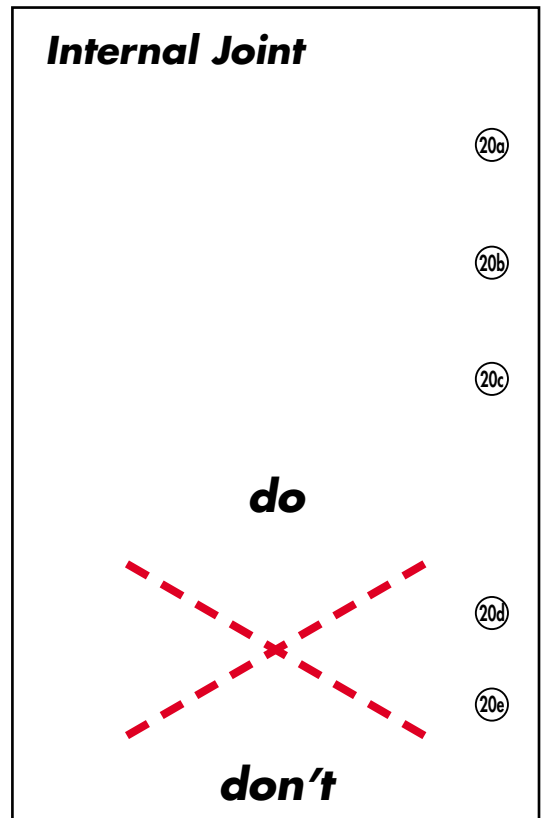


Fig. 10c) - Top closure of Mirasystem "A" cladding. Joints

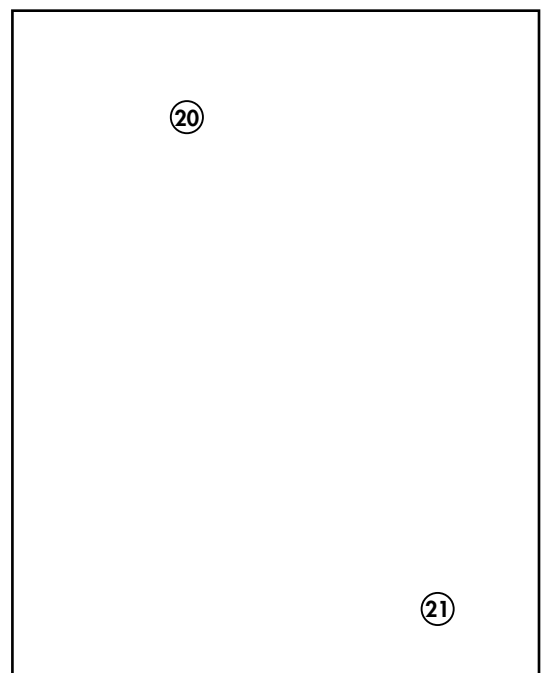


Fig 10 d) - Joint Details

2.3.3. Bottom closure

The bottom closure (**Fig. 11**) mostly has aesthetical functions. Its main features are:

a) To ensure a suitable connection between the facade and the primary wall, hiding and compensating for any possible unevenness;

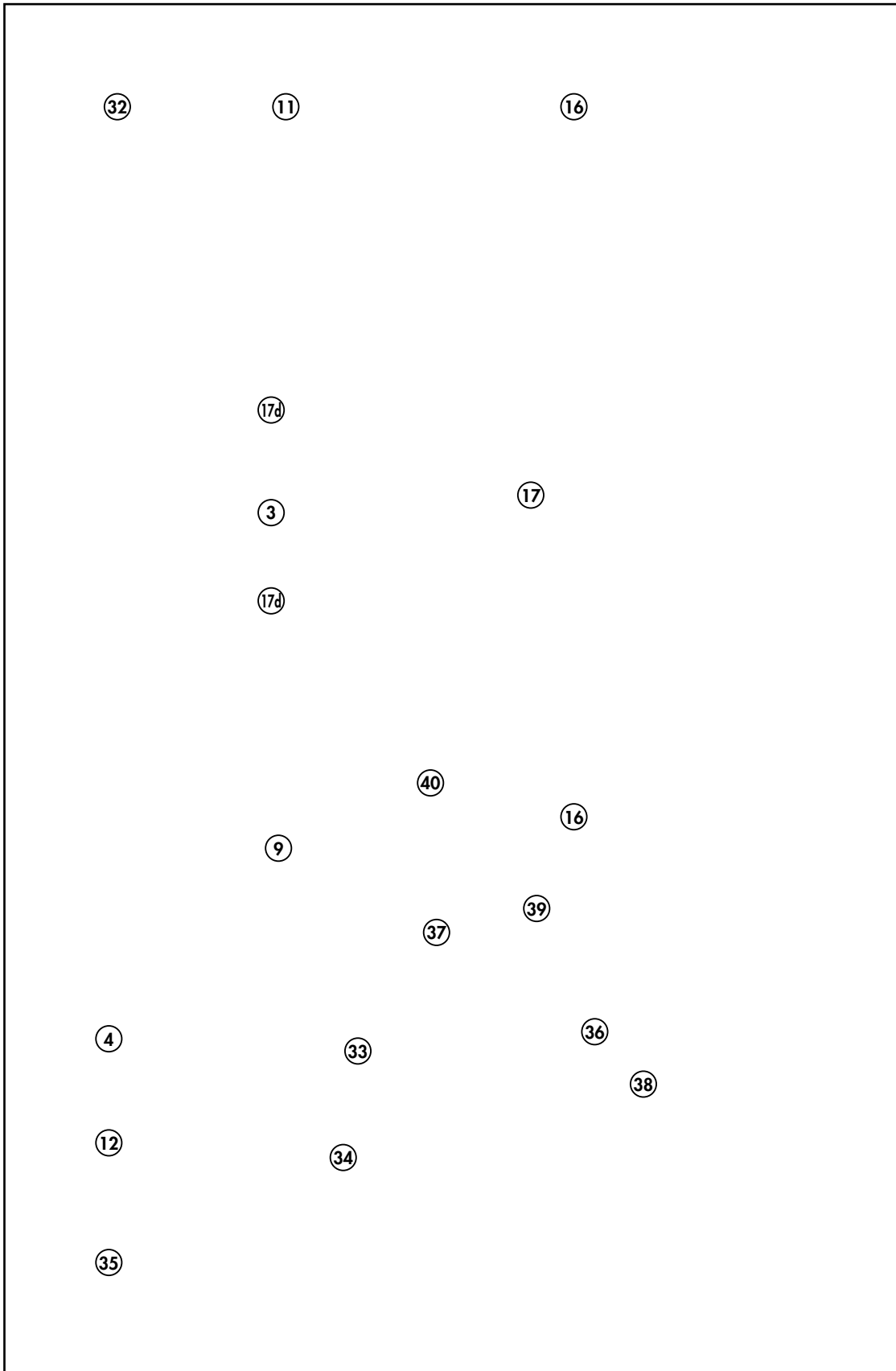


Fig. 11 - Bottom closure of "Mirasy-stem "A" cladding

- b) To provide satisfactory aesthetical finishing of the facade;
- c) To permit proper draining of the rainwater that must be drained away without flowing on the wall surface.

Different solutions can be chosen, and details (33), (33a), (33b) show some of the many possible alternatives. Version (33) is aligned with the panel bottom line, (33a) is projected downward, and (33b) maintains the same horizontal gridline distance as between panels. Detail (34) shows the adjustable closure against the wall, by means of a bracket fixed to the bearing structural mullions (11).

2.3.4. Side Closure

In principle, the side closure should be coherent with architectural gridlines, i.e. the first and last

panel should have the same width as the rest. In a regular project, the front width can be divided so to satisfy this condition of uniformity. However, this may not be possible, particularly in renovation contracts.

Therefore, 3 basic schemes may be considered for side closure, as shown in **Fig. 12a**: schemes F, G with "grid-coherent" end panels, and scheme J with non-coherent end panels. **Fig. 12b** shows construction details in a horizontal section.

The two alternatives F, G of the "grid-coherent" closure differ because F requires an additional flashing (80), while in the G version the end panel (82) itself is bent to provide the side closure, and is fixed to the end mullion (87) via an L-bracket (88). In the F version, the flashing (80) may have different widths (89) depending on aesthetics, and on one side it is hung from the structural mullions in the same way as the panels, while on the other side it is fixed by means of screws to profile (85) which is secured by wall anchors.

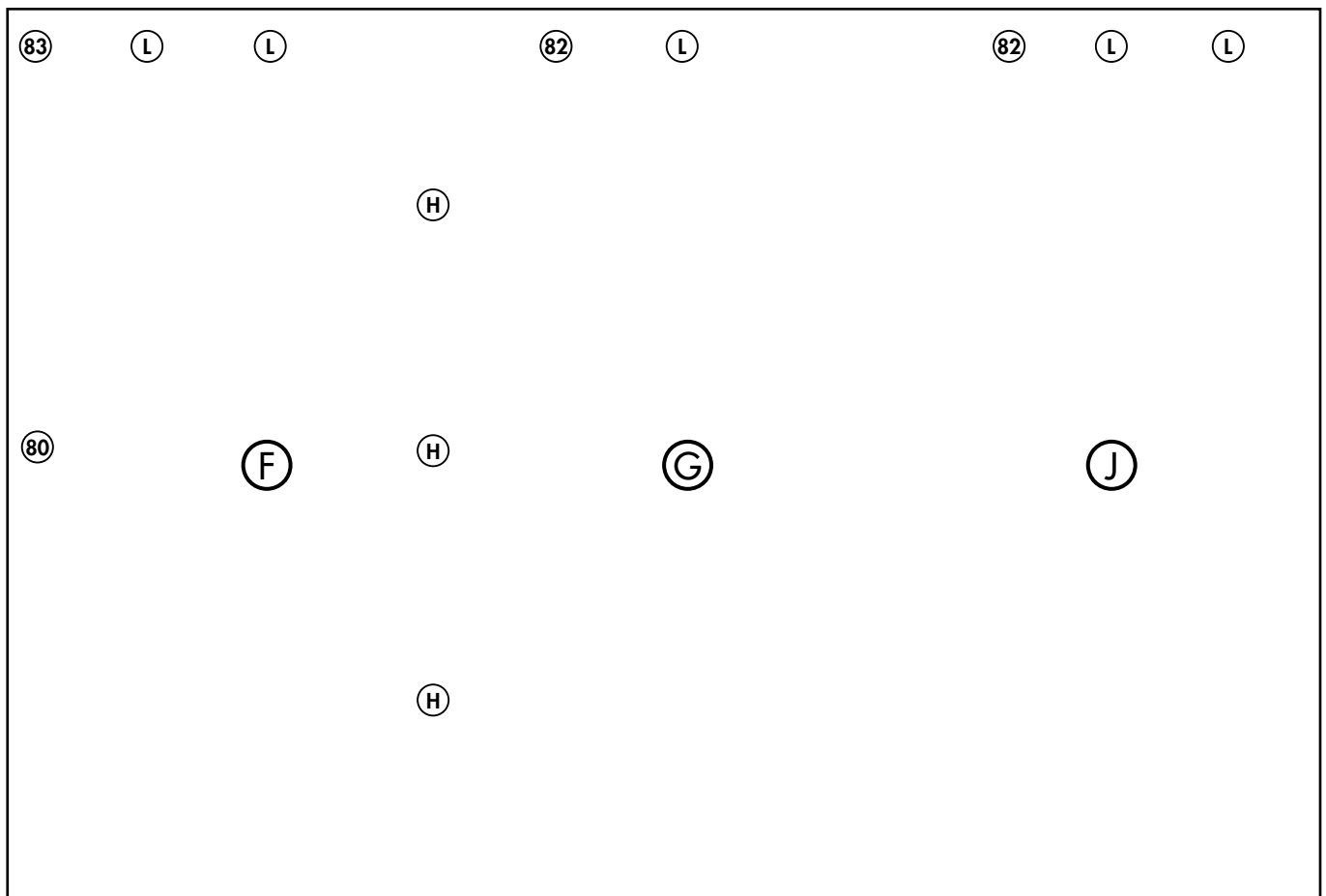


Fig. 12 a) - Three side closure patterns of Mirasystem "A": F = with end flashing; G = with 90° end panel , standard front width; J = with 90° end panel, with width different from the rest of the panels

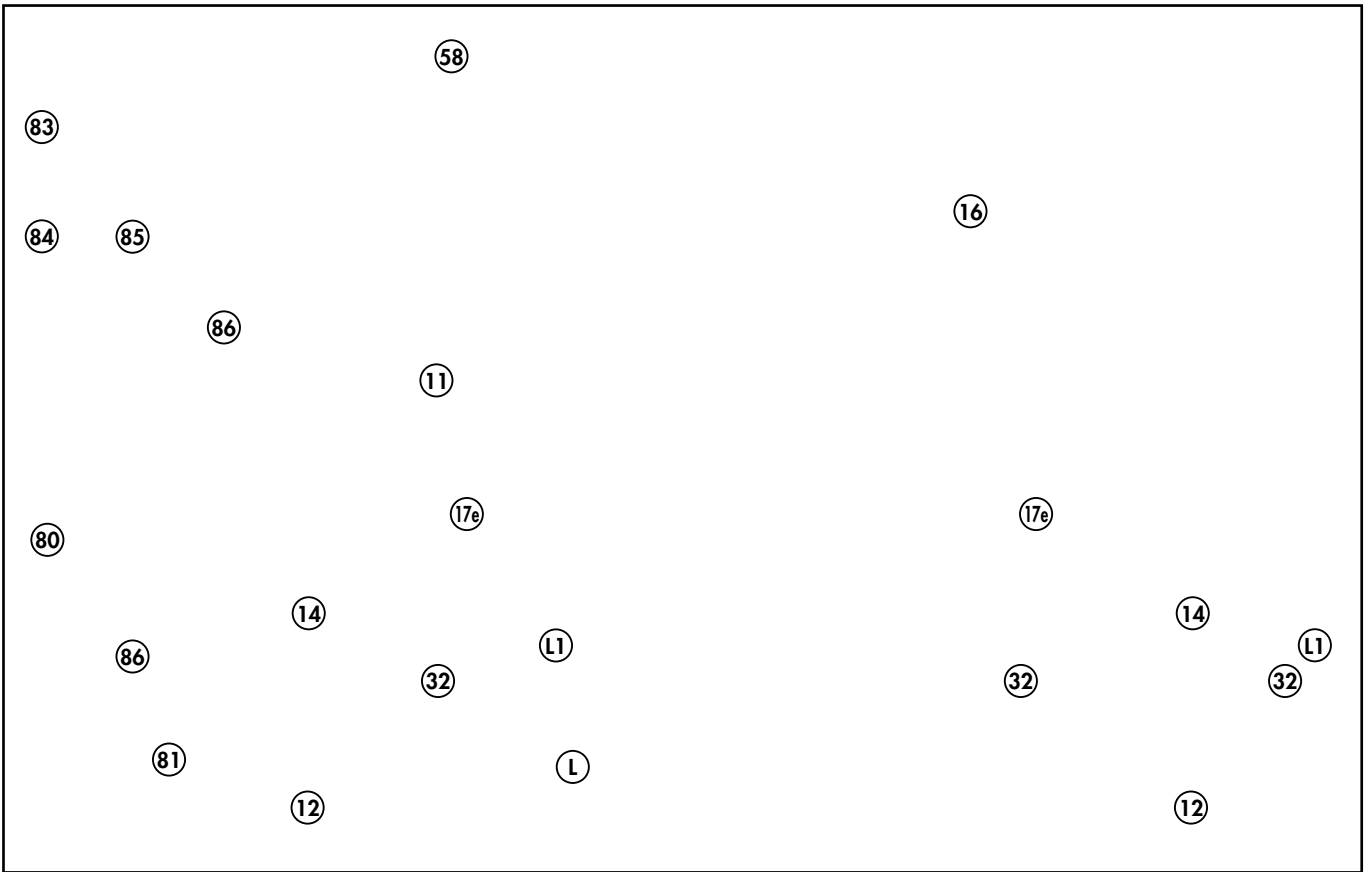


Fig. 12 b) - Horizontal section of solution F

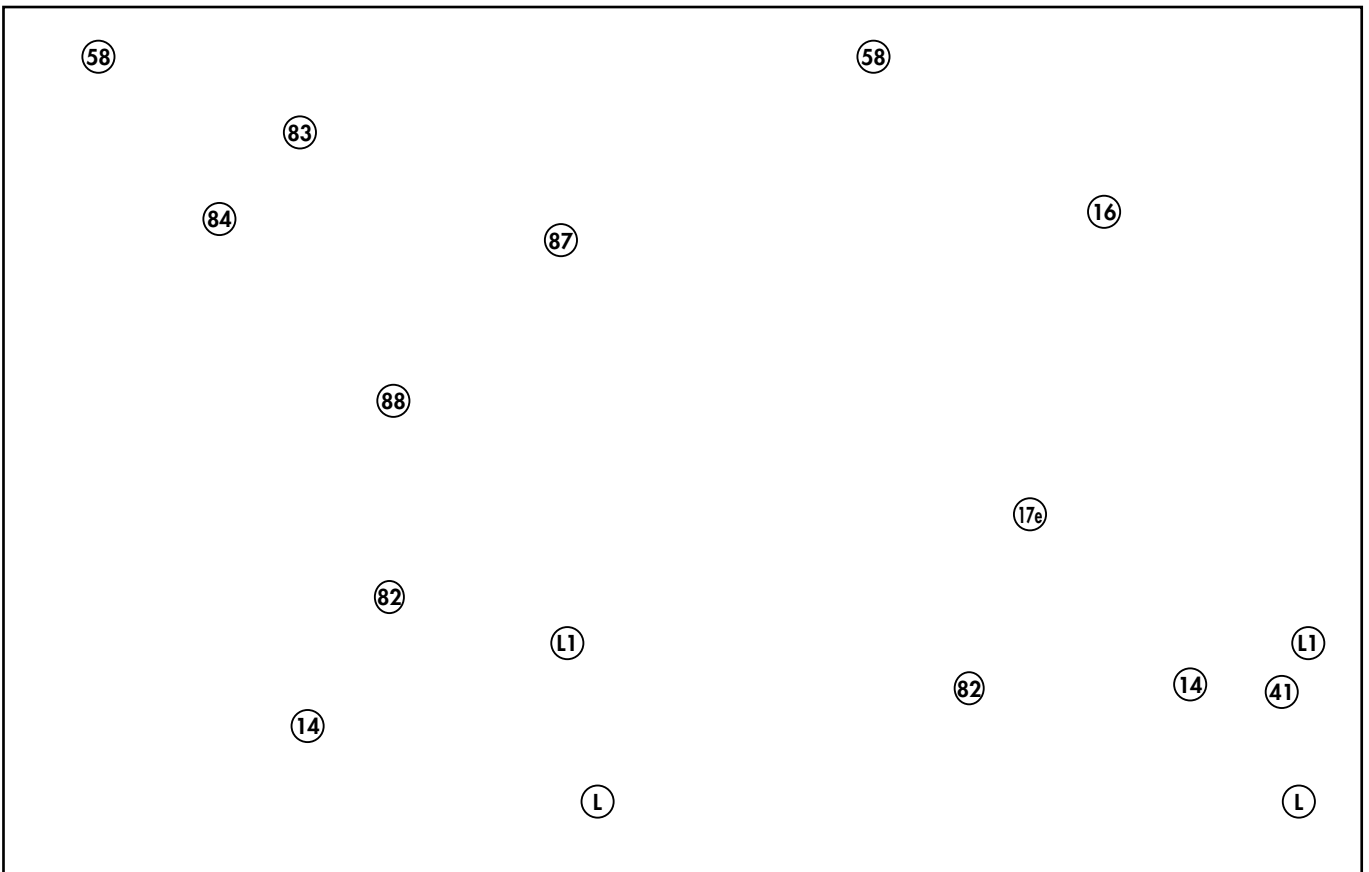


Fig. 12 c) - Horizontal section of solutions G, J

The “non-modular” closure J is basically similar to solution G; the only difference is that the front width of the panel is different from the width L1 of the standard panels (32).

Attention must be paid to sealing the joints, not only for aesthetical reasons, but also in order to avoid water infiltration while permitting thermal expansion.

This is obtained in the F solution by introducing an inner sheet (86) at the joints between two consecutive panels of the flashing profile (80) and of the wall profile (85). Gasket (86) should be at least 15-20 mm wide.

The screws connecting the vertical flashing (80, red) with the wall profile (85, blue) shall pass through 15 mm wide oval slots in order to allow for thermal expansion. In general, all screw-fixing holes in supporting profiles (80), (85), (87) and brackets of the G solution (88) shall be oval to accommodate thermal expansion.

Whichever is chosen of the three alternatives F, G, J, attention must be paid to the unevenness of the primary wall. Any waviness of the wall must be absorbed by the supporting profiles (85 in case F, 87 in cases G, J).

Therefore, these supporting profiles should have a spongy elastic backing (83), e. g. “Compriband”, between the profile and the wall, so ensuring a tight fit to the wall even in the presence of waviness. Obviously, the points where the supporting profiles are fixed to the wall anchors must have a solid backing, and this is accomplished by introducing spacers between the profile and the wall -generally an appropriate number of metal washers. Space (84) has the basic purpose of allowing the outer screen to absorb all flatness deviations of the primary wall. Its width therefore depends on the size of these deviations. It may vary from 40 mm to 100-150 mm and can even go beyond that. The exact width of space (84) must be established in advance by plumbline measurements.

2.3.5. Inside Corners

A simple solution for inside corners, as illustrated in Fig. 5, is shown in detail in Fig. 13. Fabrication procedures for the corner panels are described in Chapter 5.3, Fig. 32.

The inside corner shaped panel (70) in Fig. 13 is hung to the mullion structure in the usual way, but a “corner piece” (72) is needed to close the corner gap.

This corner piece can be fabricated by bending and welding aluminium 3003 or 5005 sheet as shown in the drawing, or it can be molded with fiber-reinforced plastic. The choice depends upon how many pieces are needed. The corner piece is attached to the panel by 2 stainless steel screws.

2.3.6. Outside Corners

An outside corner (Fig. 14) also requires a corner panel (71) and a corner piece (73). Similar considerations apply as for the inside corner.

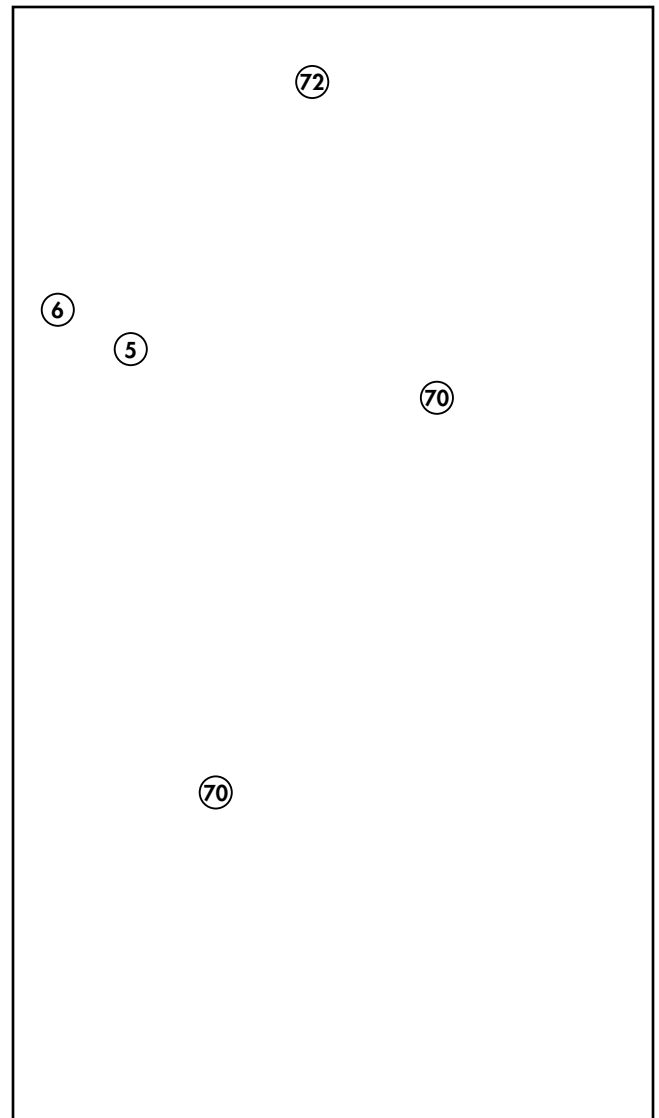


Fig. 13 a) - Prospect view of upper inside corner closure with screw-fastened corner flashing (72)

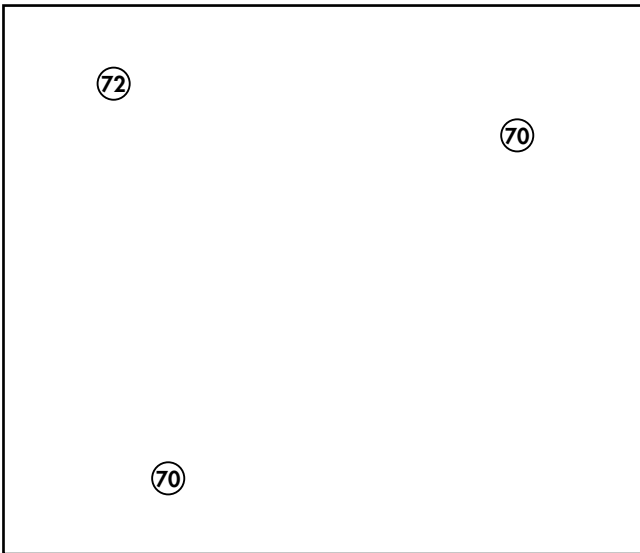


Fig. 13 b) - Horizontal section of upper inside corner flashing (72)

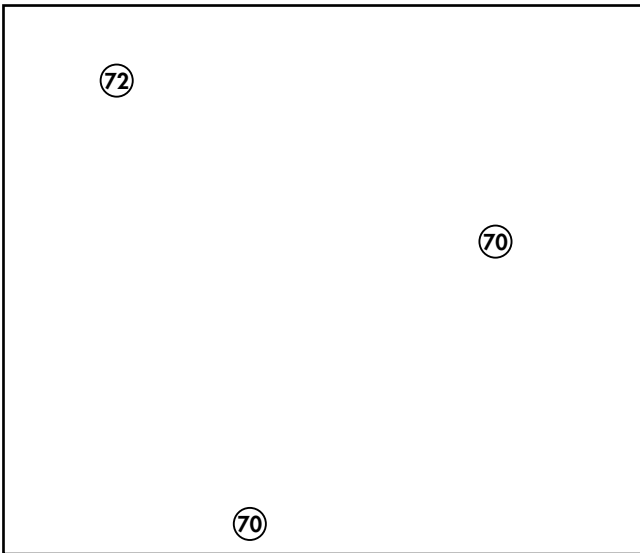


Fig. 13 c) - Vertical section of upper inside corner closure with screw-fastened corner flashing (72)

2.3.7. Rounded Outside and Inside Corners

The case of rounded corners (**Fig. 15**) is more complicated, and should preferably only be entrusted to experienced manufacturers .

Fig. 15 illustrates a rounded outside corner, and the structure of the inside corner is based on similar principles. **Figs. 15a, b** show horizontal sections of one panel and of the detail of the joint; **15c** is the corresponding vertical section, and **15d** is the curving scheme.

The curved panel (20) with radius R is supported by a back structure (25) made of L-section extruded aluminium bars curved to the same radius R. **Fig. 15** shows how the basic design details and gridlines (14) are preserved.

Note detail (11f), where mullion (11) is cut off to accommodate the bars of the back structure, which are fixed to the vertical side folds of the curved panels by means of end stoppers (76) and screws. The curved panels, obviously, do not have upper and bottom horizontal folds, which are substituted by the bars on the back, connec-

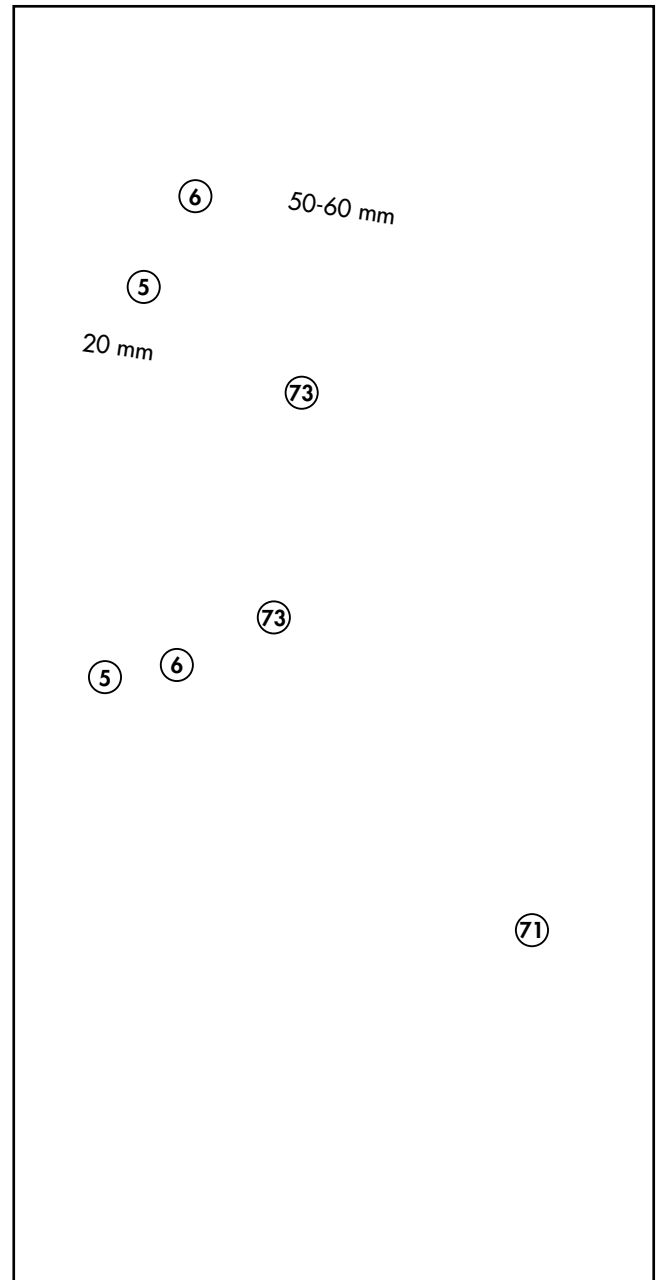


Fig. 14) - Prospect of upper outside corner closure with screw-fastened corner flashing (73)

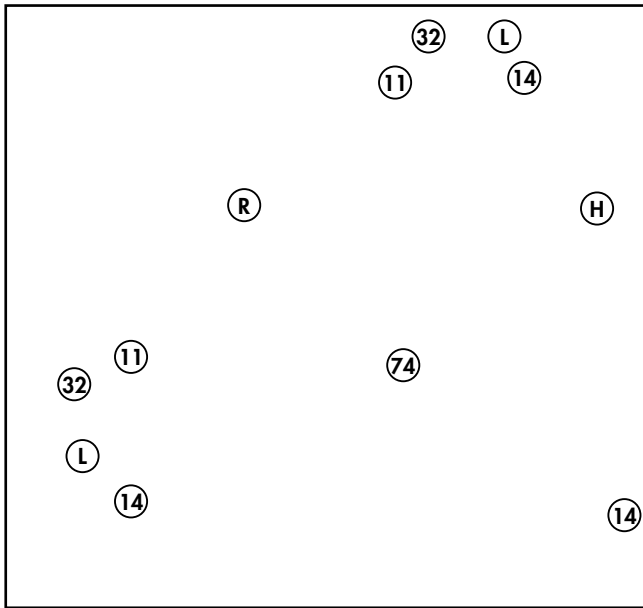


Fig. 15 a) - Horizontal section of joint between plane cladding and curved corner panel

ted to the horizontal border of the panel by double sided adhesive tape (77) , and to its vertical folds by the screws in the end stopper (76). Curved corner panels are hung to the structure mullions (11) in the same way as the flat panels, by means of hooks blanked out in the vertical folds as indicated at points 4.4.5, 5.1.

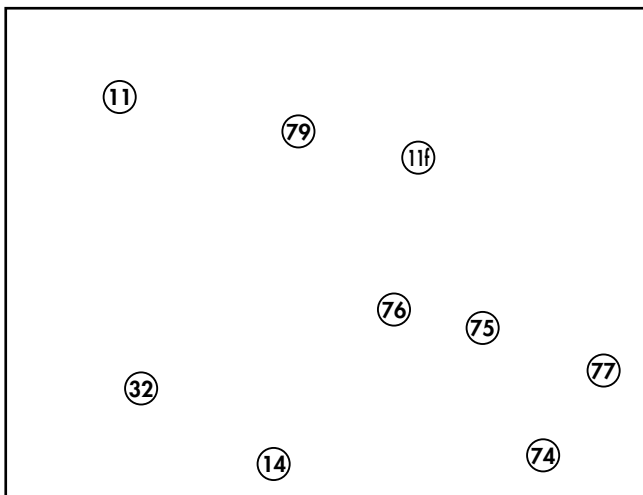


Fig. 15 b) - Detail of joint

Fig. 15 d) - Scheme of bending and assembly of the curved panel
 I, II = Bending with a wider radius;
 III = Fixing on bearing profile;
 IV = Screw fixing to final radius

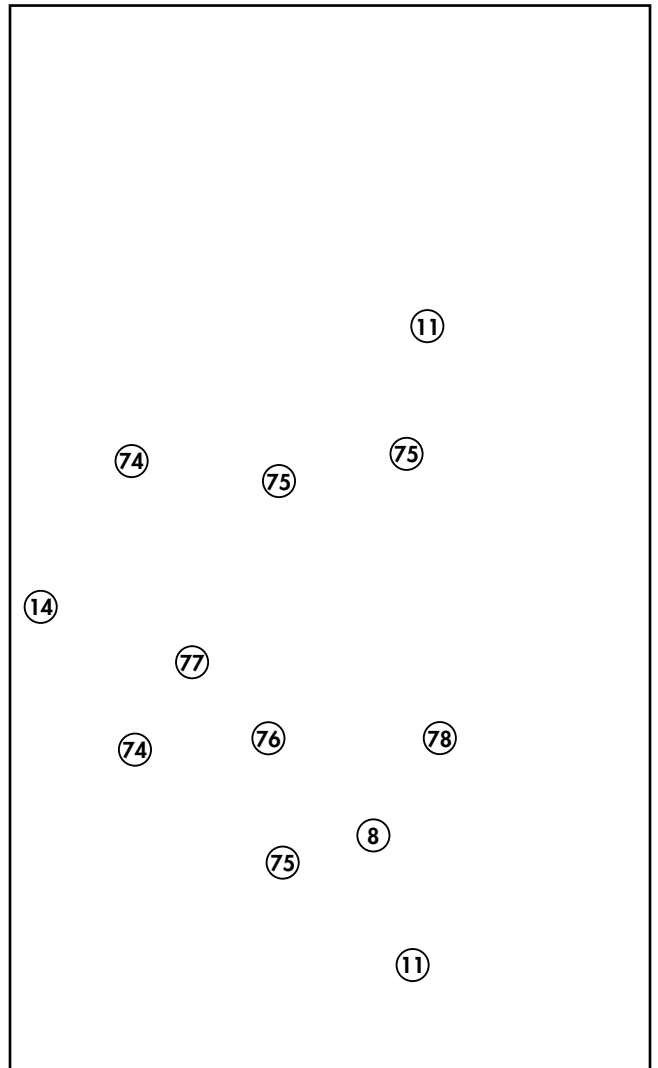
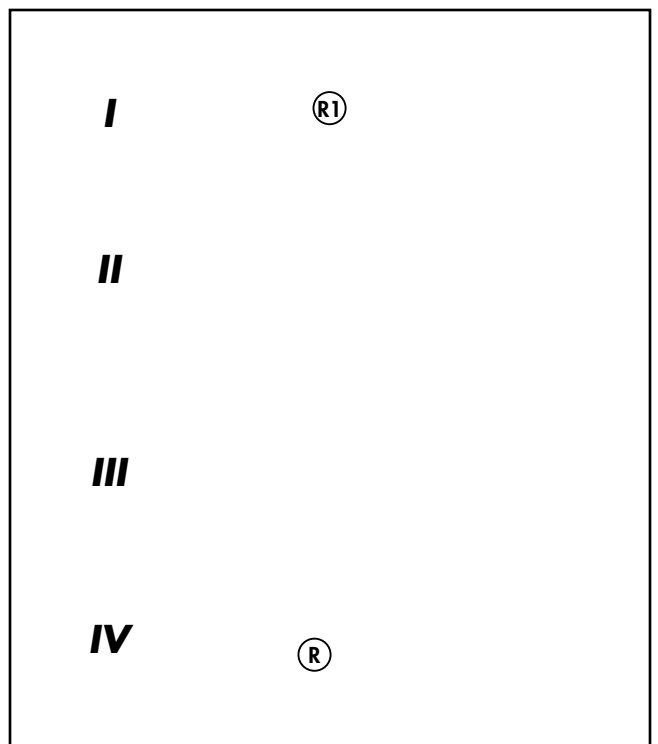


Fig. 15 c) - Vertical section



3 WINDOWS

3.0. Overview

Introduction of windows in the ventilated wall presents a great variety of possible situations, depending either on architectural design (chiefly for new buildings) or on an adaptation of the cladding/window system to pre-existing window bays (mostly in renovation work).

In all cases, the basic problem is modulation, and modulation will be determined by many factors, e.g.:

- Architectural factors, such as projecting or recessed parts, windows, etc.
- Non-straight (vertically or horizontally) planes of the facade
- Inside or outside corners
- Joints coinciding with with pre-existing windows

Out of the almost infinite variety of possible cladding/window relationships, only the 3 most frequent ones are discussed here (Figs. 17, 18,

19), in connection with a simple modular grid (B in Fig. 16a).

3.1. Window, relationship to cladding & wall

Fig. 16a shows the 3 most frequent cases of facade modules encountered in ventilated wall technology.

In the example shown, the vertical floor-to-floor height between horizontal grid lines is supposed to be 3,20 m.

Case A has square panels, with sides $1/4$ of the floor-to-floor height HP; case B has rectangular panels, with height = $1/2$ of the floor-to-floor distance; case C is a combination of those modules.

By varying module combinations, the cladding can be adapted to a variety of situations as listed at point 3 above. In choosing a module width, consideration should be given to the fact that wider modules and standardized panel dimensions lower costs.

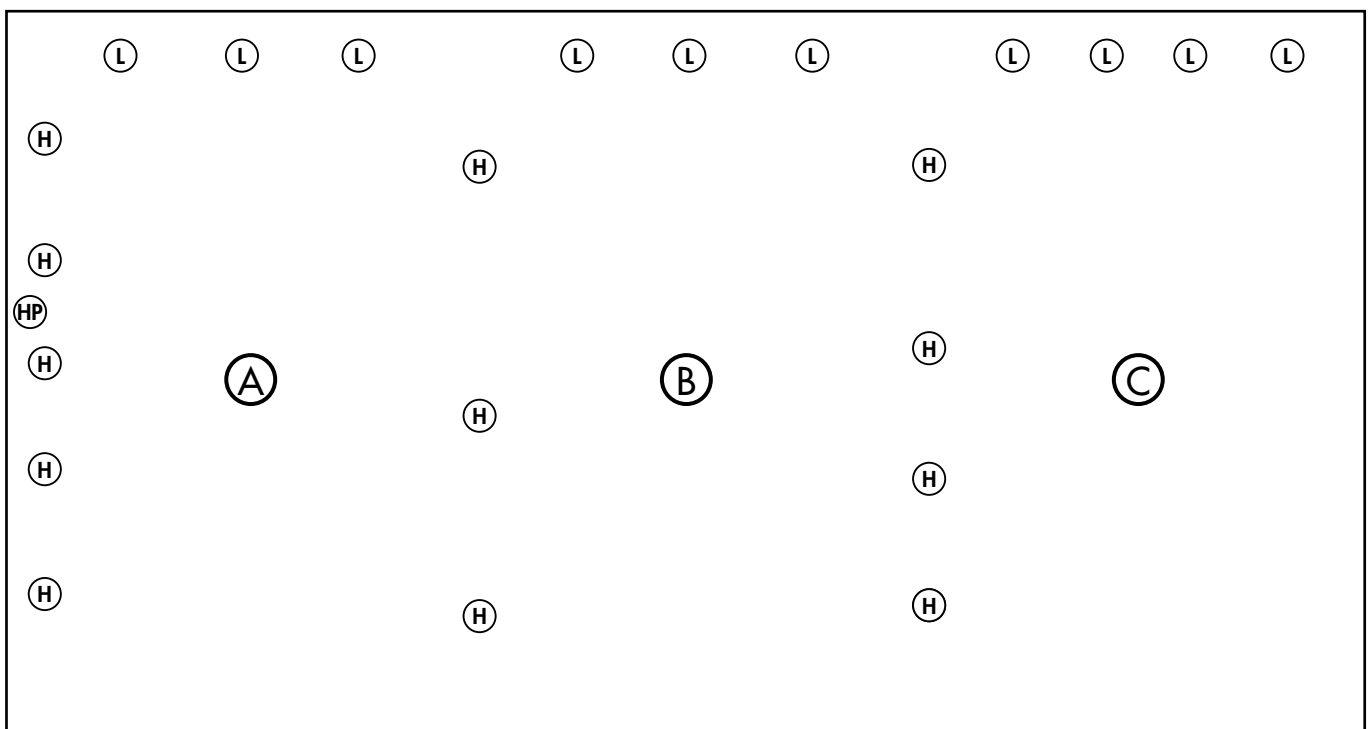


Fig. 16 a) - Facade module grids

For the sake of simplicity, the window/cladding relationship is considered here in connection with case B; however, such considerations can be easily adapted to the other cases.

Fig. 16b illustrates the 3 main positions of a window relative to the cladding module:

- Ba = 1-module wide, flush with the cladding, aligned to the grid lines
- Bb = 2-module wide, recessed from the cladding, aligned to the grid lines
- Bc = 1,5-module wide, non aligned to the vertical grid lines

Clearly, the condition of non-alignment is more likely when cladding is applied to a pre-existing facade for renovation or thermal insulation purposes.

3.2. Window Ba, flush with cladding

The Ba window in **Fig. 16b** has the vertical and horizontal sections shown in **Figs. 17a,b**. In this example, the window frame is assumed to be a

Schüco thermal-break type, but the scheme could be easily adapted to any other frame system.

Horizontal section (**Fig. 17a**)

Note the panel grid lines (14), and the 1 cm displacement (50) with reference to the inner walls which has to be reckoned with when defining the facade modulation.

The subframe of the window (41) is fixed to the wall by aluminium or galvanized steel anchors. Joint tightness is ensured by the elastic lining sheet (42) glued to the wall and the frame along the two posts and the top rail.

The structural mullion (11) is interrupted for the window height + 9 cm above and -4 cm below the grid lines of module (14). Over this length, the mullion is replaced by a square 30X30X2 mm 6060 aluminium alloy tube (56), screw-fastened above and below to the interrupted U mullion. As a consequence, the outer surface of the window is only slightly (3 cm) recessed with respect to the cladding plane, and the two panels on the window sides can be hung on a (17e) cantilever pin. The final result is that the window is correctly connected to the cladding, well insulated, and fits exactly into the architectural grid lines.

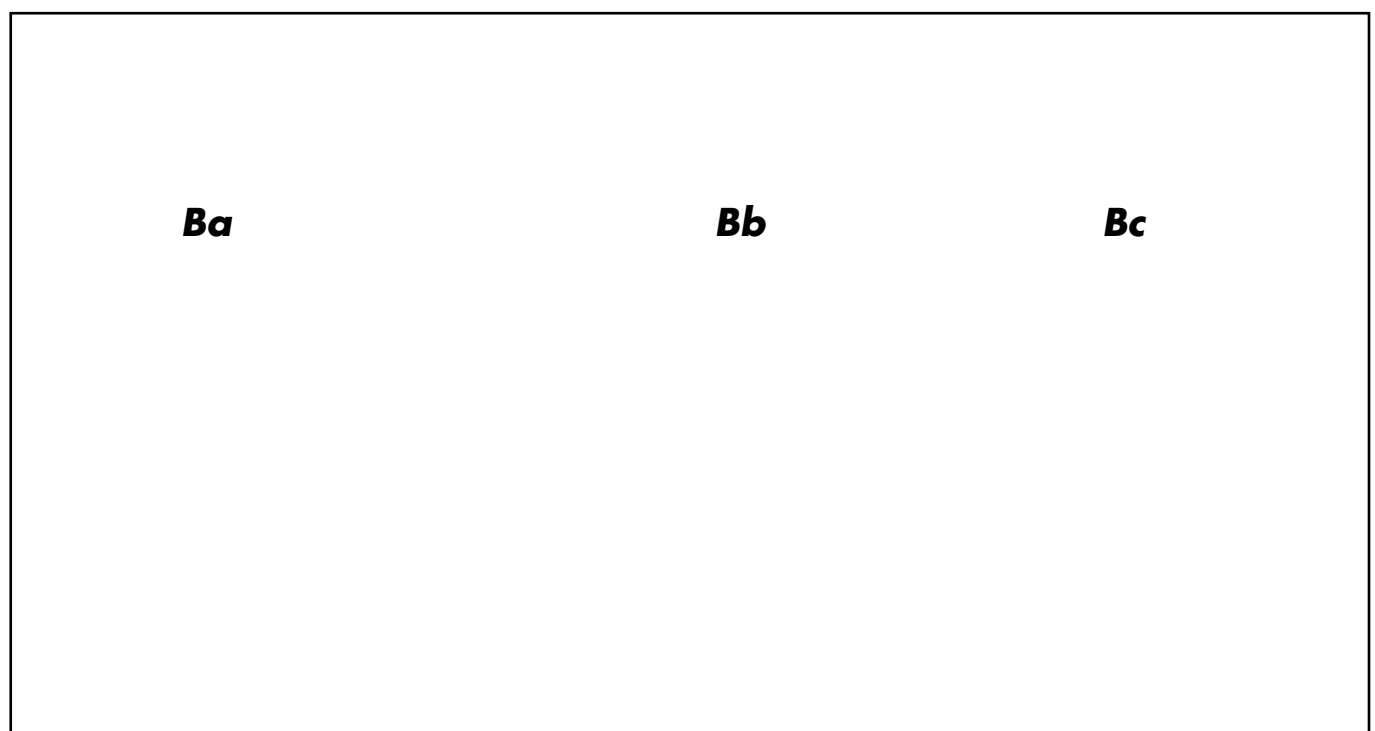


Fig. 16 b) - Window position in the facade module grid

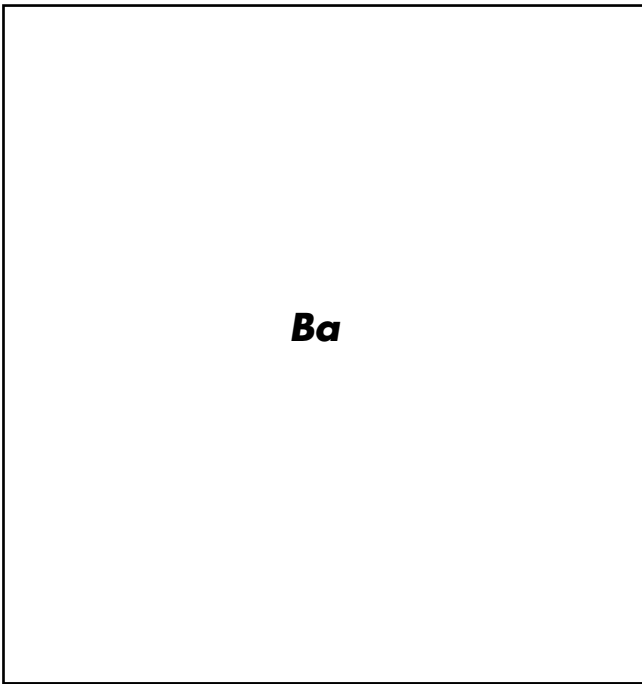


Fig. 17) - Window flush with cladding

Vertical section (Fig. 17b)

Notice here the panel modules. The panel above the window has a longer than normal cutoff step (7): 65-70 mm instead of 20 mm. The panel below the window must also have a wider (30 mm) upper horizontal fold.

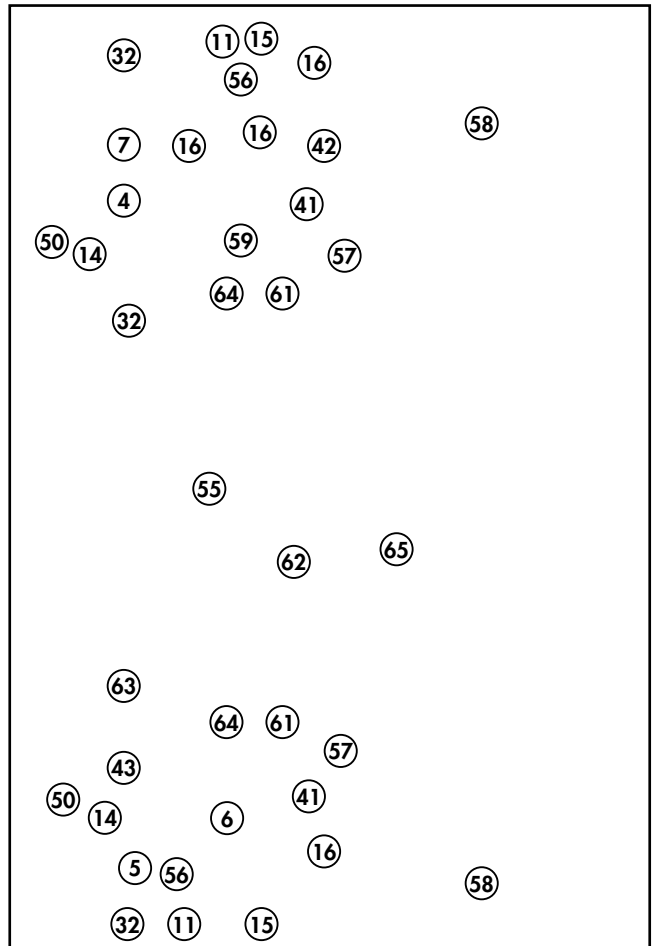


Fig. 17 b) - Window flush with cladding - Vertical section

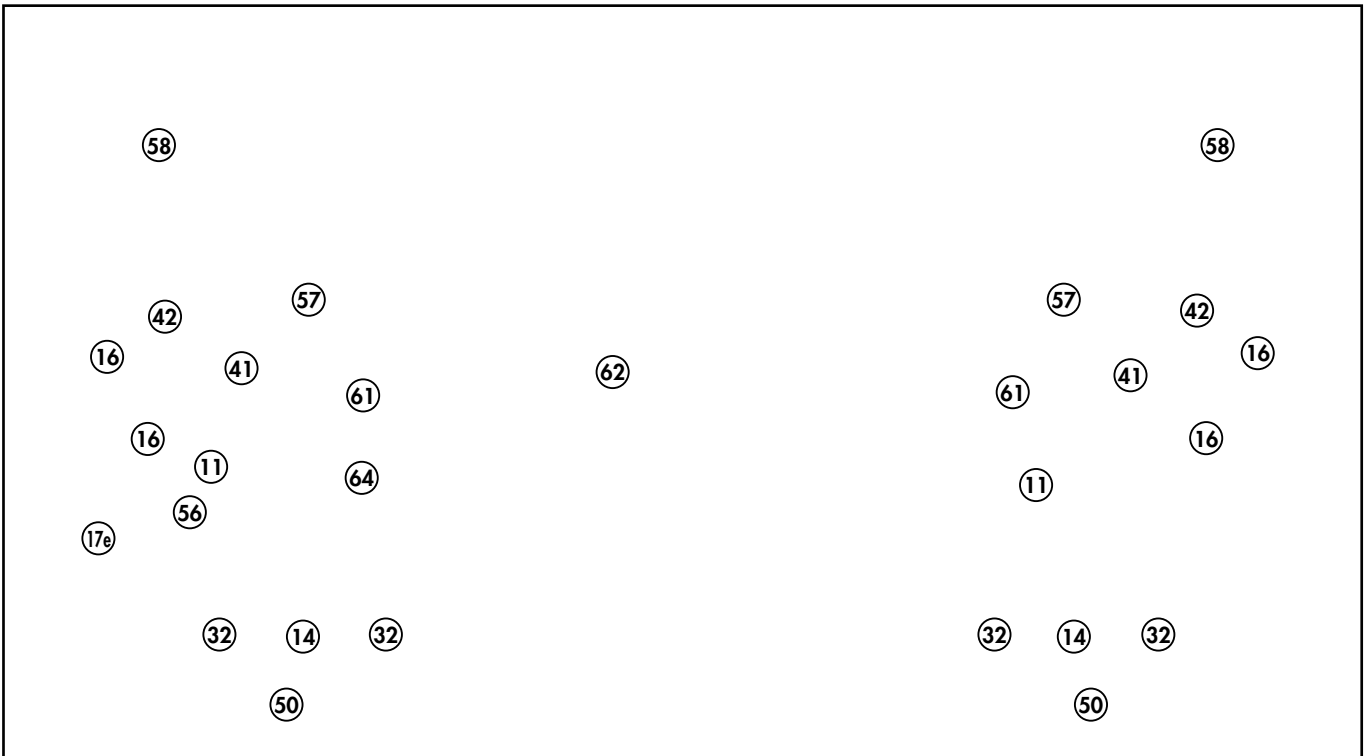


Fig. 17 a) - Horizontal section

The window has a rebate from the outside against the vertical fold of the panel below (6), and its top rail is covered by the bottom fold of the panel above. The tightness lining sheet (42) is glued on the window and on the wall before installing the insulating panel.

Also note at the top and the bottom of this section the rectangular 40X15X2 mm wall frame (41), anchored to the wall by L-brackets, where the window is attached. The thermal-break window is insulated and is joined to “warm” elements by its “warm” side.

3.3. Windows Bb, Bc recessed in the wall

Figs. 18, 19 illustrate the two typical cases that arise when the cladding is applied to a pre-existing wall already having apertures in the masonry, with or without their windows. Therefore, the window frames are not detailed as they might be any type existing in the market .

The two possibilities are: either the window exactly fits into the cladding gridlines (Bb version); or the window only fits into the horizontal grid lines, but does not match the vertical lines (Bc version).

3.3.1. Window Bb, fully aligned with the grid

Fig. 18a shows the horizontal section of a window within its original aperture, which has been aligned with the cladding gridlines by framing it with sheet flashings. The modules of the panels match the dimensions of the window aperture: this matching must be considered when deciding the cladding module.

Noticeably, the vertical mullions (11) here are not interrupted, and the bay flashing (49) is vertically hung onto the same pins as the panels (32). The upper reinforcing bar (41) is an aluminium alloy tube (40X15X2mm), fixed on the side behind the structural mullions (11).

The sill (47) has a border (48) preventing water infiltration.

Flashing (49) is fixed and sealed against the window frame (66), and the window is water-and-airtight.

The insulation panels 16 are installed into the window recess up to the window frame at the head, sill and sides.

Fig. 18b shows the vertical section of the same window. At the top can be seen the transverse tube (41) and the top flashing (46) that externally fits and matches the cladding gridlines. The window (45) encloses and supports the insulating panels (16) and the lining sheet (42) is glued to the wall before fixing the insulation layer.

The upper horizontal flashings are short (same width as the window light) and bear against the vertical flashings (49).

At the bottom, the sill (47) fixed to the underlying panel with side folds (48) is longer than the clearance remaining between flashings (49) for water tightness. The sill front is shifted inwards (hardly noticeably from outside) in order to allow the vertical flashings (49) to descend down to gridline (14) and accommodate the fin (43).

At the bottom, too, the insulating panel covers the wall up to the window.

The visible surface of flashing (49) here is 30 mm wide, identical with that of the top closure (46) and sill (47). Larger surfaces may be used. Another feature worth mentioning is the sill positioned against the window and gun sealed (44) below the level of the water drainage weepholes in the window.

3.3.2. Window Bc, interrupting the vertical gridlines

Fig. 19a shows the horizontal section of a Bc window which does not fit into the vertical gridlines with its horizontal module: therefore, the side panels must be specially cut and bent as in (52), whilst the panels below remain of the standard size (32).

The side flashings (51) are hidden behind the folds of panel (52) and do not protrude into the window bay. They run all along the height up to behind the upper panel (32).

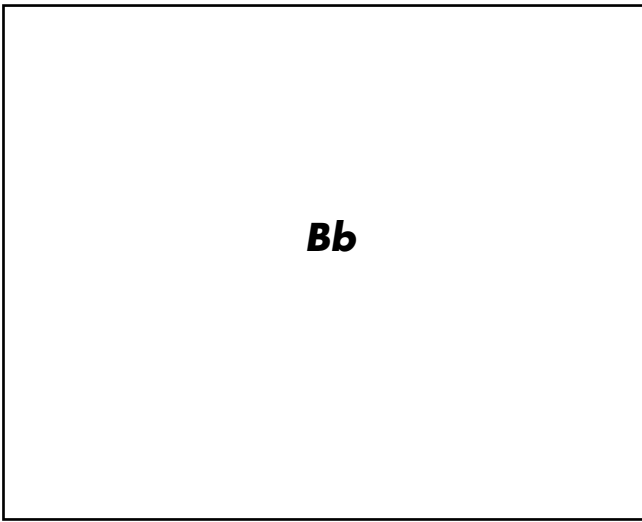


Fig. 18 - Window in the wall, aligned with both vertical & horizontal grid lines

The sill (47) is wider than the window, and has a fold (48) that prevents water infiltration. Flashing (51) is fixed and sealed (66) to the window (45), which is air-and-water tight. The insulating layer runs along the head of the wall opening up to the window.

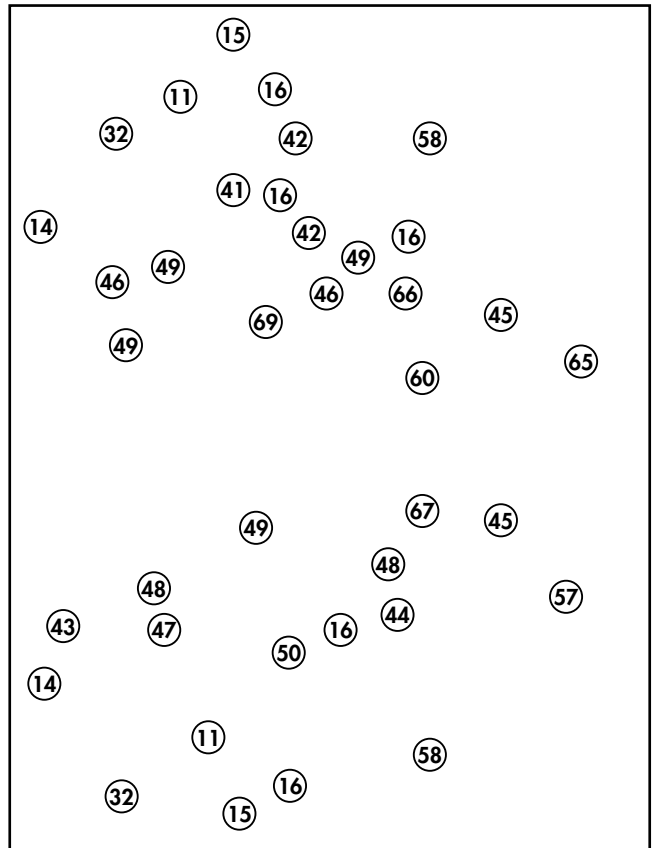


Fig. 18 b) - Vertical section of window aligned with both horizontal and vertical gridlines

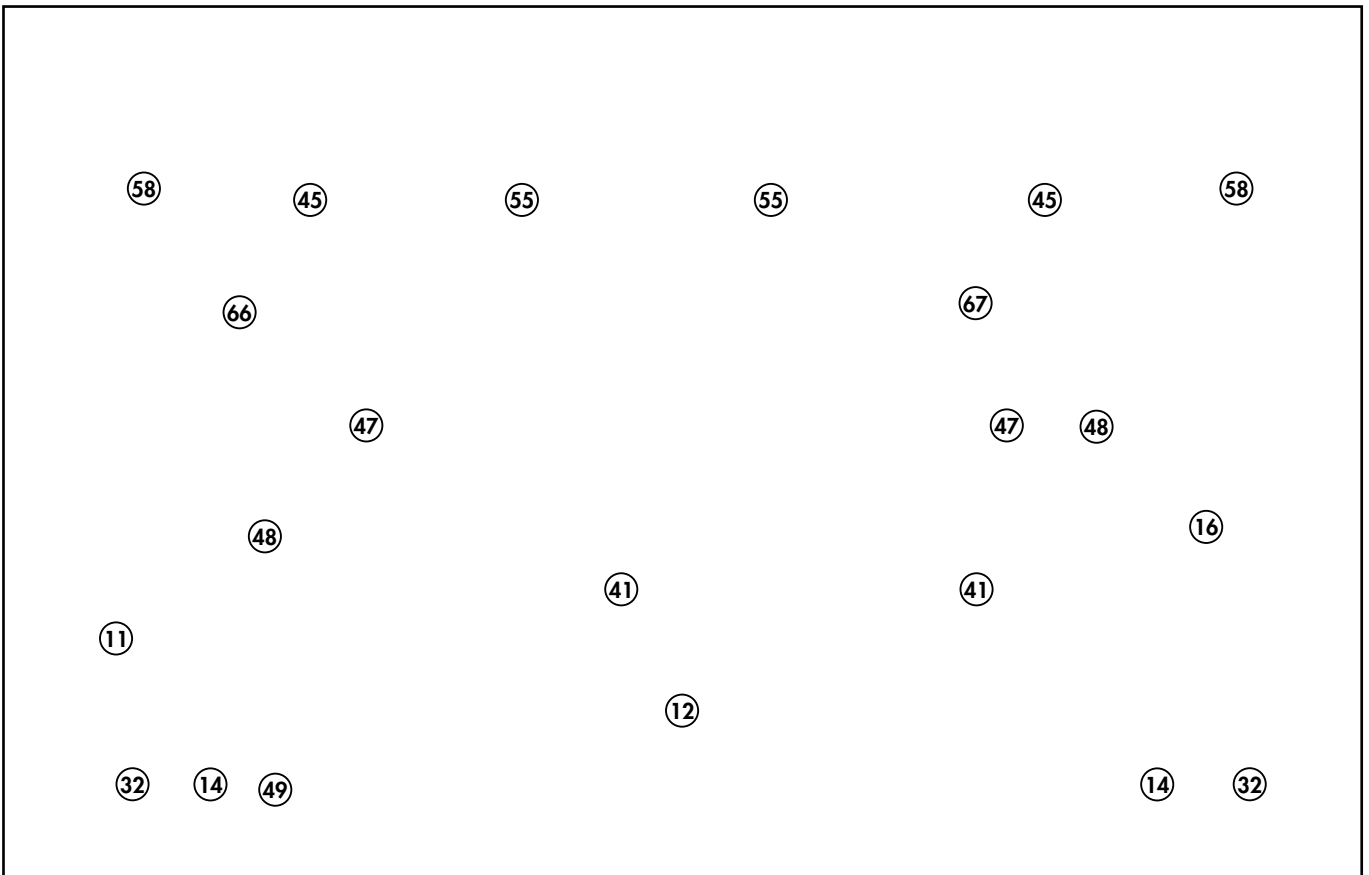


Fig. 18 a) - Horizontal section

The external flashing (53) is fixed to the tube (41), and the internal flashing (54) is fixed and sealed to the window frame. This internal flashing receives externally the lining sheet (42) and is joined to the transverse tube (41) by brackets that also block the lining sheet already glued to profile (54). These closures have the same width as the window light.

At the bottom, the sill (47) is fixed externally onto the underlying panel, and is longer than the residual clearance between the flashings (51)

for water tightness. The sill front is shifted inwards (hardly noticeably from outside) in order to allow the vertical flashings to descend down to gridline (14) and accommodate the fin (43). At the bottom, too, the insulating panel covers the wall up to the window.

Another feature worth mentioning is the sill positioned against the window and gun sealed (44) below the level of the water drainage weepholes in the window.

4 COMPONENTS

4.1. Wall Anchor System

The anchor system (17) for Mirasystem "A" (see Fig. 9) is the simplest one.

Fig. 20 shows the features of the TAM 8 wall expansion bolt and an exploded view of the system. A detailed description is given in the cover flaps.

The TAM 8 wall bolts can be galvanized steel or preferably AiSi 304 stainless steel. Brackets (17a) and (17b) have slots permitting adjust-

ment in three directions: away from the wall, horizontally and vertically along the wall. These brackets should be the same material as the wall bolts.

Some proprietary, more flexible anchor designs are offered on the market, and major curtainwallers normally design and order custom-made anchors for their more substantial projects.

4.2. Mullions and Stiffeners

Vertical mullions in the Mirasystem "A" simplest design are just U-shaped profiles, and the recommended solution is an aluminium alloy extrusion according to detail (11).

The mullions are drilled to accommodate the pins where the panels are hung.

Special care should be given to the drilling operation, as the final alignment is made much easier by having strict tolerances in hole position (see chapter 6.1).

Stiffeners are sometimes required to avoid excessive deflection when panel dimensions exceed the limits imposed by wind load (see chapter 4.4.4.).

The use of stiffeners should be preferably avoided, as they may show up on the outer surface because of temperature differentials.

Should stiffeners be inevitable, omega-shaped 6060 alloy extruded profiles should be used (see sketch below).

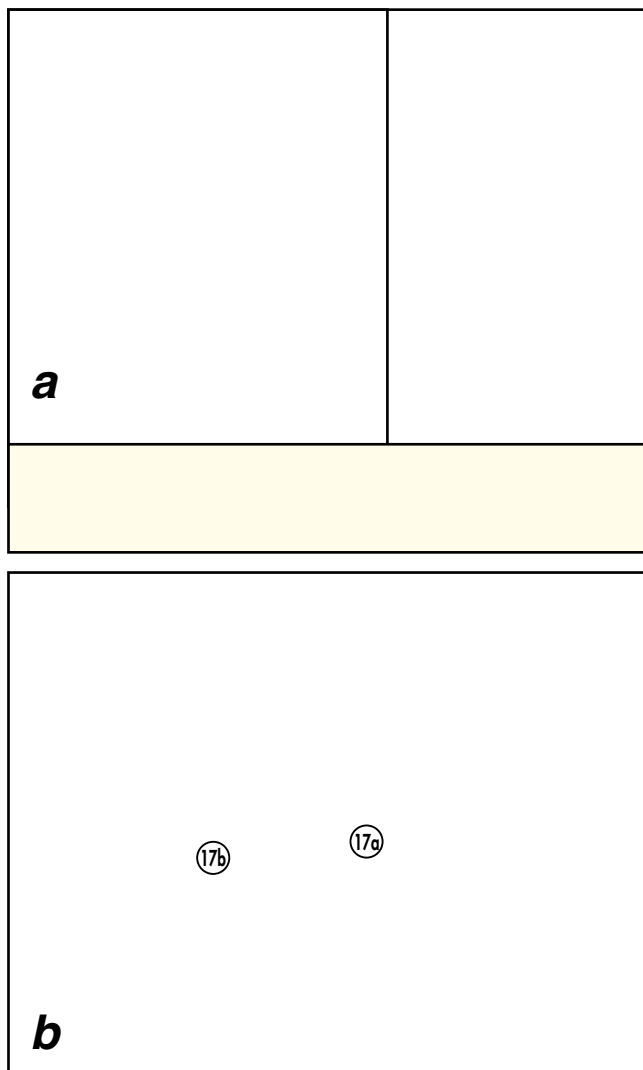
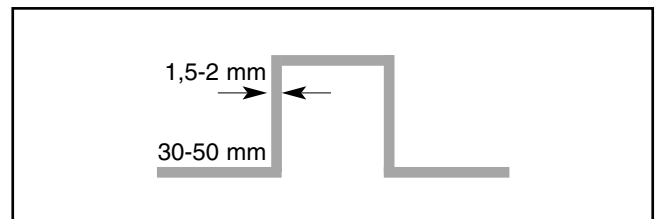


Fig. 20 - Typical design of wall anchor system, with Fischer anchor in the wall (a) and (b) the two steel (or aluminium) brackets (17) with slots permitting alignment in three directions



Stiffeners are usually fixed by silicone adhesive, or more conveniently double sided adhesive Scapa Tapes can be used.

4.3. Insulating Panels

Normally the Mirasystem "A" cladding is applied on a masonry wall and is utilized to generate an important insulation effect. Therefore the insulating layer is an essential component of the system.

The Isover insulating panels (detail 16) are made of glass fibers and have their outer face protected by a thin, vapour-permeable glass film. This external film has 4 functions:

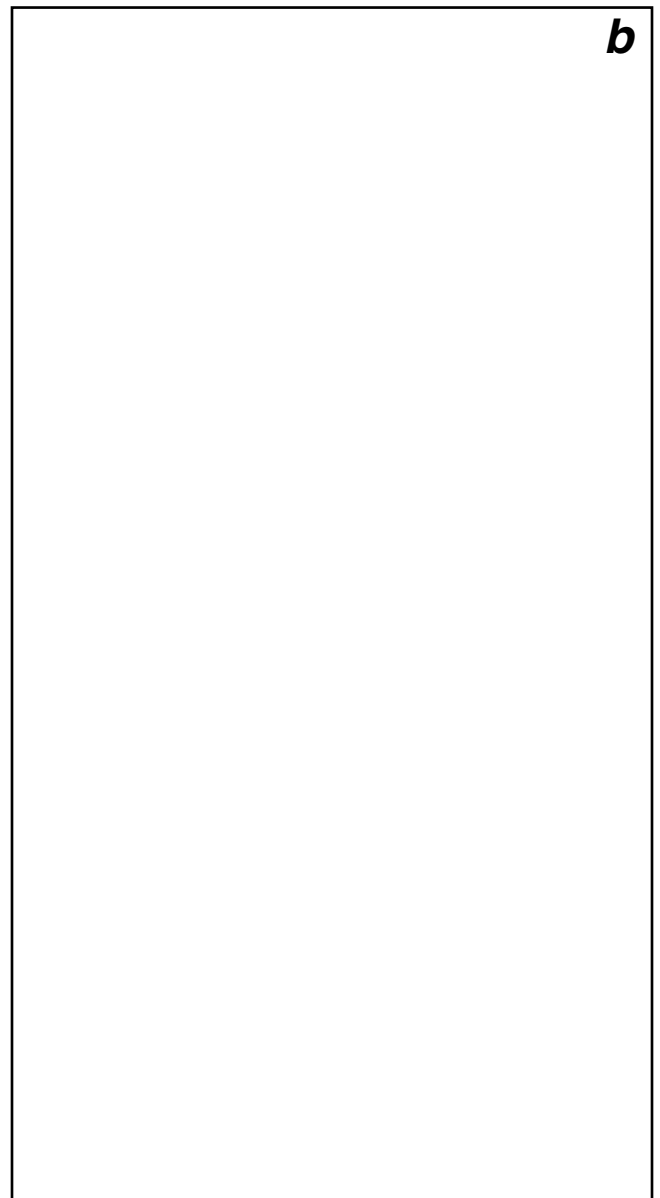
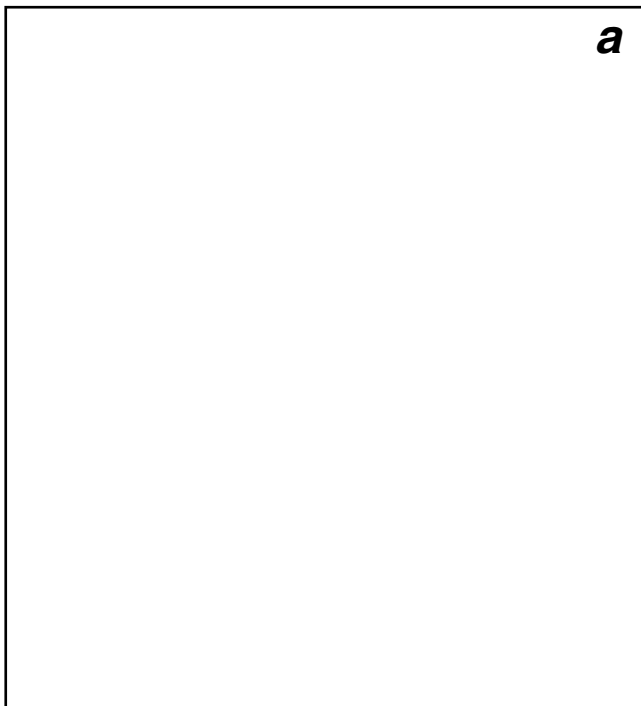


Fig. 21 - a) (left) regular air flow is favoured by the smooth glass surface of the fiberglass panels; **b) (right)** panels and anchors

a) Although permeable to vapour, it is impermeable to water and will prevent any leakage water from moistening the glass fibers inside;

b) It lets vapour from the inside of the building pass to the airspace and be carried away by the upward airflow;

c) It keeps the exterior fibers in place;

d) Its smooth, hard surface offers little resistance to the upward airflow which is essential for the performance of the ventilated cladding.

Isover panels are commonly available in 30 to 60 mm thickness, and a 40 mm panel is rated to bring down the K coefficient of a common masonry wall from 2,0 to 0,63 (**Fig. 21a**). **Fig. 21b** shows typical Fischer anchors and the way they are used to fix the insulating panels on a masonry wall.

4.4. Mirawall Panels

4.4.1. Mirawall Sheet

Mirasystem "A" panels are manufactured from Mirawall sheet produced and supplied by Otefal SpA.

Mirawall is characterized by a thick (50-70 μm) coating of special polyester powder paint applied by a proprietary coil coating process on Panel Quality rolled metal coils.

Panel Quality sheet has been developed by Otefal in cooperation with its aluminium suppliers for the purpose of obtaining a coated Mirawall sheet with optical flatness and the capability of withstanding severe deformation without cracking or exposure of the base metal.

Mirawall is currently supplied with Aluminium/Magnesium 1% 5005 H24 or Aluminium/Manganese 1,2% 3003 H24 alloy as base metal, but the tougher 5754 3% Magnesium alloy can be supplied in the H22, H24 or H34 tempers on demand .

The Table below summarizes the mechanical properties of these materials.

Mechanical properties of Mirawall Aluminium sheet			
Alloy	Temper	Yield Point N/mm ²	UTS N/mm ²
3003	H24	≥115	140-180
5005	H24	≥105	140-180
5754	H22	≥130	220-260
5754	H34	≥190	240-280

4.4.2. Deflection under static load

The basic "cassette" or "tray" panel used by Mirasystem "A" is described in detail at point 4.4.6. and **Fig. 23**. Some general outlines have been introduced in previous chapters.

A question frequently posed is:

"How should the panels and their bearings be dimensioned and designed in order to ensure that the cladding is not permanently distorted or torn off by wind forces?"

Some general information on this subject is given here, particularly with reference to static loads and to the three wind load classes (0,5 - 0,8 - 1,1 kN/m²) considered by the DIN and European Standards at the moment.

This information is meant as a guidance only: dynamic wind load is so much dependent on local conditions, that any cladding taller than 8 metres in strong wind areas should be appraised by a structural engineer taking into account the influence of such factors as turbulence, corner effects, and the configuration of nearby buildings.

4.4.3. Deflection tests

Fig. 22a shows the maximum distance permissible between bearings for *flat* sheets on 2 bearings in various alloys, tempers and thickness. Beyond that distance the sheet will incur permanent deformation.

This provides a general view of the difference to be expected when using different materials, but of course the behaviour of Mirasystem "A" tray panels could be expected to be considerably better, as the "tray" shape has more rigidity.

Some calculations have been made of the theoretical rigidity of a perfect "tray" panel, and deflection tests have been carried out on actual Mirasystem "A" panels.

The results of the practical tests illustrated in **Fig. 22b** show that the deflection of the real panels is halfway between those of flat sheet and "perfect" tray shapes.

The comparison in **Fig. 22b** is between a smaller square (1300x1300 mm) panel made from 2 mm

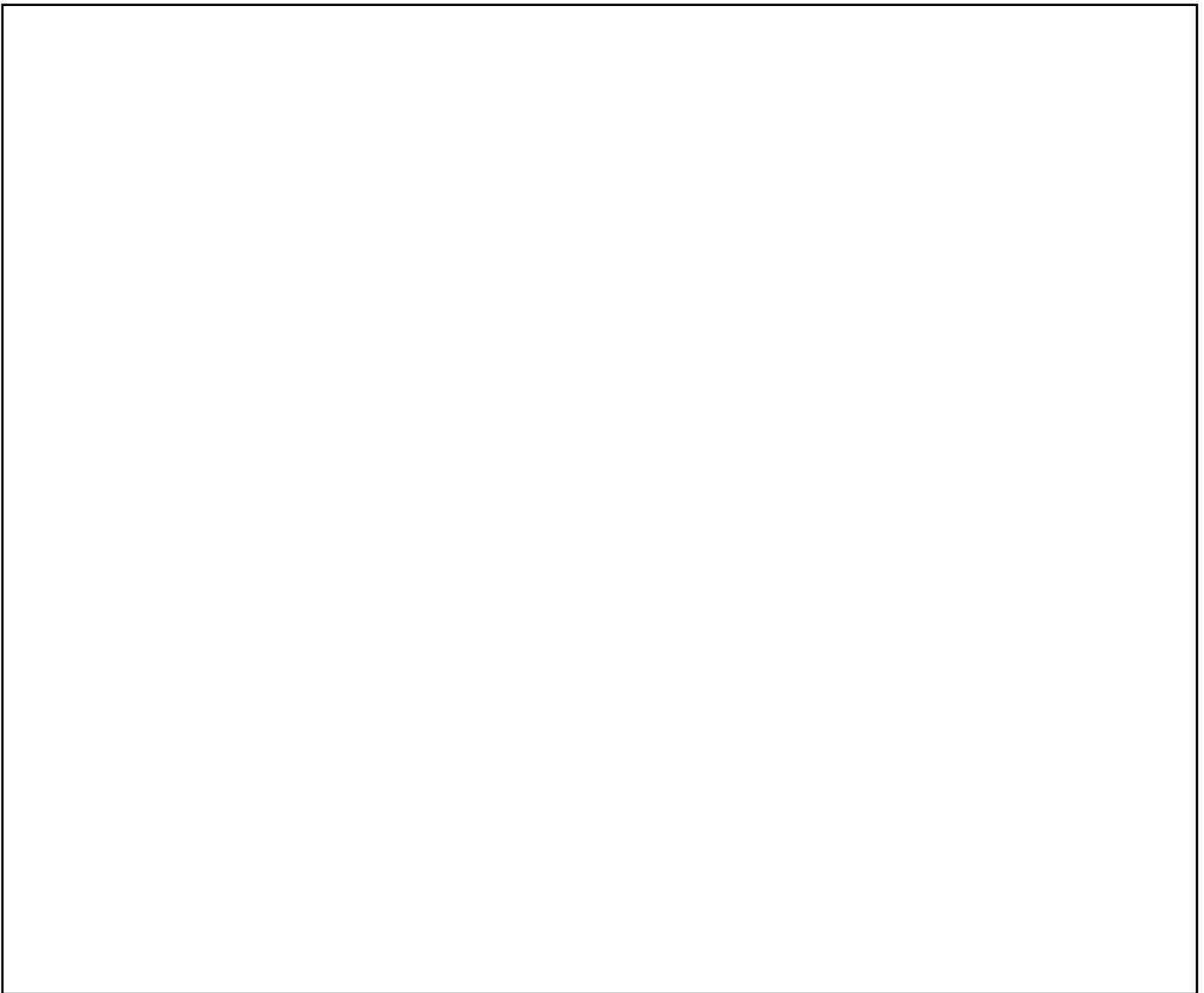


Fig. 22 a) - Maximum distance (metres) between bearings for sheets of different alloys, tempers, and thickness in order to avoid permanent deformation. /2 = 2 mm thickness; /3 = 3 mm thickness

thick Mirawall, and a much larger (3000X1000 mm) one made from thicker (3 mm) Mirawall.

The panels were hung horizontally with their outer face downward and were loaded on the back with increasing weights, so reproducing the more dangerous stress caused by depression forces (see scheme below).

Deflections were measured at the middle point. In this case, the acceptance limit was set at a deflection value of 20 mm, approximately corresponding to 1/50 of the distance between bearings. This limit for the softer alloys 3003, 5005 is not far from the limit beyond which permanent deformation is expected.

The conclusion is that a 1300 x 1300 x2 mm Mirasystem panel does not exceed that deflection li-



mit even under a static load of 1.1 kN/m², equivalent to a very strong wind. Performance in this respect was not significantly affected by either width of the folded borders nor by the distance between hooks varying from 450 mm to 900 mm. On the contrary, a much longer panel (mm 3000x1000), even if made from thicker (3 mm)

Deflection of tray ("cassette") Mirasystem "A" panels under static load. Alloy 5005 H24. Measurements taken at the point of maximum deformation. Values were little influenced by: a) back milling to depth \approx half the thickness; b) width of folded borders (65, 70, 90, 100 mm); c) distance between hooks (900 or 450 mm).

Fig. 22 b) - Results of tests on Mirasystem panels with different shapes and metal thickness (h = building height)

material, exceeded the acceptable deflection even for a relatively mild load of $0,8 \text{ kN/m}^2$.

In such a case, when higher loads may be expected, deflection of the panel should be restrained either by increasing the number of hook pairs or by reducing the distance between mullions or by applying stiffener bars on the back.

Should the harder alloy 5754 be used, the panel may be expected to withstand higher deflection, e.g. 30 mm (upper horizontal red line) without permanent deformation, although it would exceed by far the deflection limit of $1/50$.

The harder alloy might permit to use a thinner gauge of sheet, but the designer should consider how a greater deflection may affect other performances, such as water infiltration during a storm.

4.4.4. Dimensioning criteria

Based on the static tests and past experience, some guidances are presented in the following table about sheet thickness and the number of stiffeners that may be required.

Interpolation can be adopted for intermediate cases, and the cautions at the end of point 4.4.2. should be kept in mind. As a general rule, whenever wind forces higher than $0,5 \text{ kN/m}^2$ may be expected the vertical distance between hook pairs and the horizontal distance between mullions should be kept below 950 mm, or stiffeners should be introduced.

**SUGGESTED DIMENSIONS AND STIFFENERS OF MIRASYSTEM PANELS
ALLOYS 5005 H24 AND 3003 H24**

Wind Load 1,1 kN/m²

HEIGHT mm	WIDTH mm			
	1000		1500	
	Thickness mm	Stiffeners N°	Thickness mm	Stiffeners N°
1000	2	0	2	0
1500	2	0	3	0
2000	2,5	0	3	1
2500	3	1	3	2
3000	3	2	3	3

Wind Load 0,8 kN/m²

HEIGHT mm	WIDTH mm			
	1000		1500	
	Thickness mm	Stiffeners N°	Thickness mm	Stiffeners N°
1000	2	0	2	0
1500	2	0	2,5	0
2000	2,5	0	2,5	1
2500	2,5	0	3	1
3000	3	1	3	2

Wind Load 0,5 kN/m²

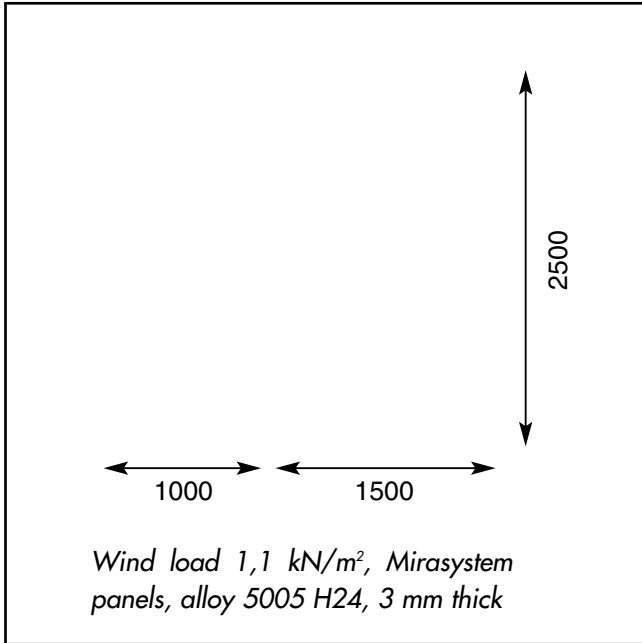
HEIGHT mm	WIDTH mm			
	1000		1500	
	Thickness mm	Stiffeners N°	Thickness mm	Stiffeners N°
1000	2	0	2	0
1500	2	0	2	0
2000	2	0	2,5	0
2500	2-3	1-0	3	1
3000	2-3	1-0	3	1

NOTES:

- 1) Vertical distance between hooks should not exceed 950 mm.
- 2) If harder alloy 5754 H34 is used, thickness can be reduced by 0,5 mm, e.g. 2,5 mm instead of 3 mm or 1,5 mm instead of 2 mm. The thinner panels of the harder alloy will deflect more deeply under wind load (1/40 of the distance between bearings instead of 1/50) but will suffer no permanent deformation.

4.4.5. Stiffeners

When panel size exceeds the normal limits, they should either have intermediate anchoring points, or be stiffened by L or Omega shaped bars on the back, fastened by silicone or adhesive tape (see 4.2). An example from table above is shown below.



4.4.6. Panel types

Mirasystem "A" uses as a panel the "Raised Wing/Integral Hook/90° joint" design, without riveted corner plate. This is the simplest type and

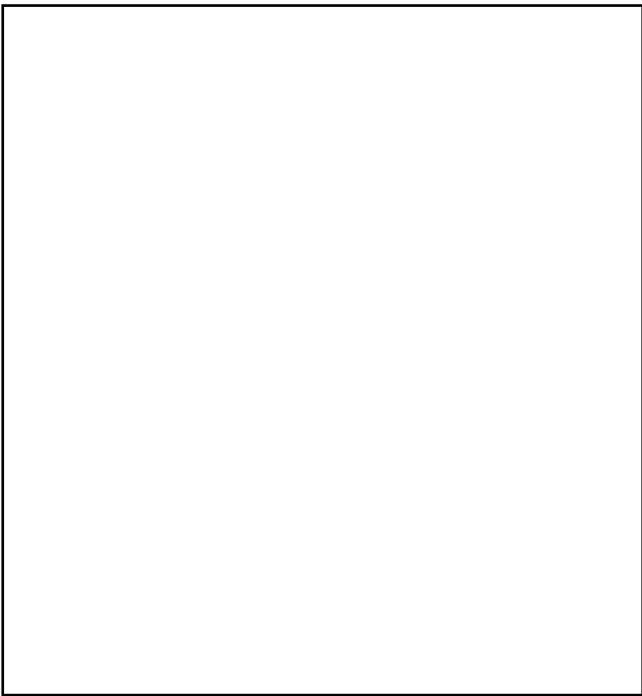


Fig. 23 b) - A panel with riveted hooks

has two possible alternatives: rounded fold corners (without back scoring) or sharp corners (with back scoring).

This basic design, using 2-3 mm thick 3003 or 5005 alloy, is sufficiently strong for normal size panels in areas where wind loads are lower than 0,8 kN/ m² (see points 4.4.2., 4.4.3.)*. It can also be used for higher wind loads, depending on metal thickness, alloy strength, back scoring and other factors.

Figs. 23a, b, c put the Mirasystem "A" panel design in perspective relative to other possible de-

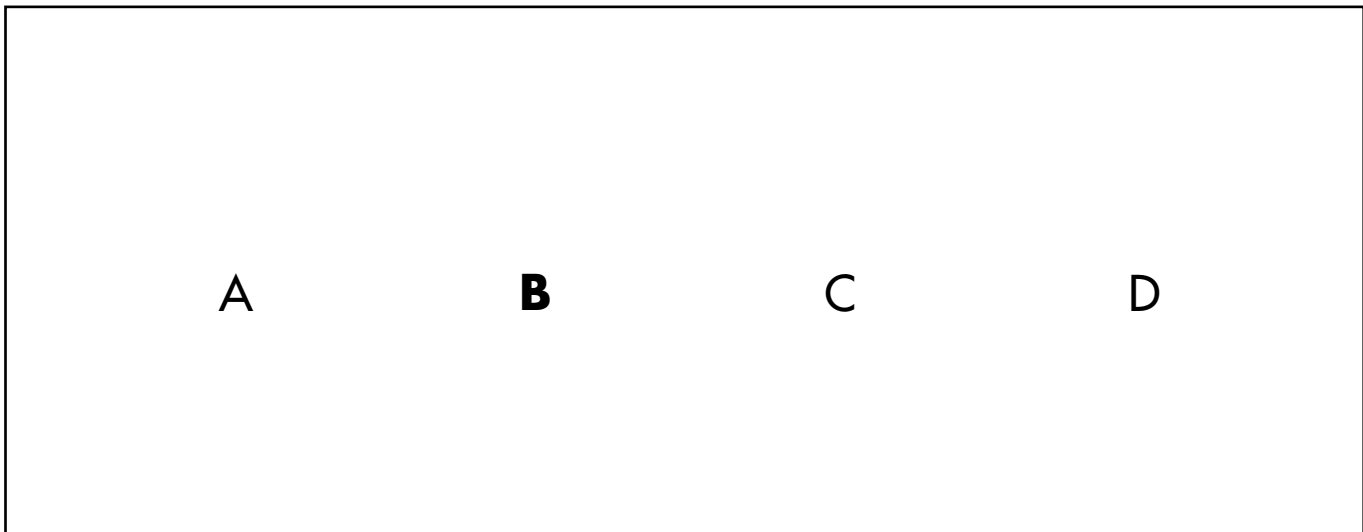


Fig. 23 a) - The Raised Wing (B) Mirasystem "A" panel compared to other designs

Riveting of
corners,
if needed

Fig. 23 c)
Section of
panel
assembly with
even folds
and cut
mullion.
45° corner
joints,
conventional
design used
for composite
sheet

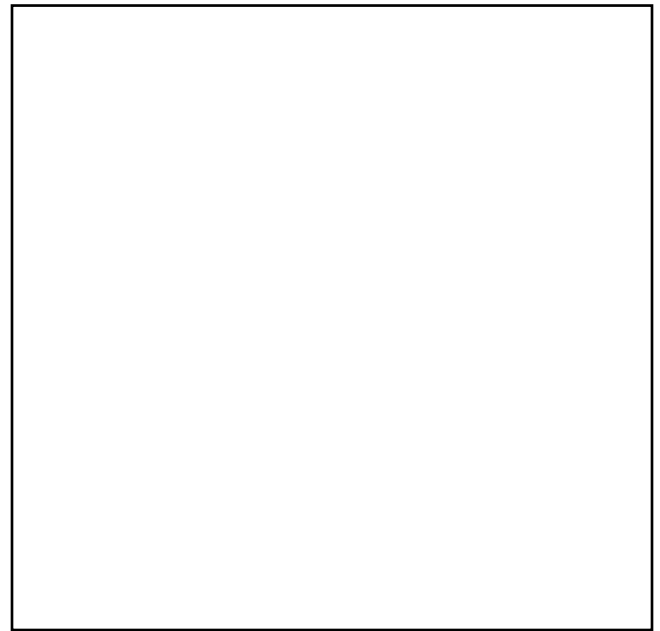


Fig. 23 d) - 90° joint seen from above: horizontal fold prevailing (VF=Vertical Fold)

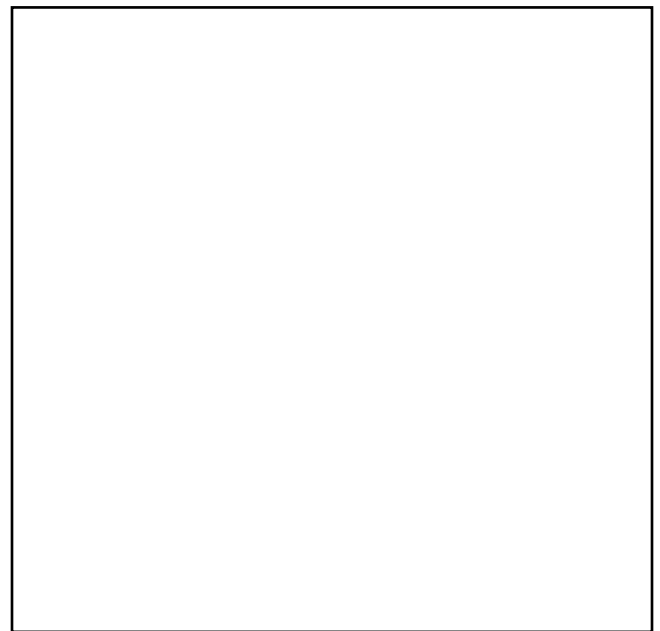


Fig. 23 e) - 90° joint seen from above: vertical fold prevailing

signs, showing that panels may differ by:

a) Having "Integral Hooks" or "Riveted Hooks". Integral hooks of Mirasystem are blanked out of the vertical folds, riveted hooks instead are separate pieces applied after folding (**Fig. 23b**);
b) The width of the vertical folds: the "Raised Wing" Mirasystem design has vertical folds wider than the horizontal folds (as examples A, B), while the "Even Wing" design has all folds with the same width (as examples C, D): in the latter

case, the bearing mullions must be cut to accommodate the horizontal borders as shown in **Fig. 23c**, unless riveted hooks are used;
c) The inclination of the corner joint: 45° as in A and D, or more simply 90° as in B (Mirasystem) and C;

d) The use, or not, of a riveted corner plate for a stronger joint, as in A, D: this is only neces-

sary when composite aluminium/plastic/aluminium laminates or thin aluminium sheet are used, or where exceptional wind loads can be expected;

e) The use of sharp or radiused fold corners (**Fig. 23g**), depending upon whether the back of the sheet has been scored or not on the back before folding. Mirawall can have either of these features. This will be either for aesthetical reasons, or because the fabricator needs to use scored panels in order to fold by hand.

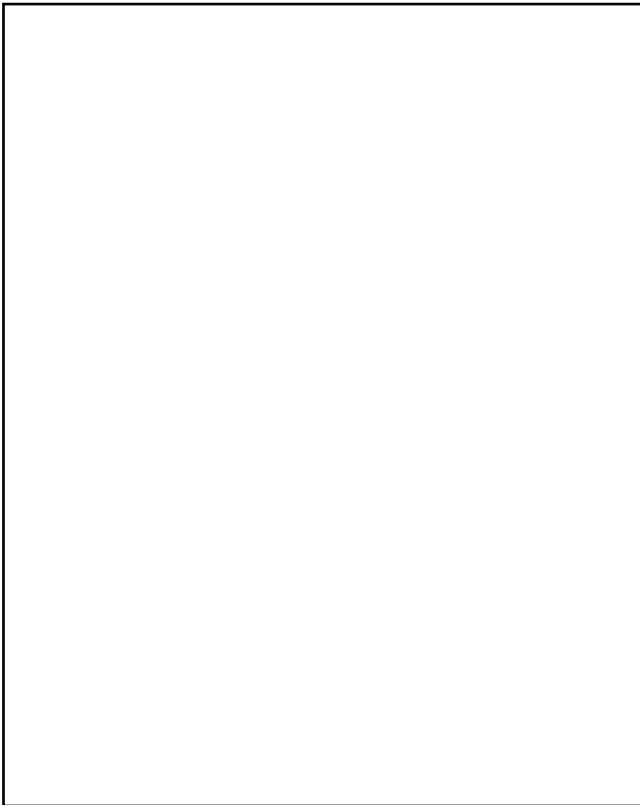


Fig. 23 f) - The panel shown in the two previous figures. HF = Horizontal fold; VF = Vertical Fold. This is a "raised wing" panel with vertical folds wider than horizontal folds

The basic Mirasystem "A" panel was chosen among all those possibilities as the most economical choice, and it can be fabricated in two slightly different ways, as shown in **Figs. 23d, e, f**.

The difference between the two alternatives depends upon which of the folds -the horizontal or the vertical one- overlaps the border of the other.

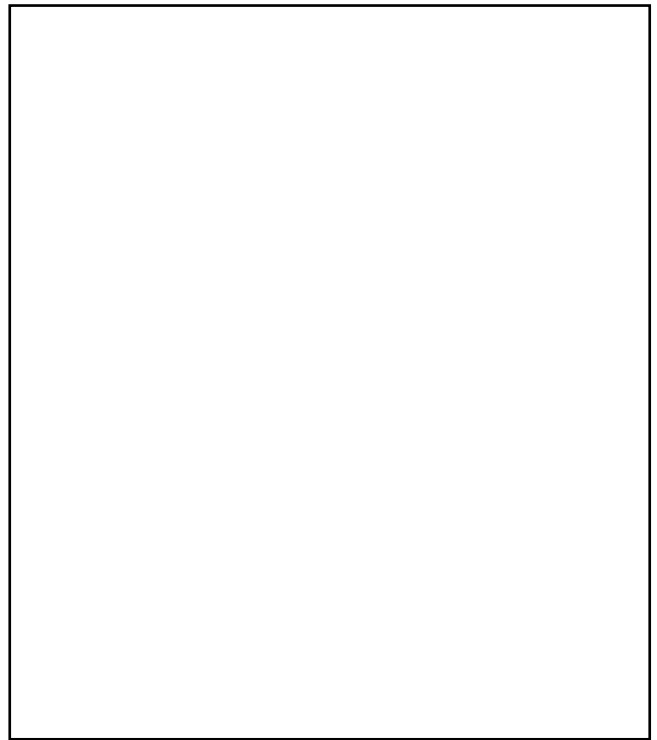


Fig. 23 g) - Scoring before folding (above) is necessary with multilayer composite panels. It produces sharp corners but is expensive and weakens the material (only 0.5 mm is left after scoring). Folding without scoring, or with shallow scoring (residual thickness 1 - 1.5 mm), as done with Mirawall, is simple and maintains panel strength

The choice between the two should be made on aesthetical grounds, considering which bare borders will be more visible.

A final consideration about the basic panel is that it is not a completely watertight panel. In the majority of cases ventilated walls do not need costly watertightness: water leaks are channelled and water drained away down the mullions.

Should a watertight panel really be necessary, the 45° design could then be adopted, as its joints can be more easily made watertight by applying a silicone sealant.

*** NOTE: The range of conditions in actual exposure is so wide that the supplier of Mirawall, while offering this technical information at the best of his knowledge, can not take responsibility for structural resistance, which should be calculated by the utiliser for each particular case.**

5 PANEL FABRICATION

The fabrication of Mirawall for Mirasystem "A" involves the following operations:

- a) Scoring (when needed)
- b) Blanking hooks and corners
- c) Folding

5.1. Scoring and Blanking

A typical pattern of blanking and scoring operations for the basic Mirasystem "A" panel is shown in **Fig. 24**.

Scoring of course is optional and it is not usually needed when Mirawall is used in thickness of 2 mm or less (Note: scoring or routing is necessary with alternative laminated materials having a plastic core clad with thin coilcoated aluminium). Thicker metal (2,5-3 mm) may require back scoring for the reasons said at e), point 4.4.6. (see also 5.2.1, 5.2.2).

By avoiding the back scoring process, considerable economy ($\approx 7 \text{ \$/m}^2$) may be achieved in panel fabrication.

5.1.1. Scoring Techniques

When scoring is needed, the simplest equipment is a machine such as the Holzer shown in **Fig. 25**, where the Mirawall sheet can also be cut and squared before scoring.

This machine uses disc saws, 250-300 mm diameter, and the section of the groove should preferably be a U-shape as shown in **Fig. 31**.

V-grooves are sometimes used, but these may become too tight after bending, and cause distortion when thermal expansion occurs.

Whenever scoring is considered to be necessary, the depth should be kept as little as possible in order to reduce cost and preserve the mechanical strength of the panels. If the reason for scoring is aesthetical, i.e. sharpness of fold corners, then the groove can leave a residual metal thickness of 1,5 mm.

This residual thickness of 1,5 mm may not be acceptable if the fabricator must fold directly by hand as in **Figs. 27, 32**. In this case the scoring may go down to leave only 0,8-1 mm of metal, depending on the auxiliary equipment available:

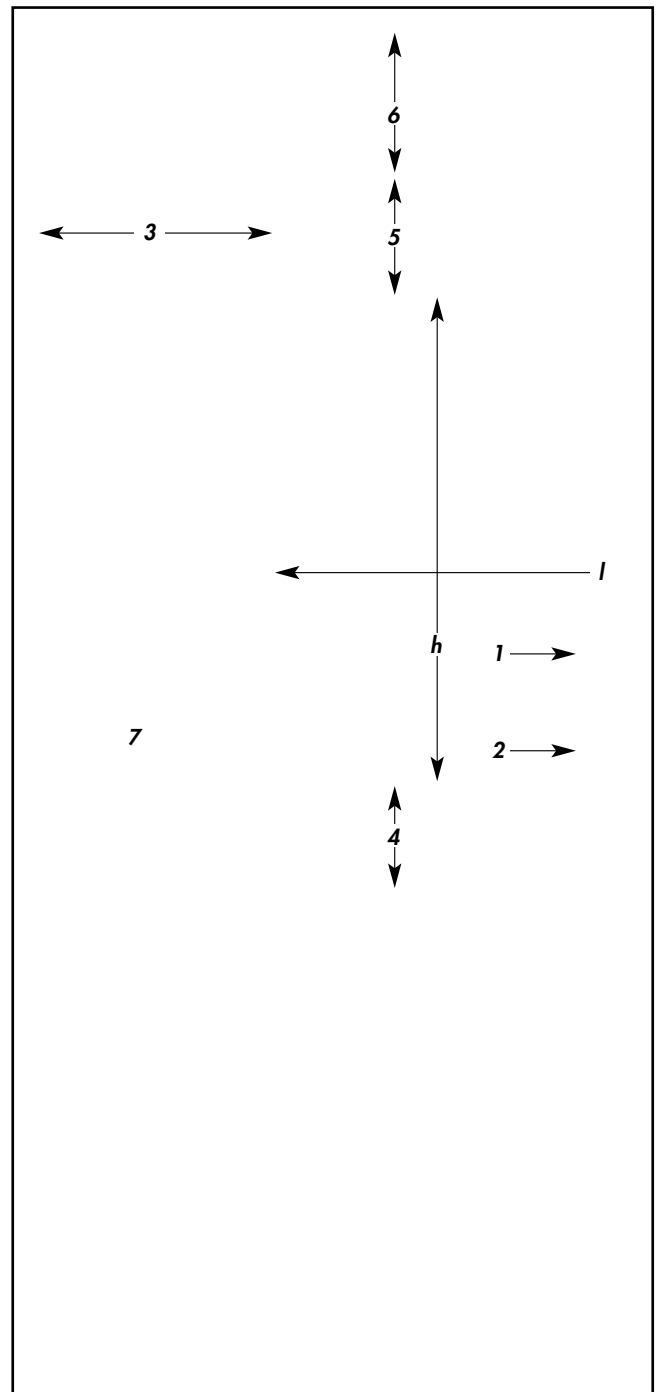


Fig. 24 - Back scoring and blanking pattern of a Mirasystem panel

h = Vertical distance between cladding gridlines

l = Horizontal distance between cladding gridlines

1 = Thickness of Mirawall sheet

2 = Residual thickness after scoring

3 = Width of side folds

4 = Width of lower horizontal fold

5 = Horizontal upper fold

6 = Horizontal upper 2nd fold

7 = Cut-off step at bottom end of vertical folds (to facilitate overlapping)

(see example of typical dimensions in **Fig. 4**)

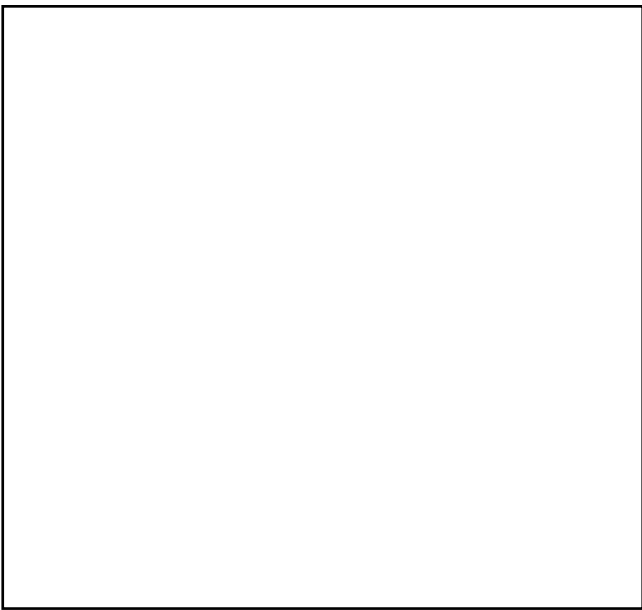
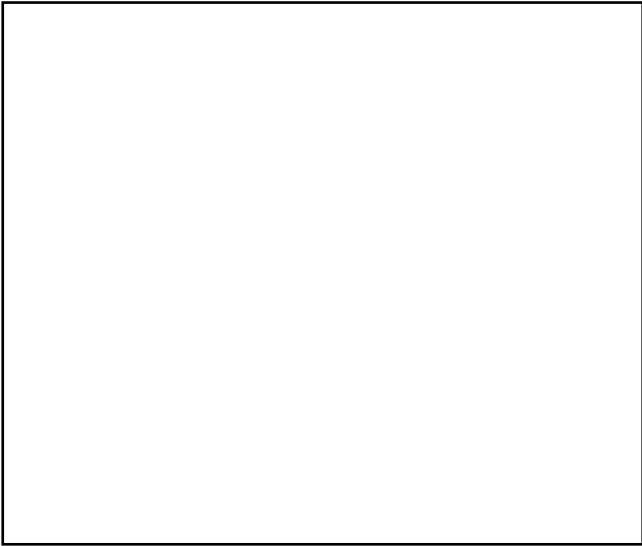


Fig. 25 - The Holzer Scoring Machine, also used to trim and square the panel blanks

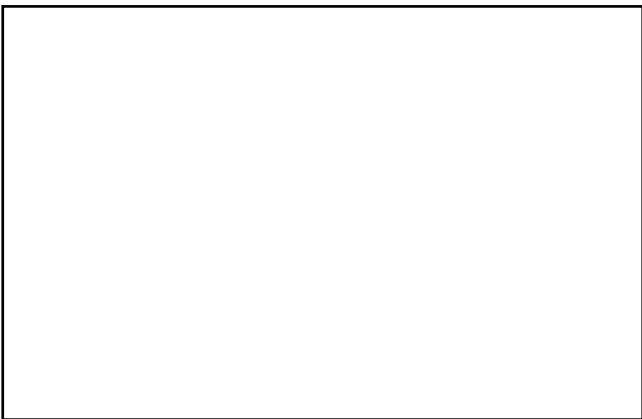


Fig. 26 a) The Euromac Squaring and Scoring Machine

this residual thickness, anyway, is still nearly double the thickness remaining after back milling of the composite laminates as Alucobond.

For larger operations, more complex and expensive computer-programmed custom-made machines are available, and these usually work on the horizontal sheet. The Euromac machine (**Fig. 26a**) will automatically square, blank and score the sheet. Other special units, such as the Salvagnini work center, can also do the folding and therefore will deliver a finished panel.

5.1.2. Blanking

Blanking is always necessary to create the corner notches required for folding, and to cut the hooks in the vertical sides.

Blanking can be carried out on a simple machine such as the Tekna unit in **Fig. 26b**, or it can be

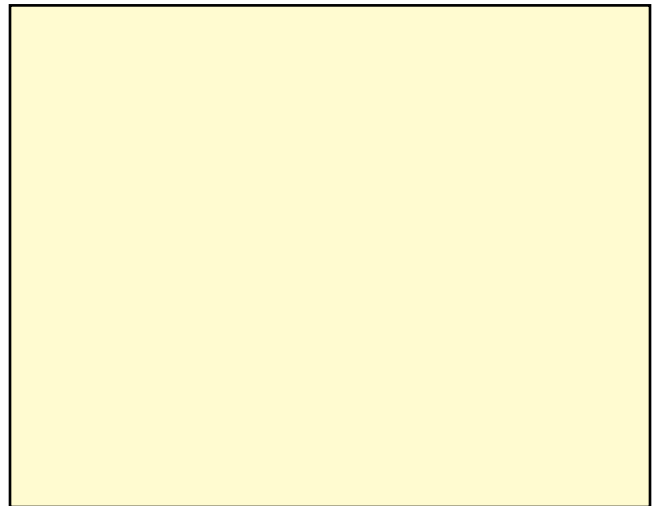


Fig. 26 b) The Tekna Blanking Machine

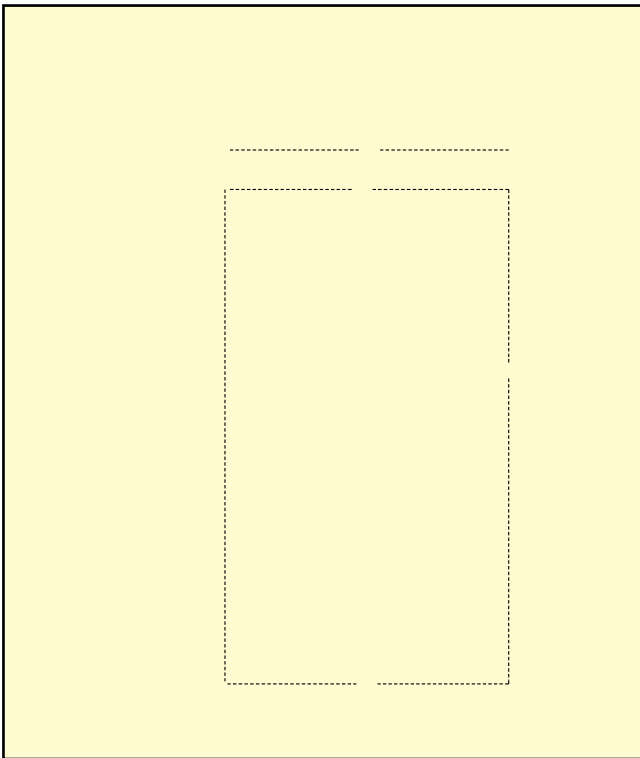


Fig. 26 c) - General blanking scheme for the basic Mirasystem "A" panel. Width of bottom horizontal fold to be defined in consideration of sheet thickness, to permit hanging



Fig. 26 d) - The CIMSA U.T.A.4 corner blanking unit

one of the many steps in a cycle performed by one of the automatic centers mentioned above. Manufacturers that do not have a specific blanking machine but do have a hydraulic bending press, can use it for blanking by adapting the punching tools to suit the press, which will therefore be used alternatively for blanking and for bending. The basic blanking scheme in **Fig. 26c**, and **Figs. 26d** to **26f** show how blanking of corners and hooks can be carried out in a common hydraulic bending press by attaching to the press the special tooling supplied by CIMSA. A flat beam is applied to the upper part of the

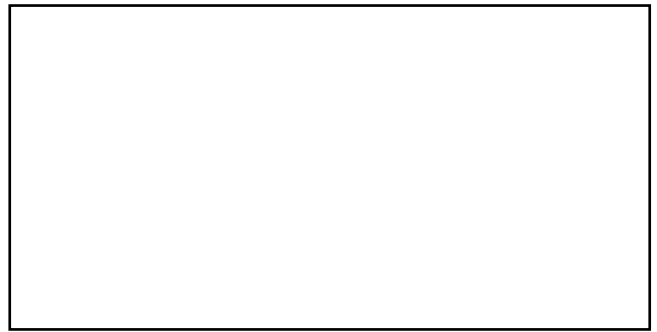


Fig. 26 e) the CIMSA U.F.4-80 hook blanking unit

press instead of the bending blade, and the punching tools are fixed to the lower part. This adaptation is conveniently adopted when small series of panels are involved and an investment in special punching machines would not be justified.

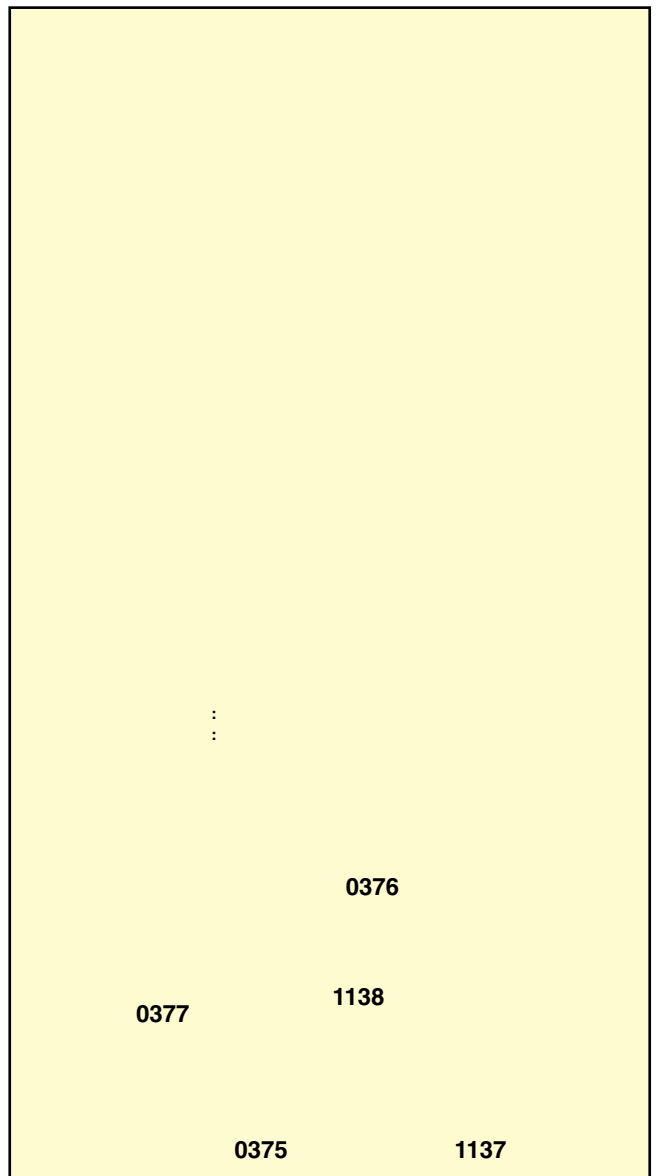


Fig. 26 f) The beams that are mounted on the bending press to fix the CIMSA blanking tools

5.2. Shaping the Panels

Mirasystem "A" panels can be fabricated in 4 ways:

- a) By simple hand folding (**Fig. 27a to 27f**): this involves using either thin gauge Mirawall sheet, or pre-scored 2-3 mm sheet;
- b) By a folding machine (**Fig. 28a, b, c**);
- c) By a hydraulic brake press (**Fig. 29**);
- d) By a computerized high-productivity working center like the one shown in **Fig. 26a**, which may also include the final folding step.

5.2.1. Hand folding

Simple hand folding obviously is a slow, labour-intensive operation, and can only be done on

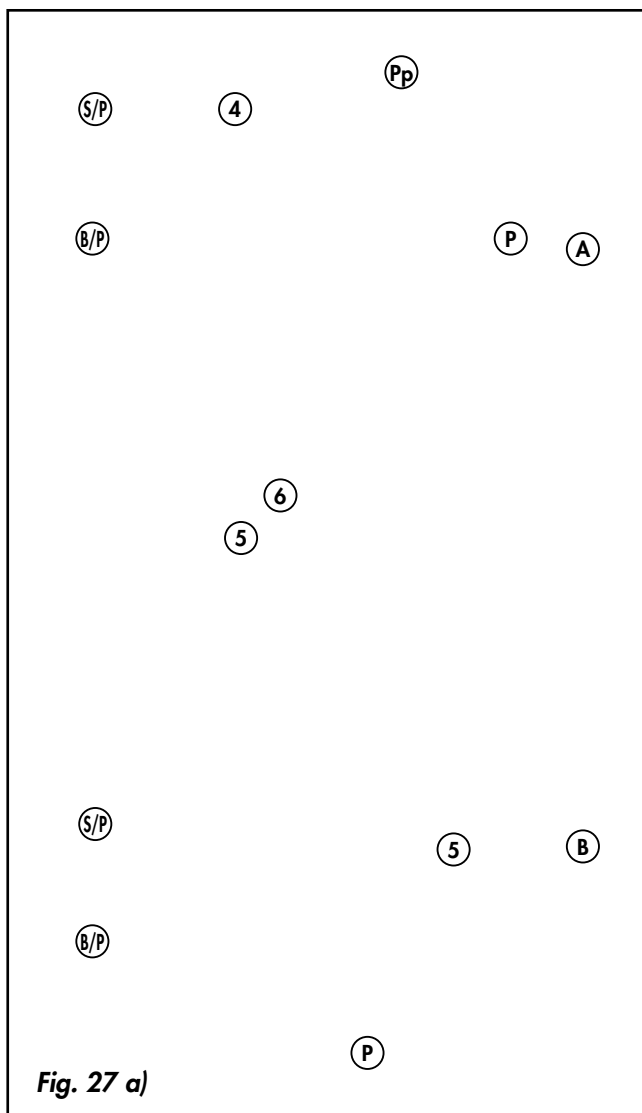


Fig. 27 a), b), c), d), e), f), g) - Basic steps of hand folding a scored panel

thin or back-scored sheet. However, it may be convenient for small lots, and of course it may be the only solution where no mechanical equipment is available and/or labour is cheap.

It is worthwhile to illustrate in some detail the steps of hand folding (**Fig. 27a, g**), as they mostly apply to other mechanical folding methods as well.

Fig. 4, page 13, presents the example of a typical Mirasystem panel and the sequence of folding steps, which are then described in **Figs. 27a to 27g**.

Basic hand folding equipment can simply consist of a fixed bench (**B/P** in **Fig. 27a**) and a lever-handled bar **P** hinged along one bench border, so that it can be gripped by the handles and swung upwards to push and fold the borders of the sheet. The bar **P** has a longitudinal U-channel, which is needed at stage B (**Fig. 27a**) to accommodate the first of the two top folds while the bar raises to produce the second top fold.

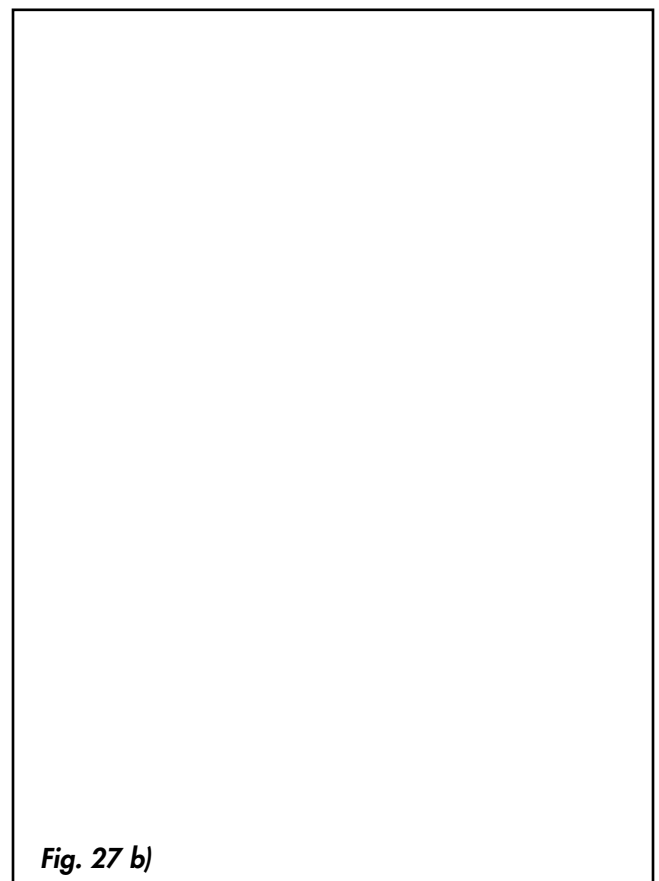
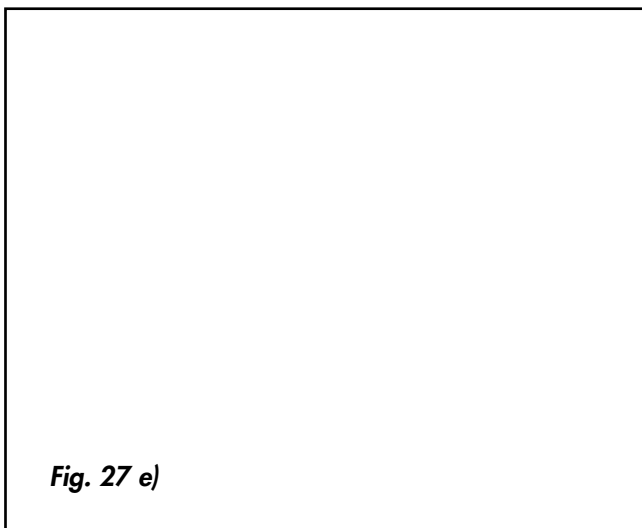
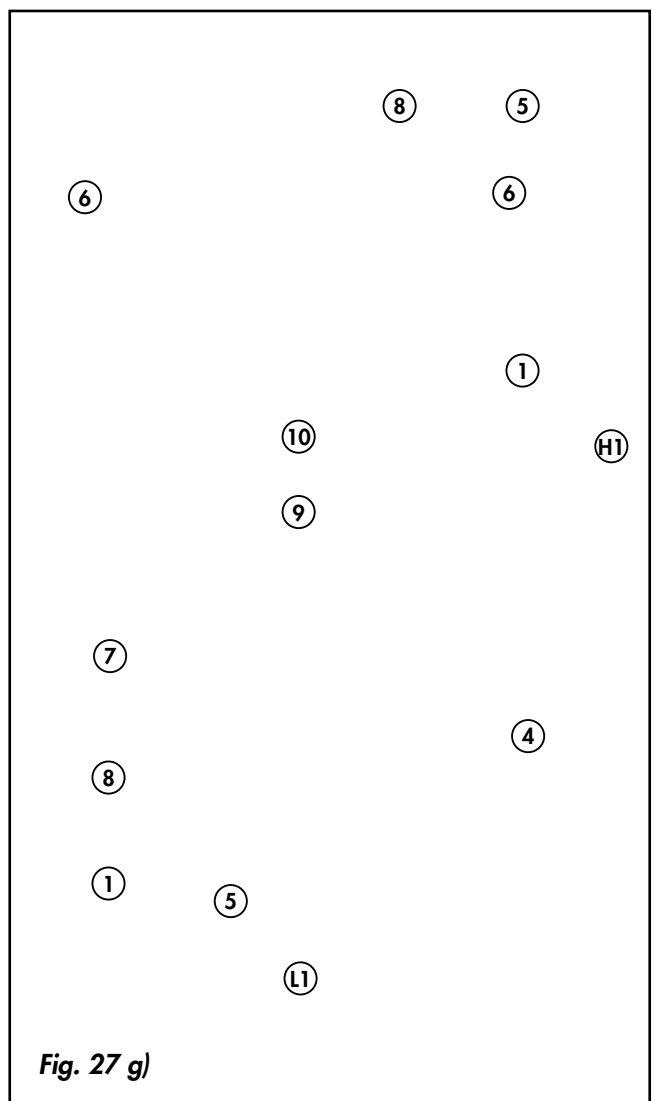
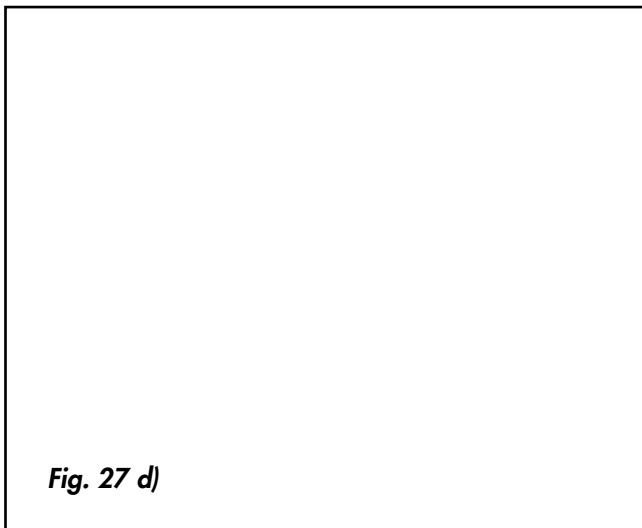
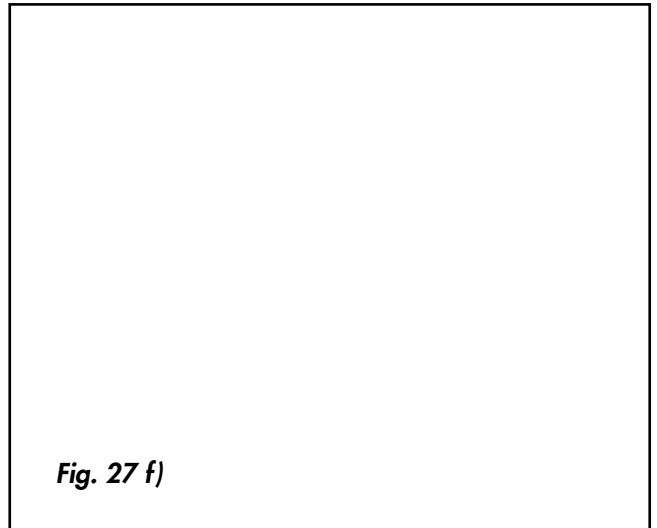
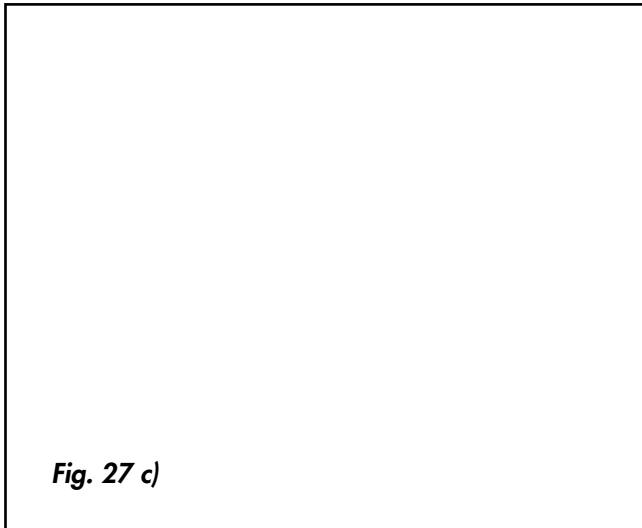


Fig. 27 b)

Pressure blocks, generally wooden, are used to hold the sheet firmly in place, by pressing them with adjustable screw-clamps as shown in **Fig. 27 b**.

The wooden blocks may have the same length, longer than the fold, except for the final bend (closing the cassette, **Fig. 27f**) when the block should be 1 cm shorter than the fold length.



5.2.2. Using a swing-folding machine

A swing-folding machine is shown in **Fig. 28**. Such a machine works much in the same way as the simple hand folding described above, pushing up the border from the underside.

Machines of this type come in a wide range of powers and prices: from the simplest smallest ones that are hand-operated and have limited capacity as to sheet length and thickness, up to fully mechanized units that automatically clamp the sheet adapting the length of the clamping blocks to the length of the fold.

The border of the fixed upper beam against which the sheet is pushed may have different

shapes, and the most frequently used is a radiused ($R = 3-6 \text{ mm}$) edge.

Such mechanical folding machines can usually bend up to 2 mm thickness without the need for scoring the back.

Thicker sheet is usually scored, leaving 1,5 mm metal at the bottom.

However, some of the more powerful units - usually incorporated into a full-cycle automatic machine- will bend 3 mm Mirawall sheet without back scoring.

This of course will produce a radiused bend: Mirawall's special flexibility permits folding the un-scored sheet with minimum radius equal to thickness (T1 bend), so that a 3 mm sheet can be bent with an inner radius of 3 mm and an outer radius of 6 mm (see **Fig. 23g**).

The harder grades of Mirawall, based on the 3% Magnesium alloy 5754, are sometimes folded with a double radius, depending on the temper and on the available equipment.

The radius of curvature of the fold corners is influenced to some extent by the shape of the upper beam border, but the major factor is the distance between the active lower beam and the fold line: the greater the distance, the more rounded the fold corner.

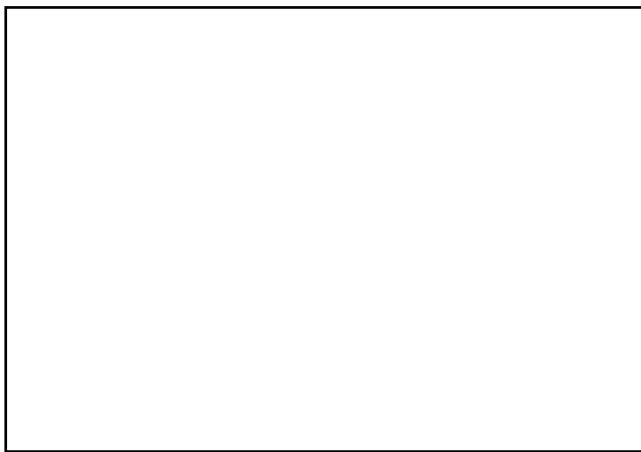


Fig. 28 a) - A mechanical MA folding machine (Schlechtl / Carbonini)

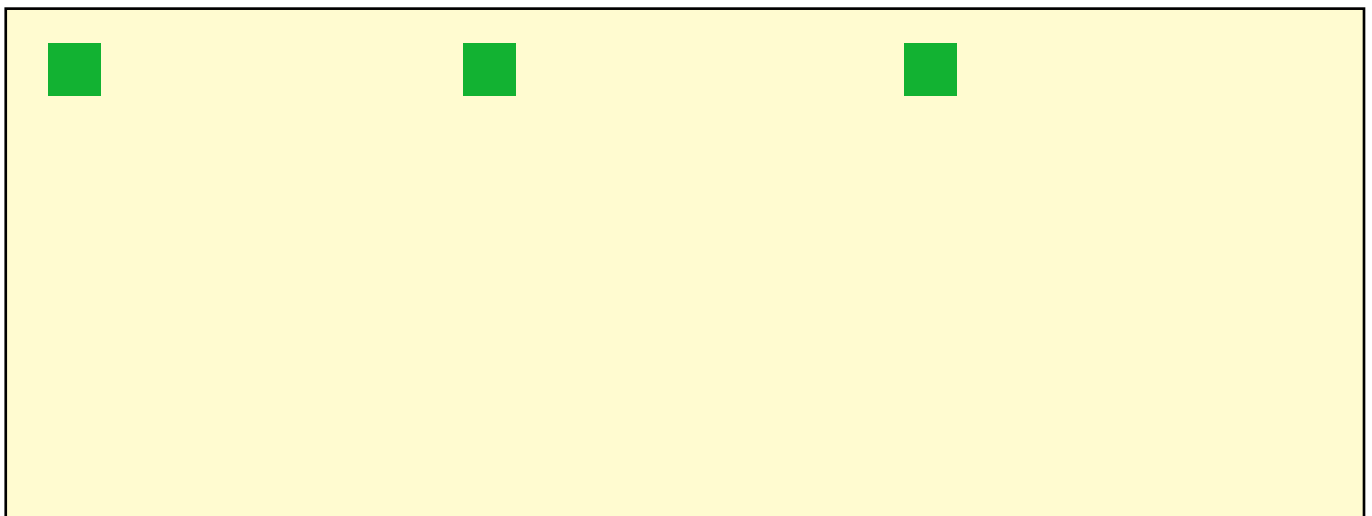


Fig. 28 b) - Sections of three MA machines with different folding power raising to push the sheet border upwards (arrows), much the same way as is done by hand folding.

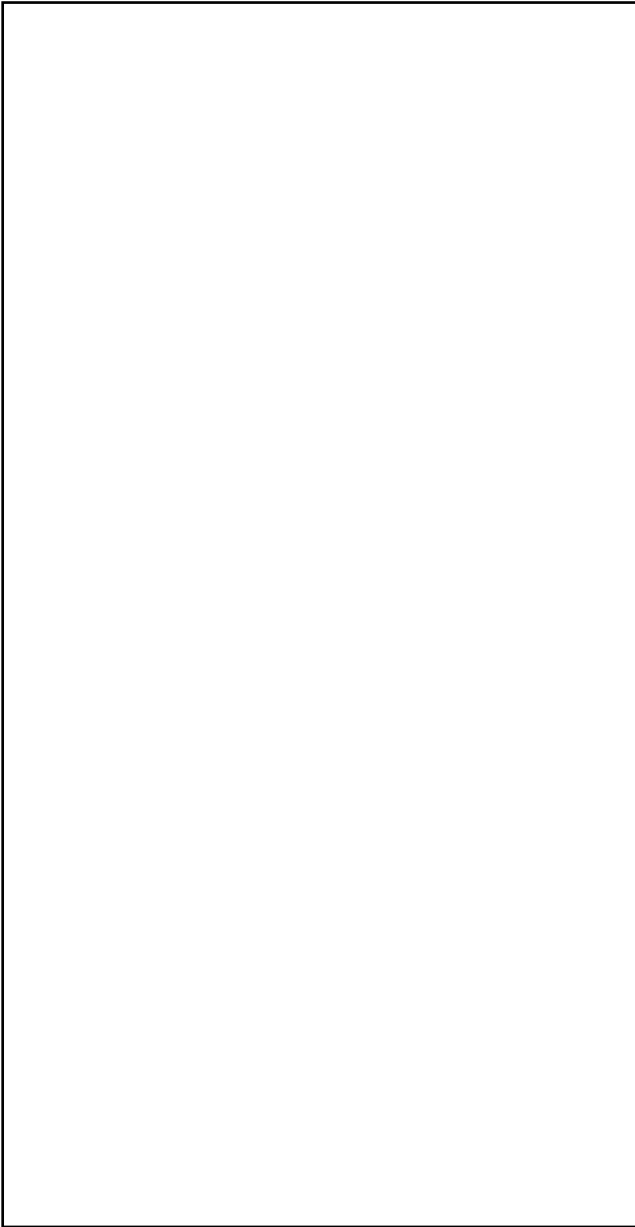


Fig. 28 c) - A Mirawall sheet ready for folding in a machine of the same type. Bending is caused by the beam on the left raising to push the sheet border upwards (see arrows in Fig. 28 b)

5.2.3. Using a Hydraulic Brake Press

While folding machines are probably the simplest and most effective equipment to be used for shaping the panels, they are not so commonly available as hydraulic brake presses, and most Mirawall fabrication is eventually done by this kind of press (**Fig. 29**).

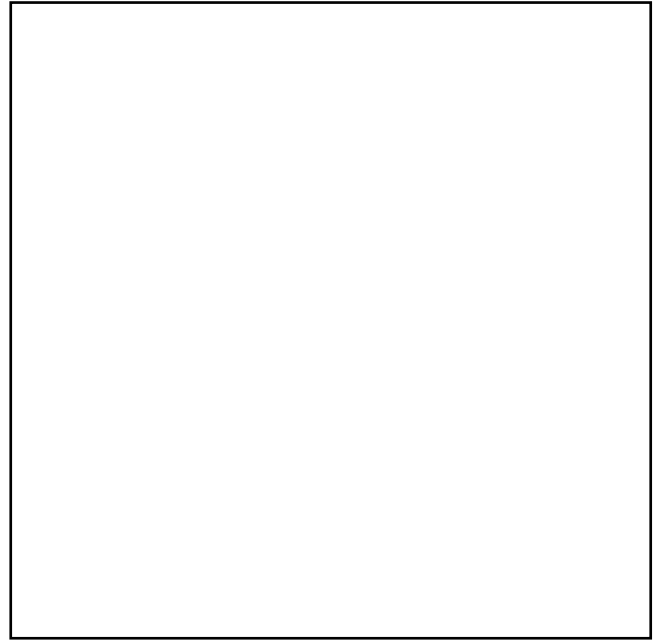


Fig. 29 - Bending in a hydraulic brake press

Excellent results are obtained by using slow, finely tuned pressure increase as is possible with state-of-the-art presses (mechanical presses are not suitable).

In order to obtain straight corners, the punch blade should be as long as possible and its section profile should be specially shaped depending on the type of bend to be done, i.e. either a sharp bend on a scored panel, or a radiused bend on a non-scored one.

a) The radiused bending of non-scored Mirawall is almost a classic operation, and it follows the general rules of sheet bending. The tooling shown in **Fig. 30** is quite conventional.

However, it is worthwhile to underline that according to recent experiments the radiused bend is not obtained using a rounded punch blade: the tip of the blade is rather flat, with a 2 mm width, and the radius of the bend is a function of the width of the V-die.

b) The sharp bending of scored panels may be carried out with a very sharp punch blade, penetrating into the scored groove, but more re-

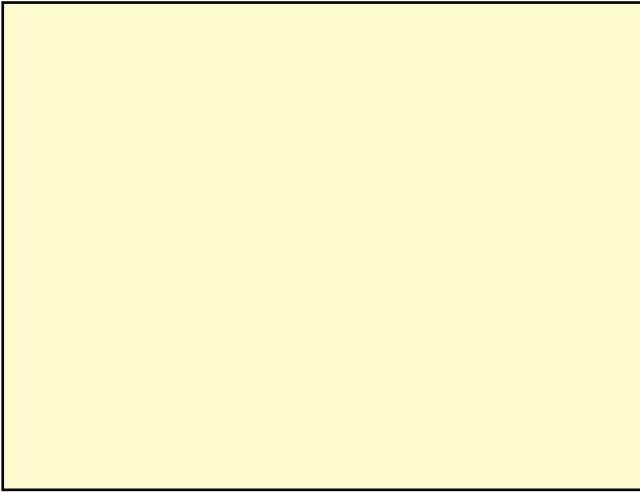


Fig. 30 - Prospect of a typical tooling for radiused bending of non-scored 3 mm Mirawall

cently better results have been obtained with a tooling as in **Fig. 31**, where a rather large rounded punch is used, and the V-die has a rounded -rather than a sharp- design.

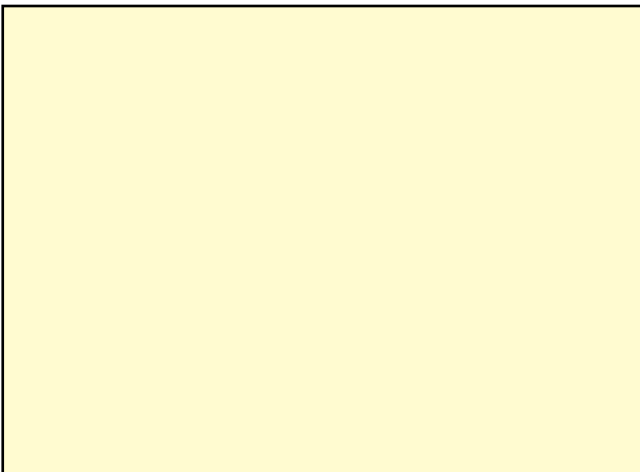
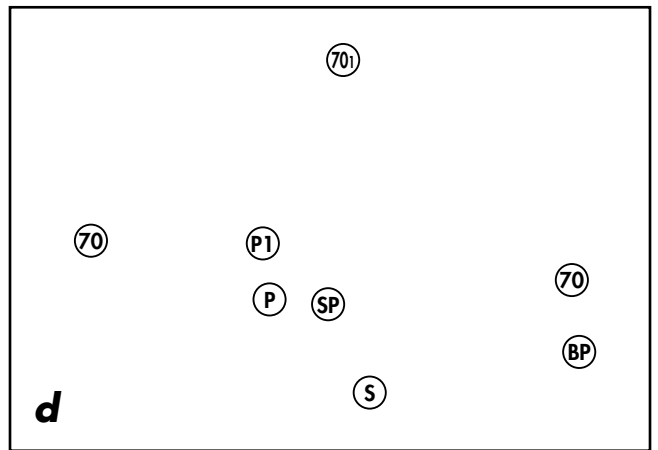
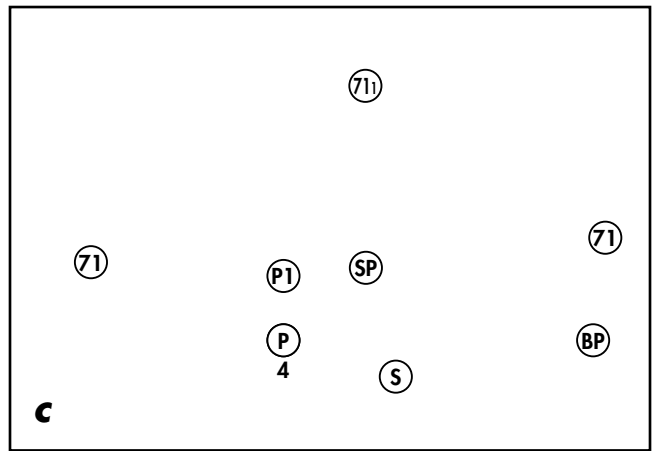
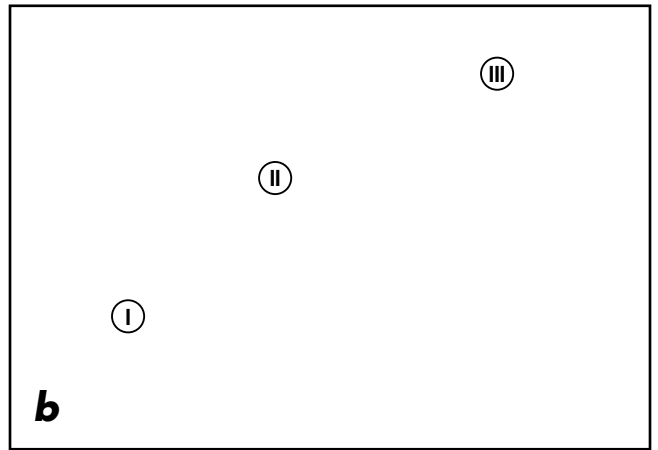
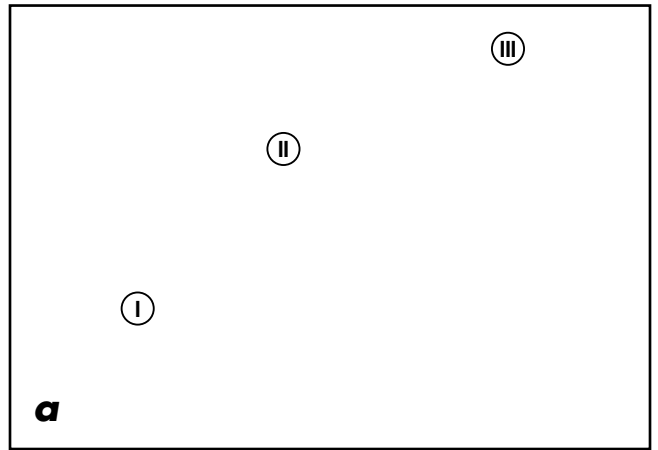


Fig. 31 - Tooling for sharp bending of a scored 3 mm Mirawall panel on a brake press

5.3. Folding of corner panels

Corner panels are special pieces (see 2.3.5., 2.3.6., 2.3.7.) and only hand folding is considered in this document. **Figs. 32a, b, c, d**, show the basic steps followed when using the tooling previously discussed for the normal panels.

Fig. 32 a), b), c), d) - Basic steps of hand folding a corner panel: a) Panel scored & punched as the flat one with upper (I) and lower (III) border punching and scoring on bend line (II); b) folding of borders same as with plane panels; c) folding of outside protruding panel; d) folding of inside protruding panel



6 INSTALLATION PROCEDURES

Installation is the most important operation in rainscreen technology. Since the very size and shape of the tray panels, and the choice between different modulations, come out of a previous forecast of the installation problems, installation must be thoroughly planned before any other step of the whole process. The dimensions of the surface to be clad, the solutions chosen for corners, the size and collocation of windows have to be taken into account, as they will influence the installation procedures.

If properly assembled and erected, even a poorly manufactured rainscreen will look and perform well. Conversely, a defective installation of otherwise perfect components makes a rainscreen unacceptable, both from the aesthetical and functional points of view.

To these effects, the main features to be considered are:

- perfectly vertical installation of the facade as a whole;
- perfect alignment of the grid lines;
- adequate compensation for the primary wall unevenness and disalignments

6.1. Vertical And Horizontal Alignment

The vertical structure of Mirasystem "A" actually consists of the U-shaped supporting mullions. The horizontal elements are the panels themselves together with their bearing pins.

In order to guarantee verticality to the rainscreen as a whole, the basic step is the right installation of the first mullion range.

Since all the other structural components are fixed and adjusted with reference to this range, the utmost care must be given to its exact positioning. It is worthwhile spending as much time as possible for this step, which will spare much more time in the following operations: indeed, all the rest of the

structure shall be fixed and adjusted with reference to that first range, and therefore any defect in that range will affect all the rest of the cladding.

Fig. 33a shows how the first (red) range of mullions is assembled starting from the bottom.

Fig. 33b shows how to use plumb-lines in order to ensure verticality on both the parallel and perpendicular planes to the primary wall. After the first (low) section of the mullion range has been fixed into place, the lower end of the second section is inserted on the upper end of the first one via the joint (89) (see details in **Figs. 33c, 33d**), and the upper end of this second section is fixed to the primary wall by the adju-

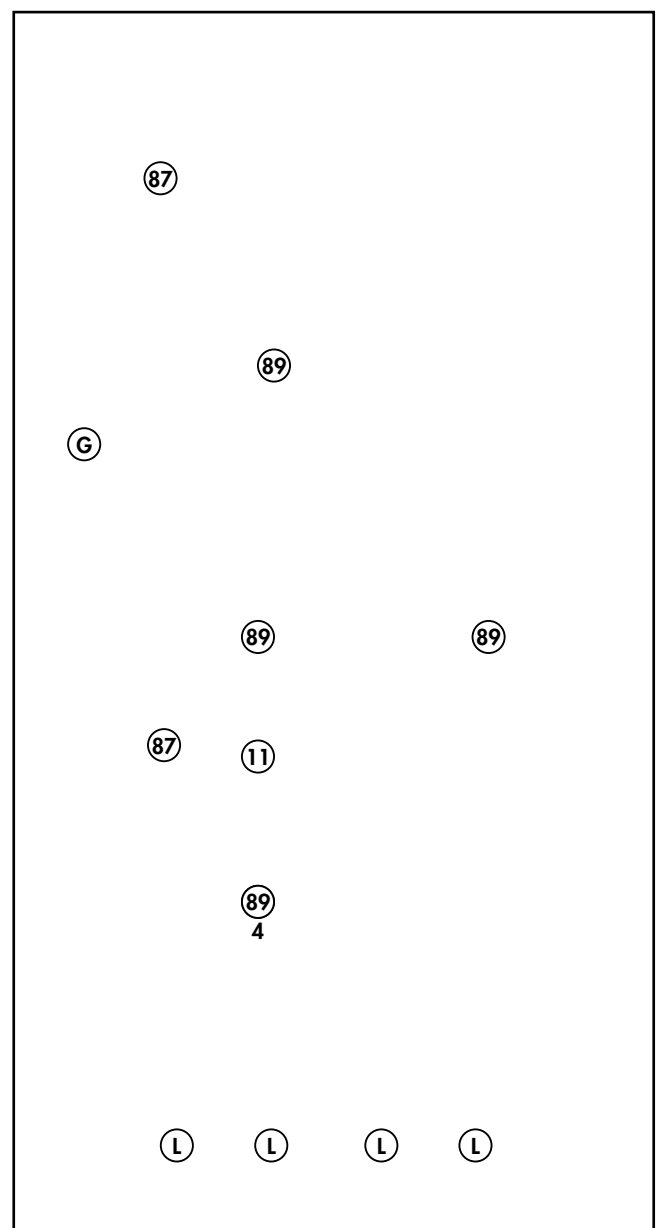


Fig. 33 a) - Mullion installation: in red, the first range: the case illustrated is (G) in **Fig. 12 a)**

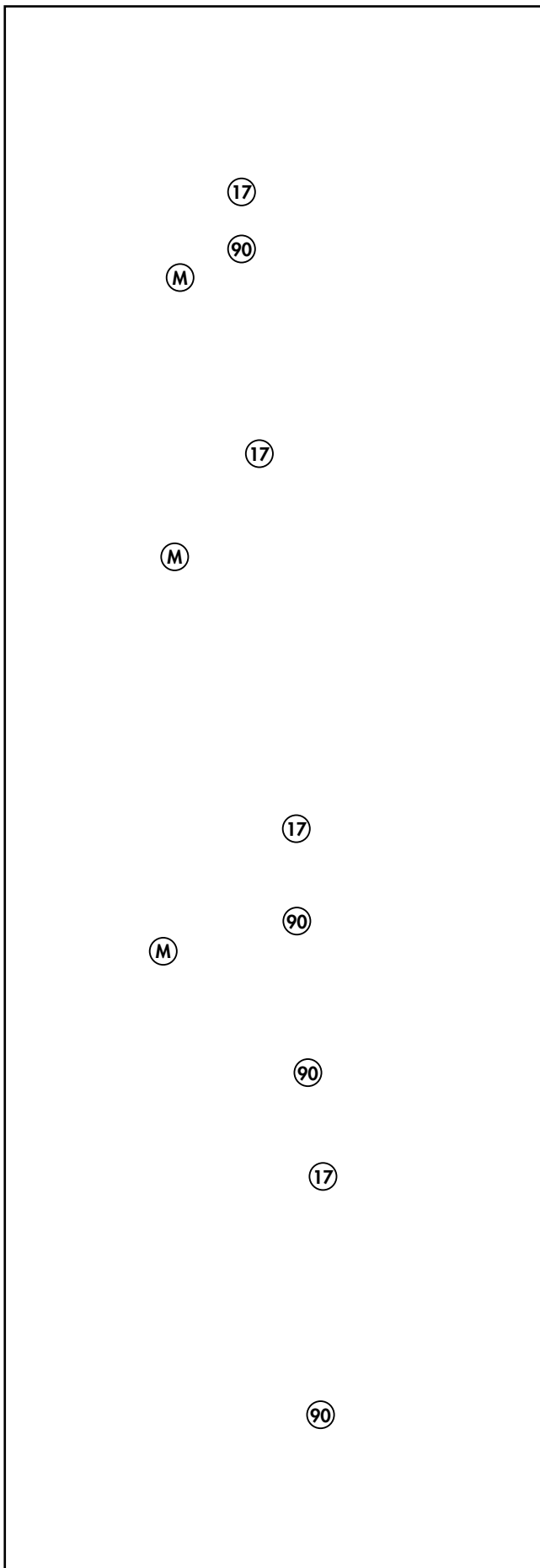


Fig. 33 b) - Use of plumb lines to ensure verticality

stable anchor (17). **Fig. 35a** shows an overall view of the vertical range of mullions fixed to the wall. Details of the anchoring system are shown in **Fig. 35d** and can be also observed in **Fig. 7** (page 15) and **Fig. 9** (page 17).

The operation is repeated with the next sections until the whole mullion range is installed. Vertical regulation is carried out by adjusting the upper ends of the sections: use plumb-lines after each section is installed, in order to ensure verticality to the whole range.

Once the first mullion range is put into place, each section has to be tightly secured by the fixed anchors 90, as shown in **Figs. 35 a, b, c**.

The following mullion ranges are assembled and installed with reference to the first one. A spacer

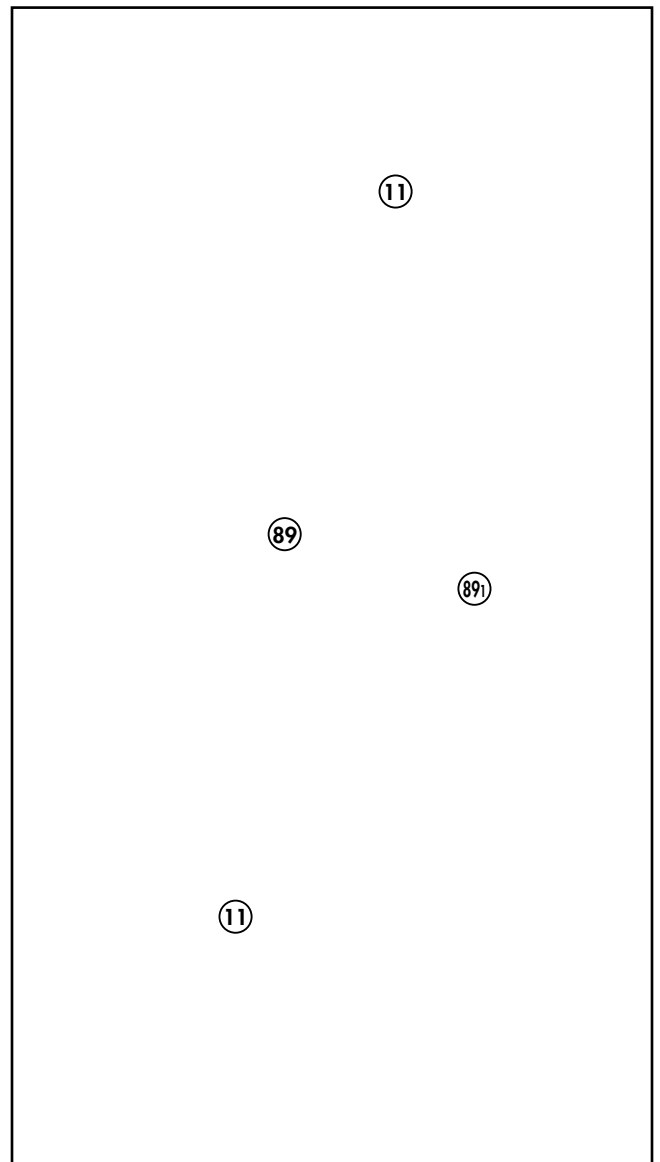


Fig. 33 c) - Detail of joint (89)

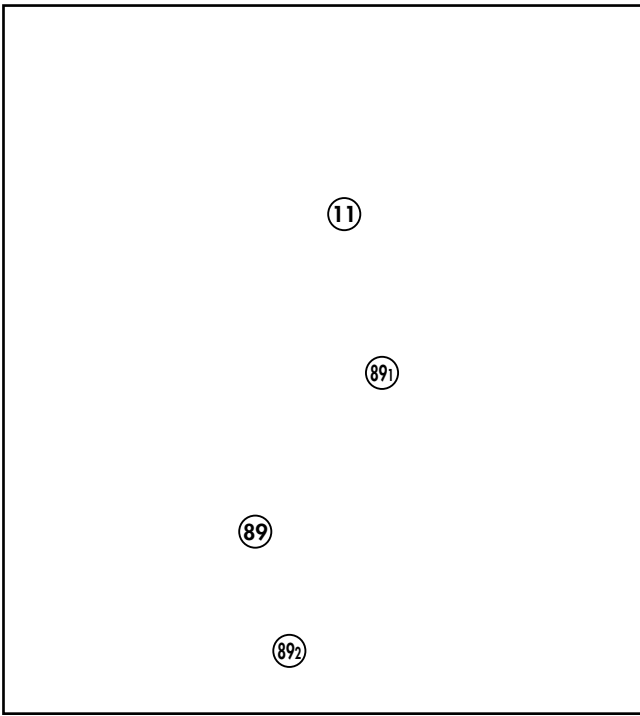


Fig. 33 d) - Plate (89.1) on the side of the mullion facing the masonry wall

bar with the same length as the module is used to ensure the right distance between mullion ranges. For horizontal alignment, a string should be pulled between mullions as a reference line.

6.2. Fixing The Mullions

Figs. 34a, b, show in detail the features of the joint (89) which connects each mullion section to the next one below in the vertical range by accommodating the ends of the two sections. This joint is a U-shaped stainless steel sleeve, 1 mm thick, with inside-bent ends to facilitate insertion into the ends of the mullion profiles. It is completed by a 4 mm aluminium fixing plate (89.1) connected to the mullion and the joint by two screws. To allow for thermal expansion, the gap between mullion sections should be 8-10 mm in normal weather areas and should be raised to 10-12 mm in areas with thermal excursion $\geq 60^{\circ}\text{C}$. These suggested values apply when installation takes place in the coldest months: conversely, the gap should be reduced when installing in the warmest months, considering that the mullions have then their maximum expansion length. The adjustable

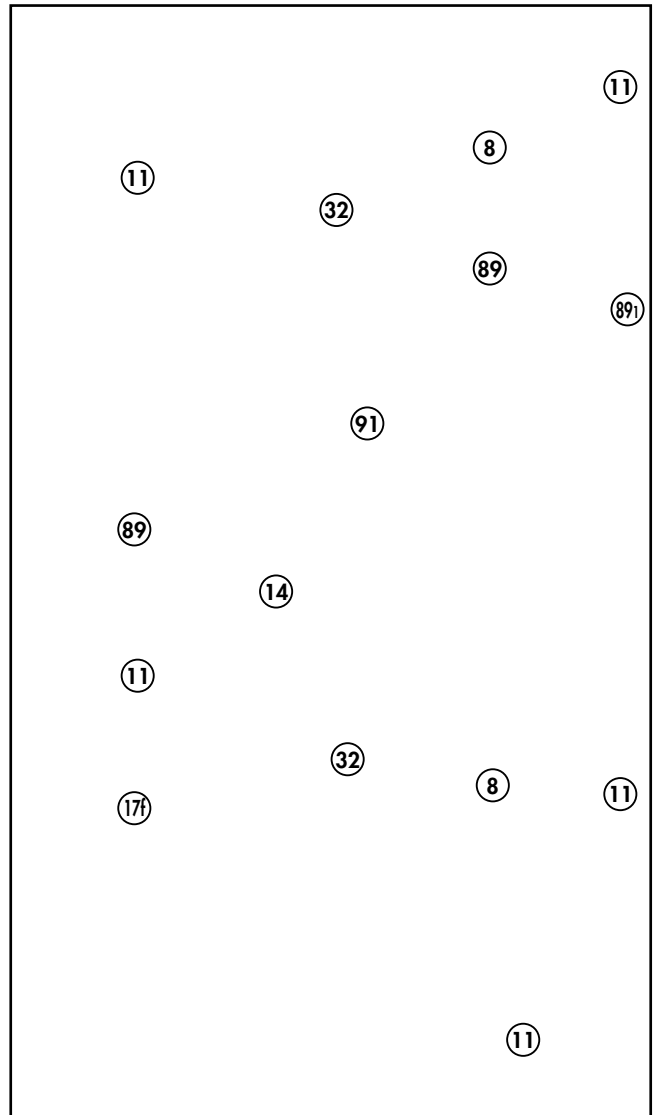


Fig. 34 a) - Joint (89) connecting the sections of the mullion. Overall view

anchor (17) (section in **Fig. 35d**, full detail in **Fig. 9**) thanks to its oval slots permits vertical adjustment after fixing to the primary wall, in order to compensate for unevenness of the primary wall.

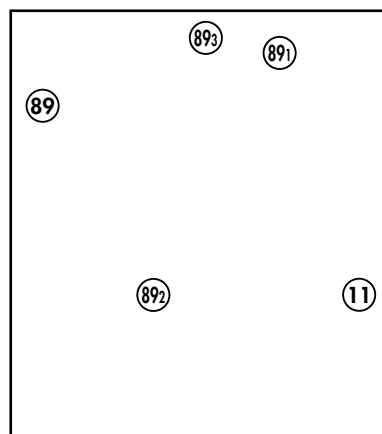


Fig. 34 b)
Detail of joint (89):
89 1: 4 mm aluminium plate behind mullion, facing wall
89 2: stainless U inside of mullions
89 3: screws for fixing joint 89 to bottom end of upper mullion

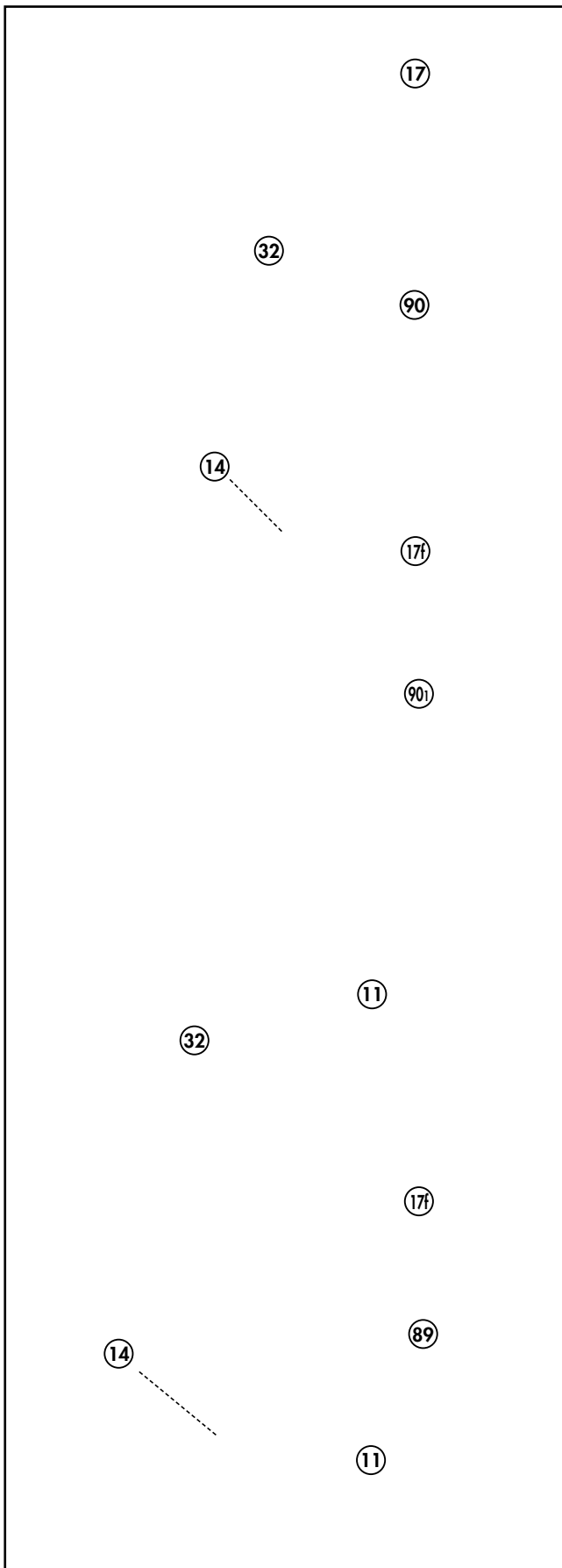


Fig. 35 a) - Stiffening the mullions by anchors (90). Note the different positions of the anchors relative to the mullion axis, to compensate for wall unevenness

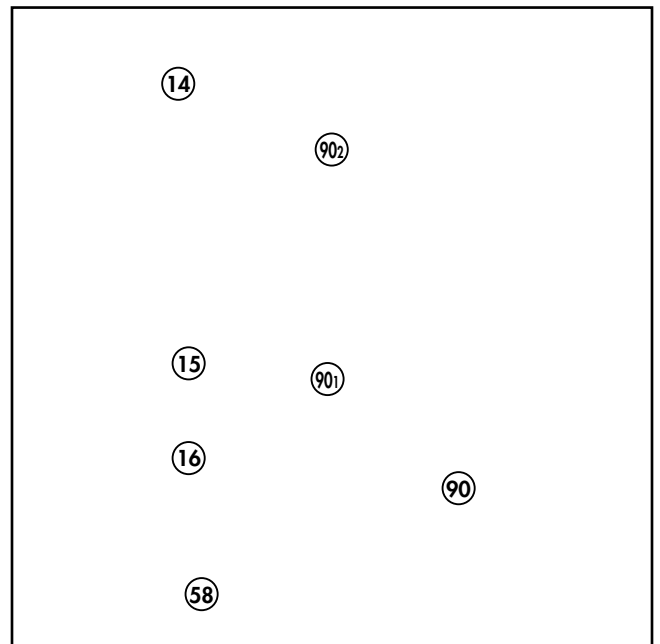


Fig. 35 b) - Example of simple fixed anchor applied to an installed mullion. The pairs of holes in anchor (90) permit to compensate for wall unevenness

Once the mullion sections have been put into place by means of joints (89) and anchors (17), fixed anchors (90) fix firmly the mullion to the primary wall (see **Fig. 35b** and **Fig. 35d**). Fixed anchors can be made out of aluminium or galvanized steel. When using steel anchors, a plastic membrane should be introduced between steel and aluminium.

Fig. 35b shows how the twin slots permit adjustment of the fixed anchors (90) in order to compensate for unevenness of the wall. In order to allow a wider adaptation range, the fixed anchors (90) have two ranges of holes. The anchors are fixed by stainless steel, self-threading screws.

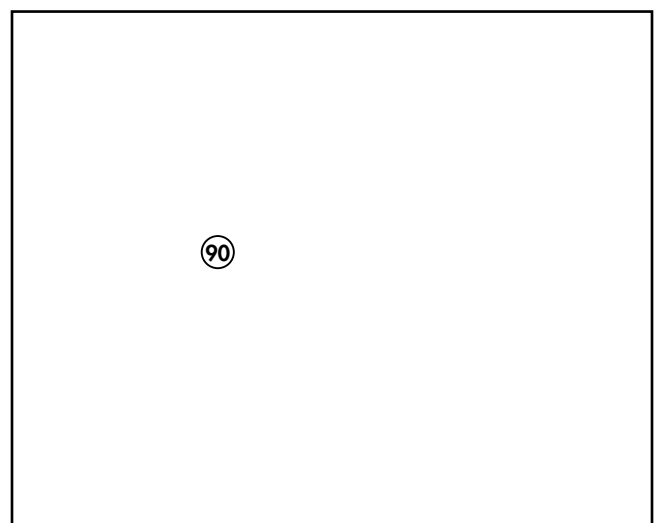


Fig. 35 c) - Detail of fixed anchor (90)

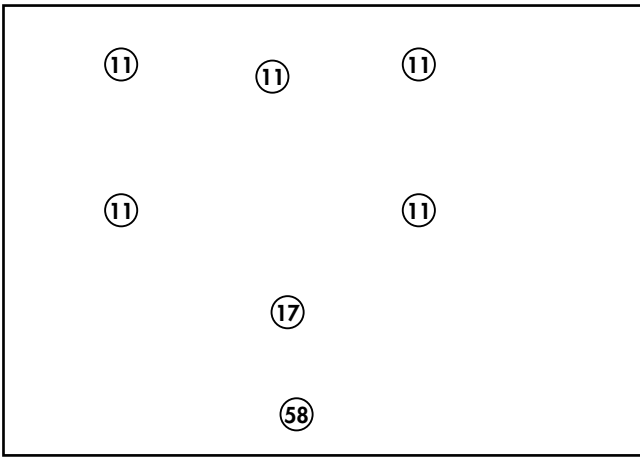


Fig. 35 d) - Detail of adjustable anchor (17)

6.3. Insulation

Once the structure is installed, insulating panels are applied on the wall. In order to avoid leakages, the panels have to be carved to fit corners, recessions, and anchors (Fig. 36a).



Fig. 36 a) - Insulation

6.4. Windows

Fig. 36b shows the final step: introducing the window frames. In the case illustrated, the windows are of the Bb type as explained in chapter 3, page 31 and following. In this case, the windows were already installed before cladding.

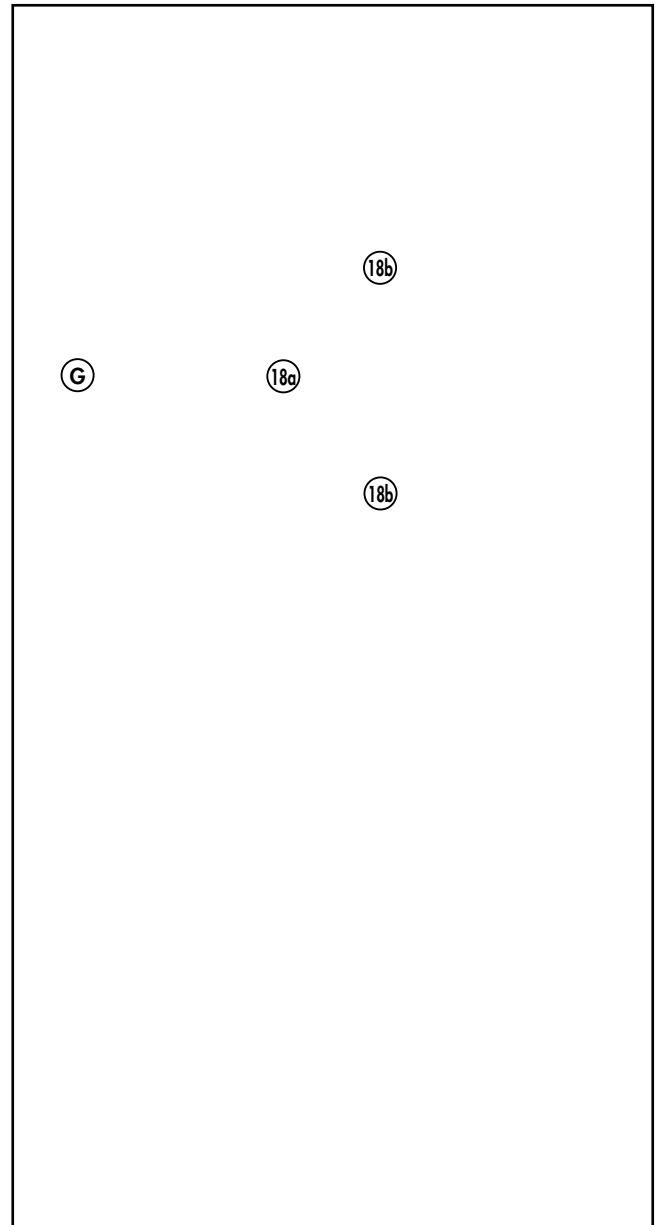
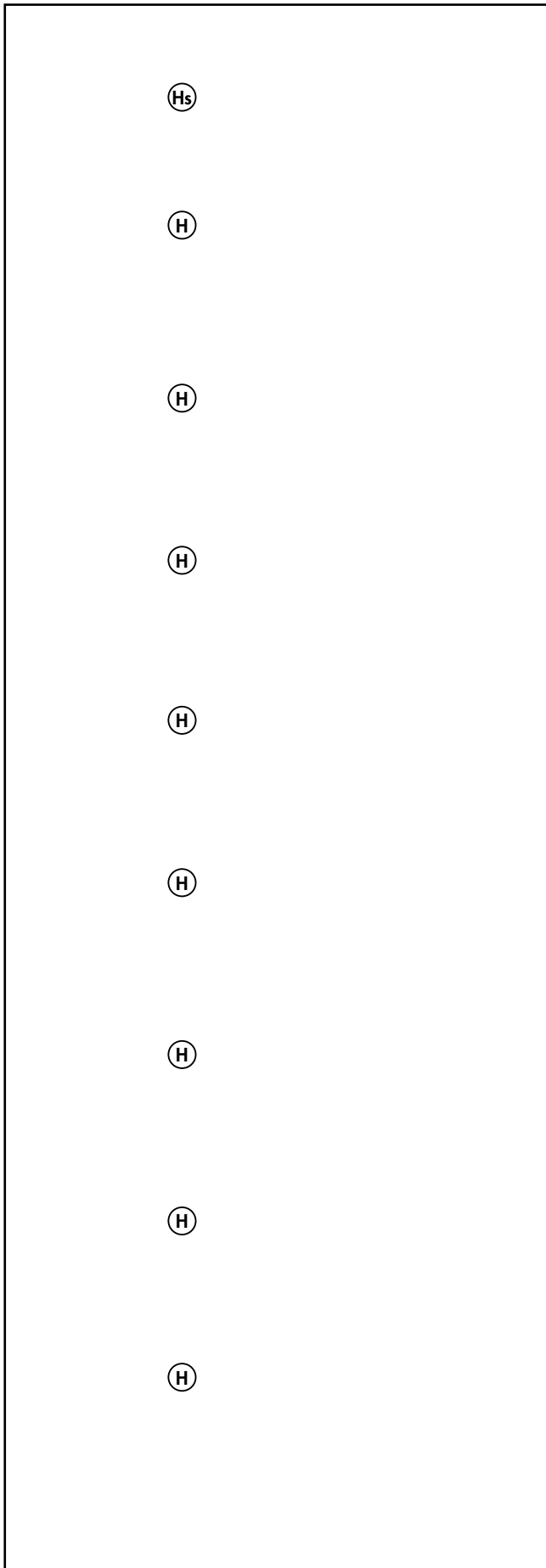


Fig. 36 b) - Front view of the installed facade



6.5. Overall View

Fig. 36b and **Fig. 36c** show the front view and section of the finished facade. In this case, the facade has been finished with a side closure of the "G" type (see chapter 2.3.4.).

In the vertical section, **Fig. 36c**:

- Brown = Masonry primary wall
- Orange = Insulation panels and gaskets
- Blue = Supporting structure
- Red = Supporting anchors
- Green = Tray panels

Fig. 36 c) Vertical section of the installed facade

7 OTHER SYSTEMS: PANEL ALIGNMENT AND WEATHERTIGHTNESS

In markets where Mirawall is now established, most claddings use the simple, basic design described here as Mirasystem "A". However, hundreds of variations of this design have been developed by particular firms, and most of these

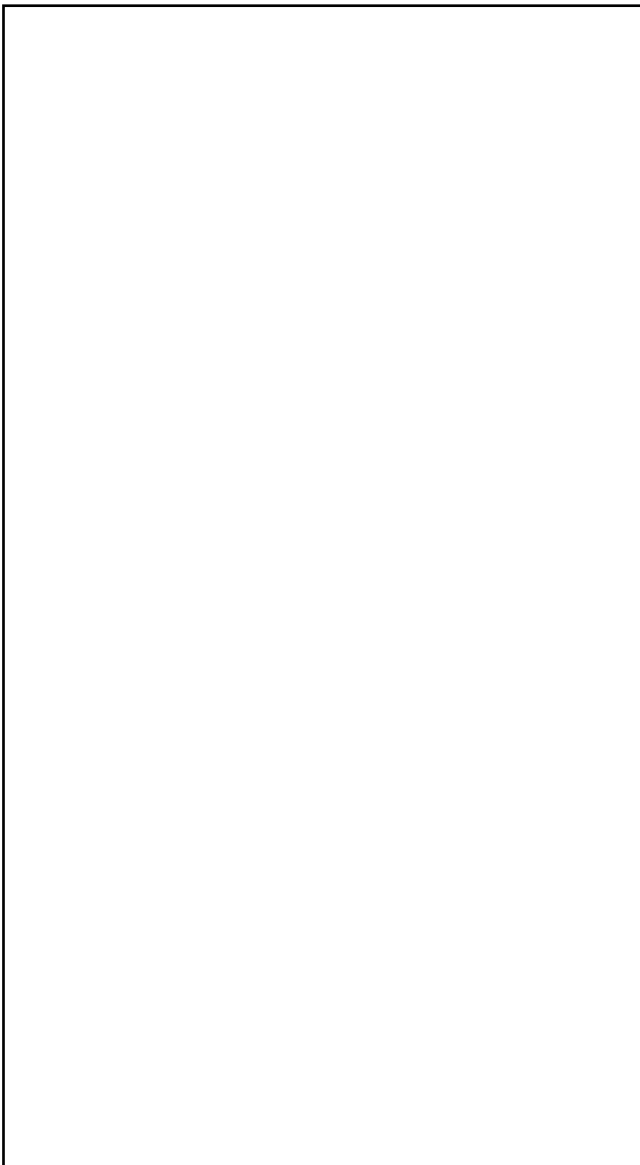


Fig. 37 - A recent system (Fenzi Panel Wall) that is designed to permit assembly and alignment with a screwdriver only

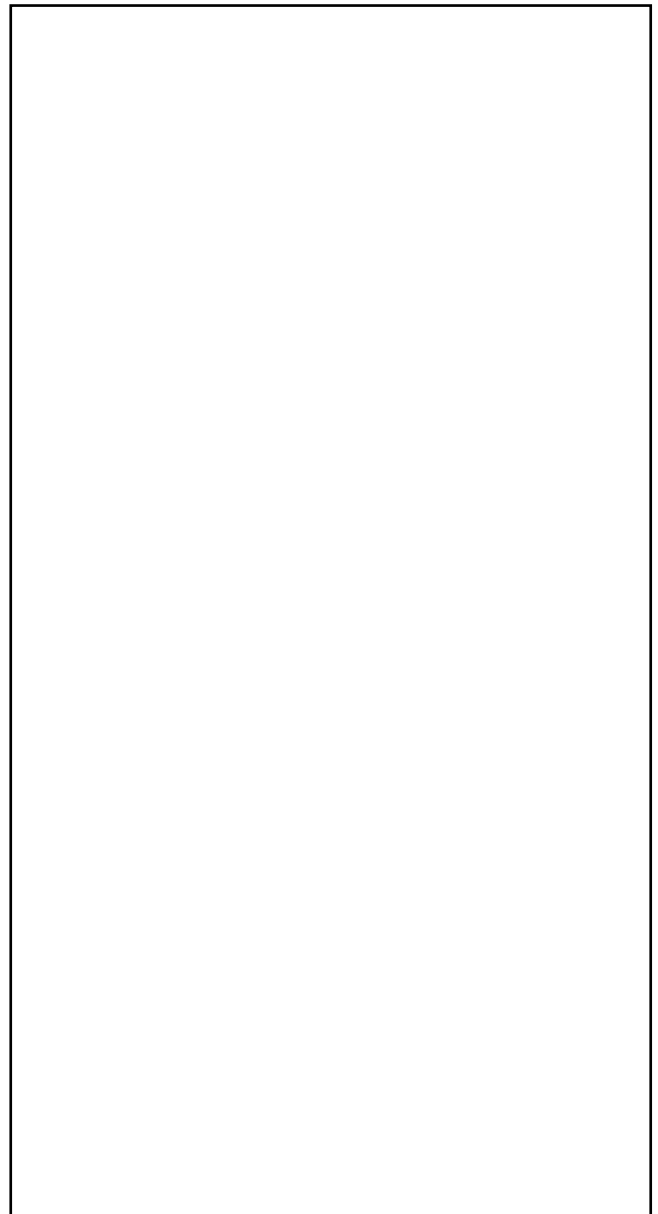


Fig. 38 a) - The Alcoa Teknowall MP (Modular Panel) system: riveted hooks, equal fold width, and two alternatives (see **Fig. 38 b, c**): either normal, or with weatherstrip

alternatives have been designed with two main purposes in mind:

- a) Permitting an adjustment of the single panels relative to the mullions;
- b) Permitting the construction of weathertight claddings.

Three most recent examples of such special designs are given here: the Fenzi system (**Fig. 37**), that can be installed with a screwdriver as the only tool, the Alcoa Teknowall MP (Modular Panel) system (**Fig. 38**), and the "Urano" system (**Fig. 39**).

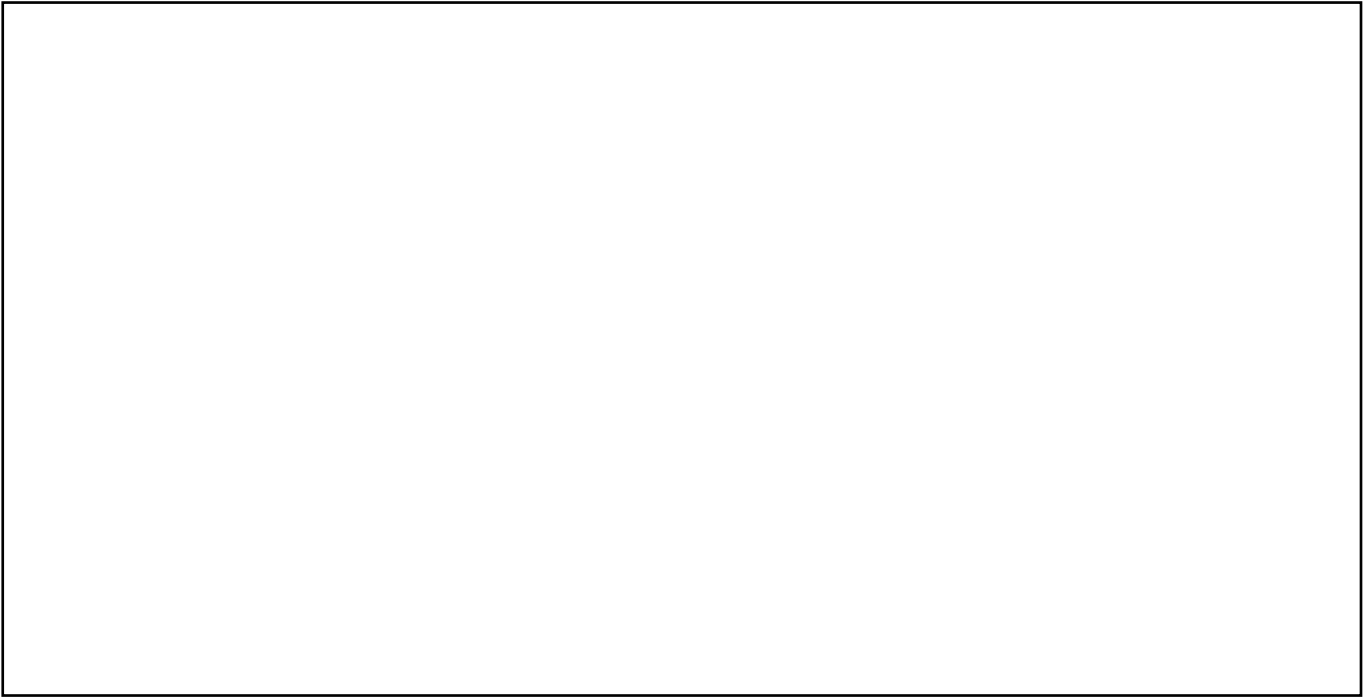


Fig. 38 b) - Horizontal section of the Teknowall MP cladding system: normal version

These systems, as any system having the possibility of weathertightness, are characterized by an extruded bearing mullion with a section more complex than the basic U design. Essentially, the mullion has a protruding fin with a channel where an elastic weatherstrip can be fixed.

The Alcoa system is also an example of cladding that uses tray panels with folds of the same thickness all around, where the hooks are not cut out of the vertical folds but are supplied as accessories and riveted to the side folds.

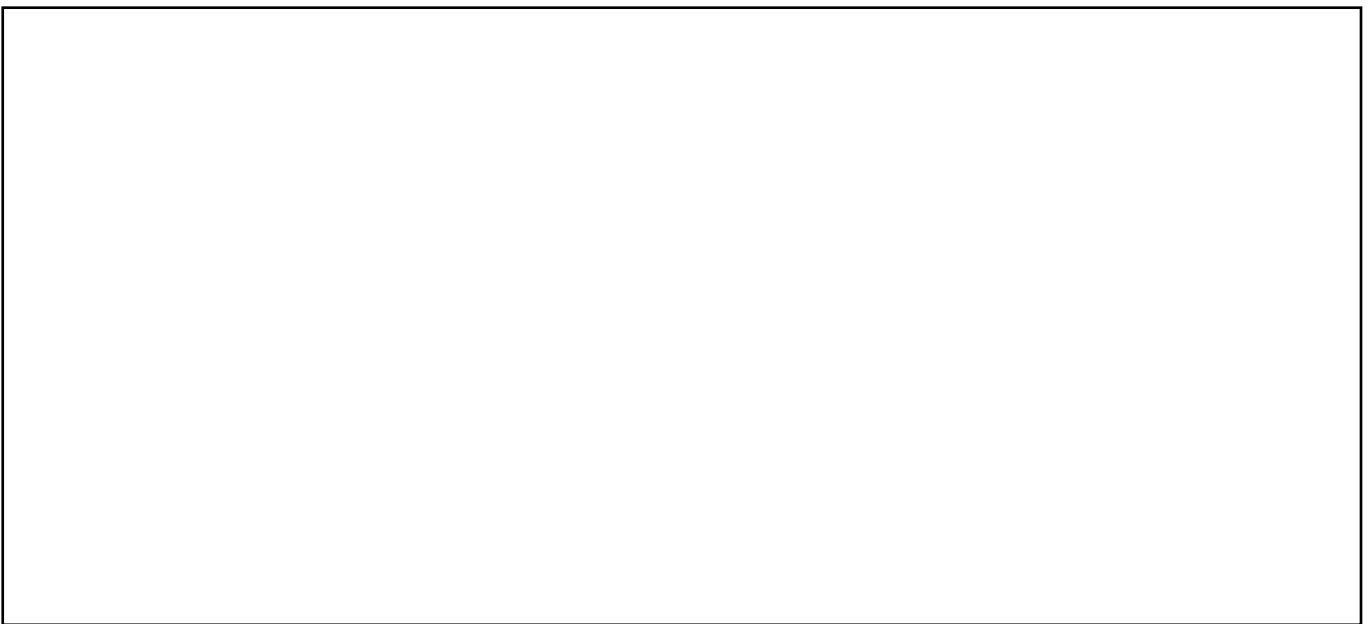


Fig. 38 c) - Horizontal section of the Teknowall MP cladding system: version with weatherstrip

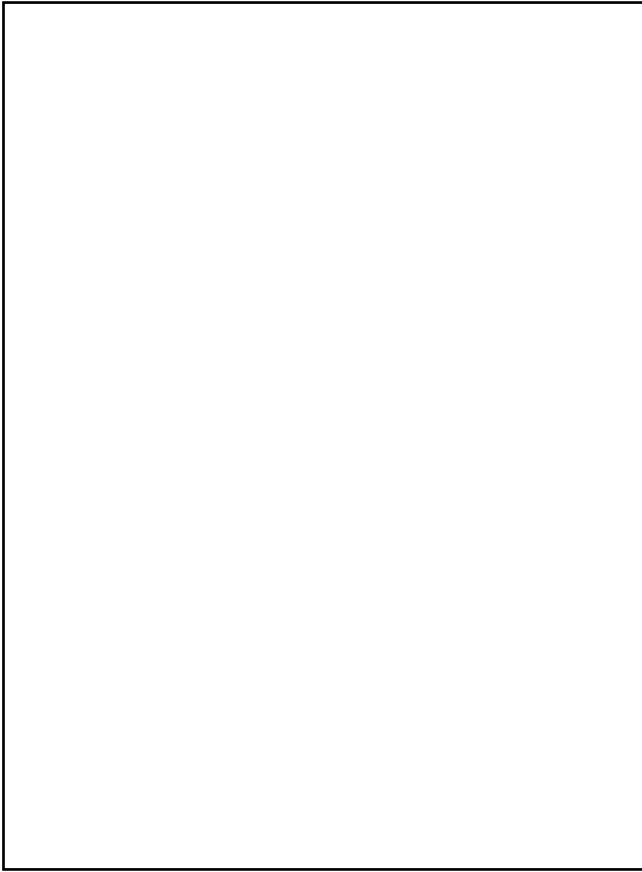


Fig. 39 a) - Prospect of "Urano" system, with panels hung to V-shaped springs sliding within extruded aluminium mullions. The springs are shifted to align the panels and protrude outwards, so permitting to use cassette panels with equal wings

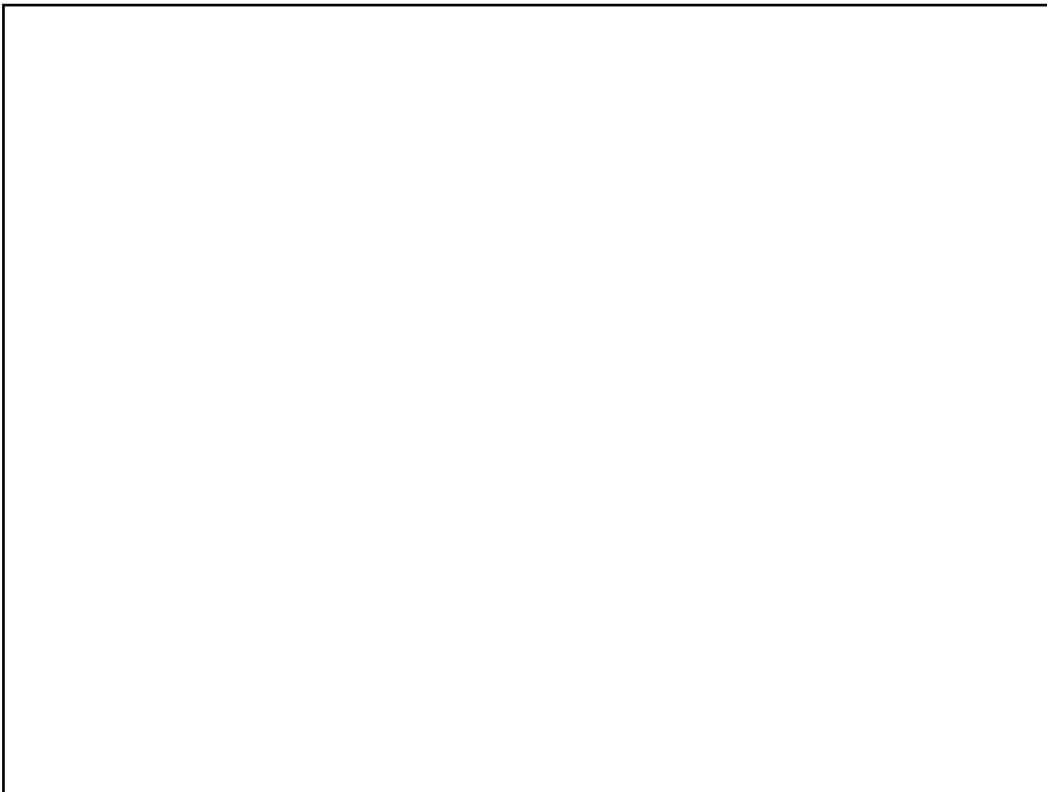


Fig. 39 b) - Components of the "Urano" system. Note on low right the stainless spring that can slide along the mullion in order to align the panels.

8 SUPPLIER LIST

Wall Anchors

- Fischer - C. Stati Uniti 25 - Z.I. Sud
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Fax ++39 (0)49 8063395
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24059 Urganano BG (Italy)
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