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GB 1260929

(58) Field of search
B6X

(54) **Production of engineering drawings**

(57) A method of drawing the construction of a joint between a plurality of steel structural members, comprising storing for each of a number of types of members representations associated with each of a number of different possible end configurations for each member. Representations of at least three standard sizes of member are stored for each possible end configuration. Each representation has a datum point to enable a plurality of the representations to be superimposed such that the respective members are correctly orientated with respect to the joint to be drawn. The end configurations of the various members constituting the joint, is ascertained, and the sizes of the members entering the joint are compared, and classified into one of the standard sizes. One of the said standard size representations is thus selected for each member, and the selected standard size representations are combined, to produce a drawing of the joint.

The representations may be drawings, for example conventional elevational and plan drawings, and may be provided on transparent film, or in the form of transfers. In a preferred embodiment, however, the representations are stored digitally on a computer disk.

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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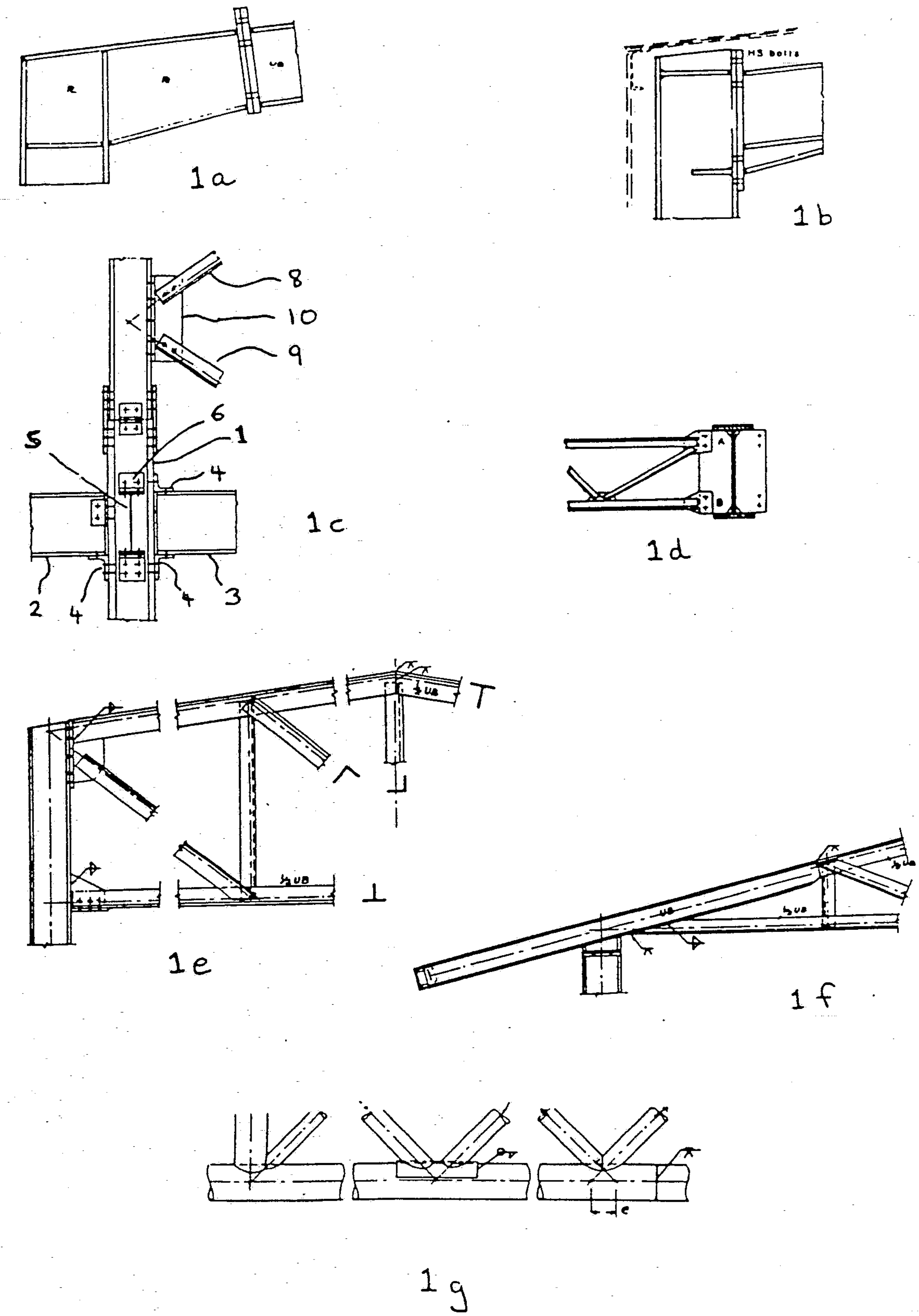
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2
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1f
e
1g

Figure 1

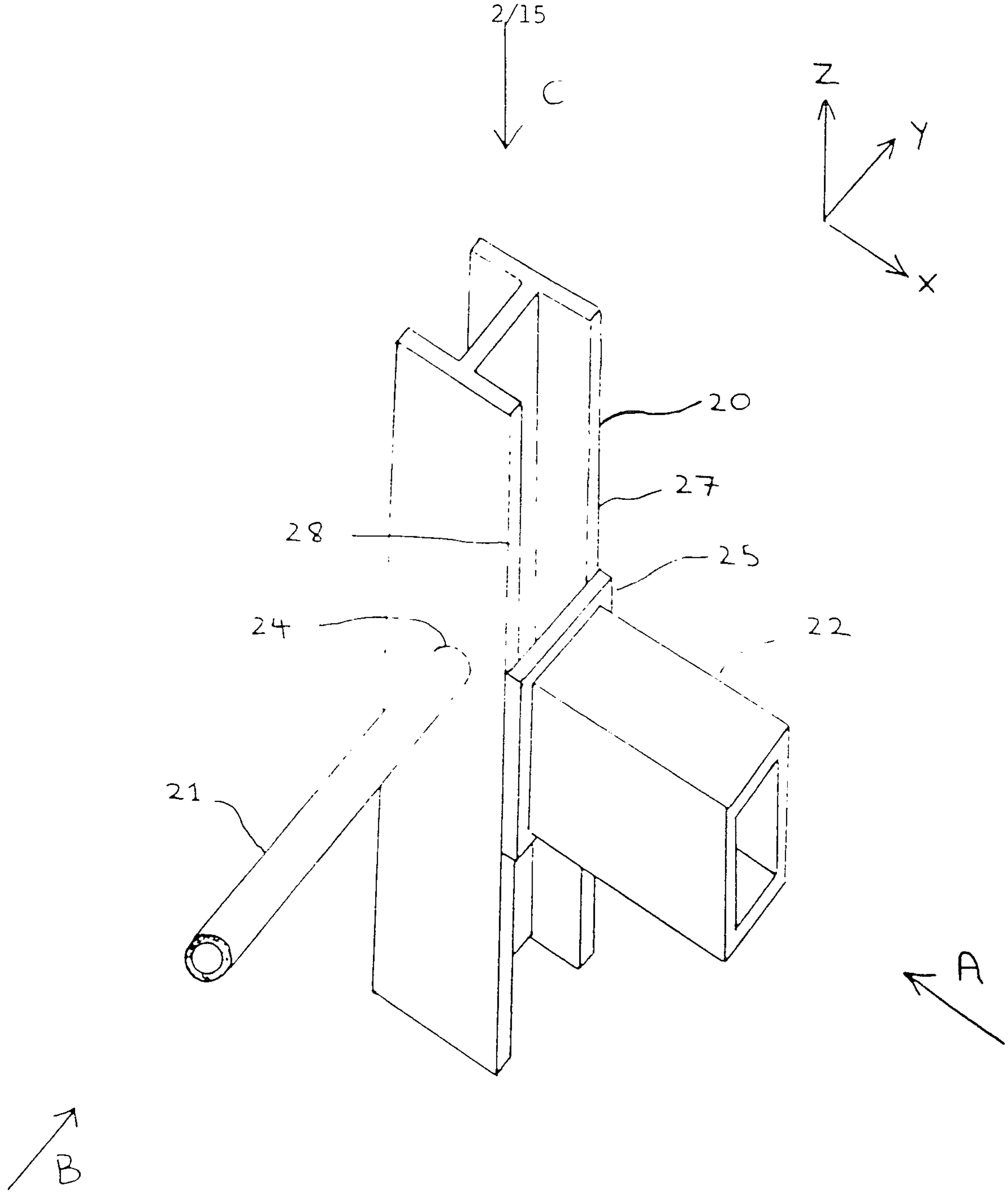



Fig 2

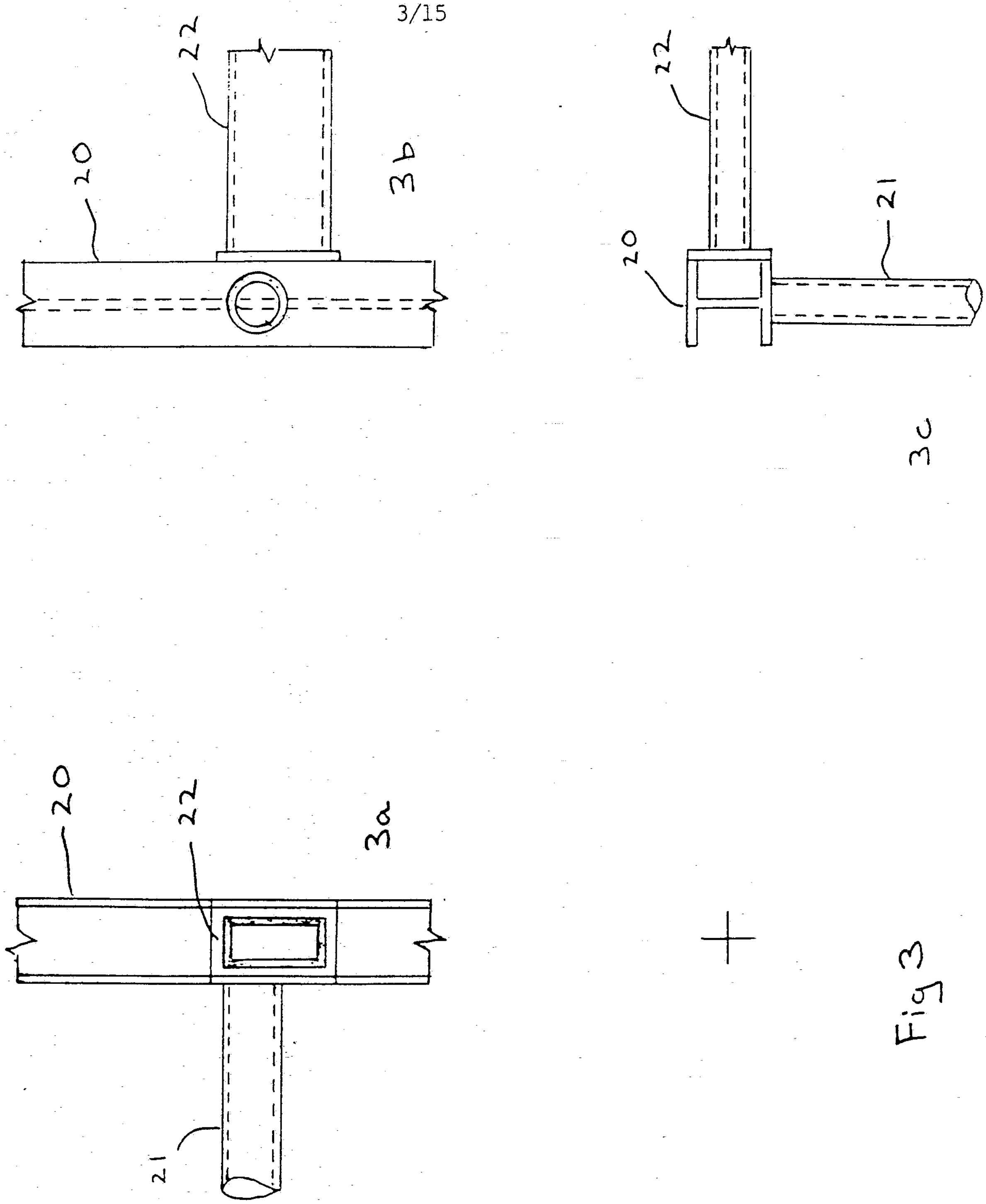



Fig 3

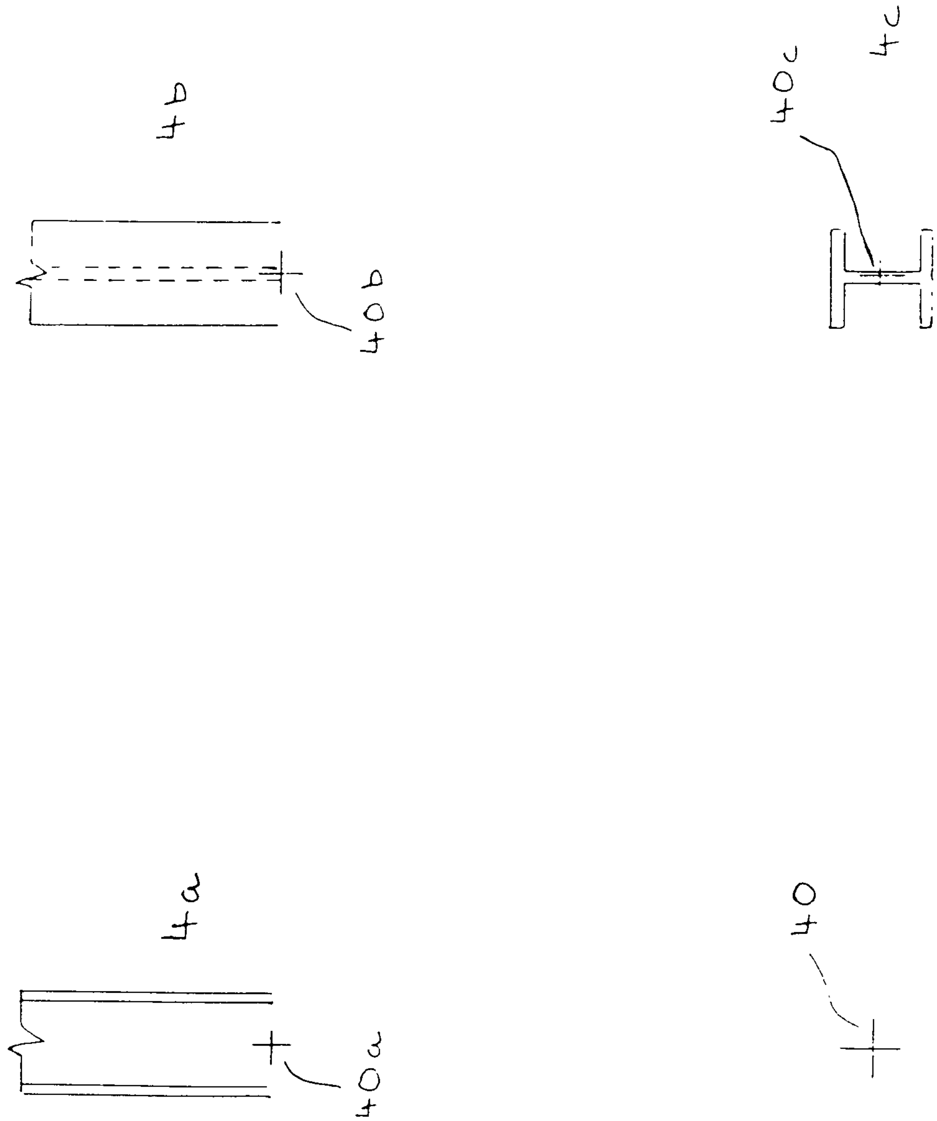



Fig 4

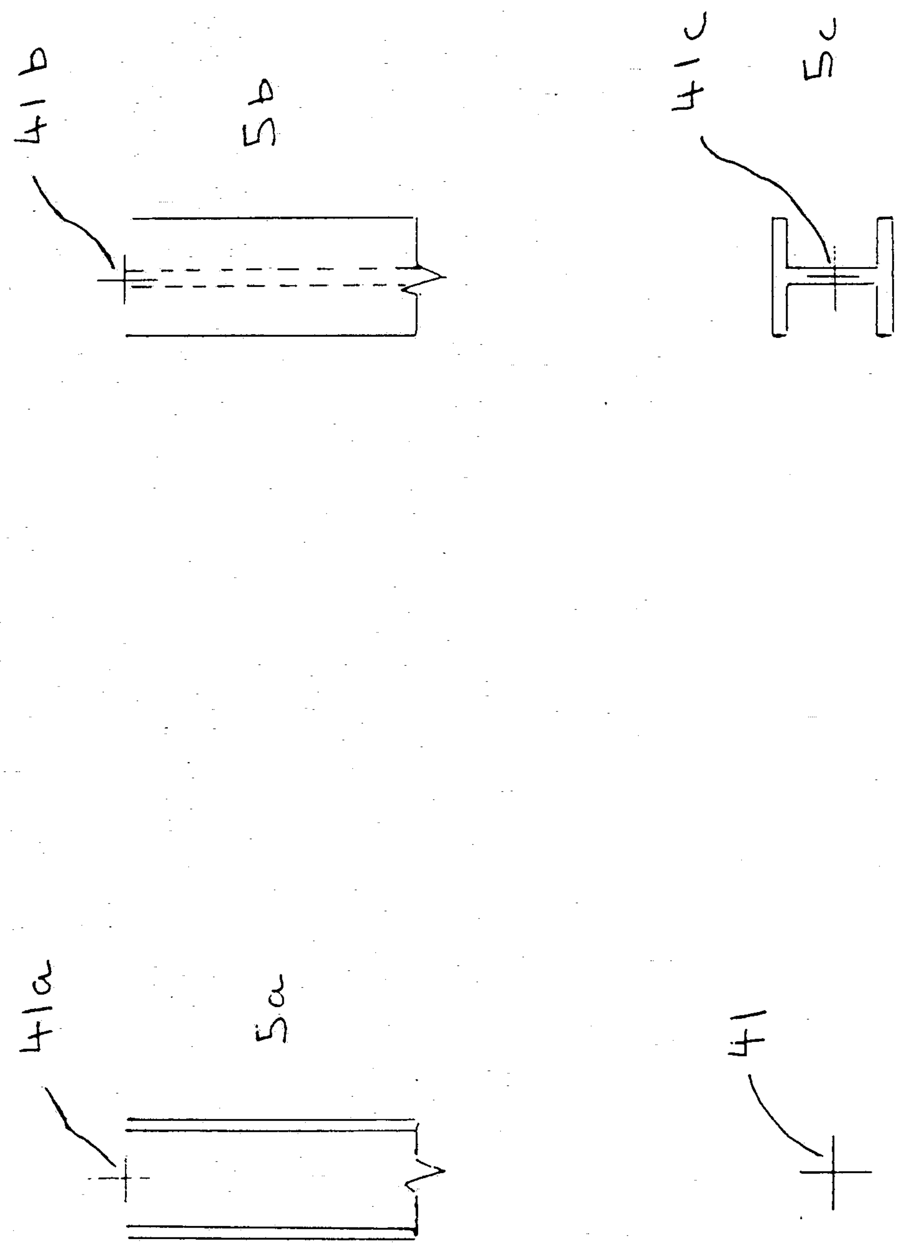



Fig 5

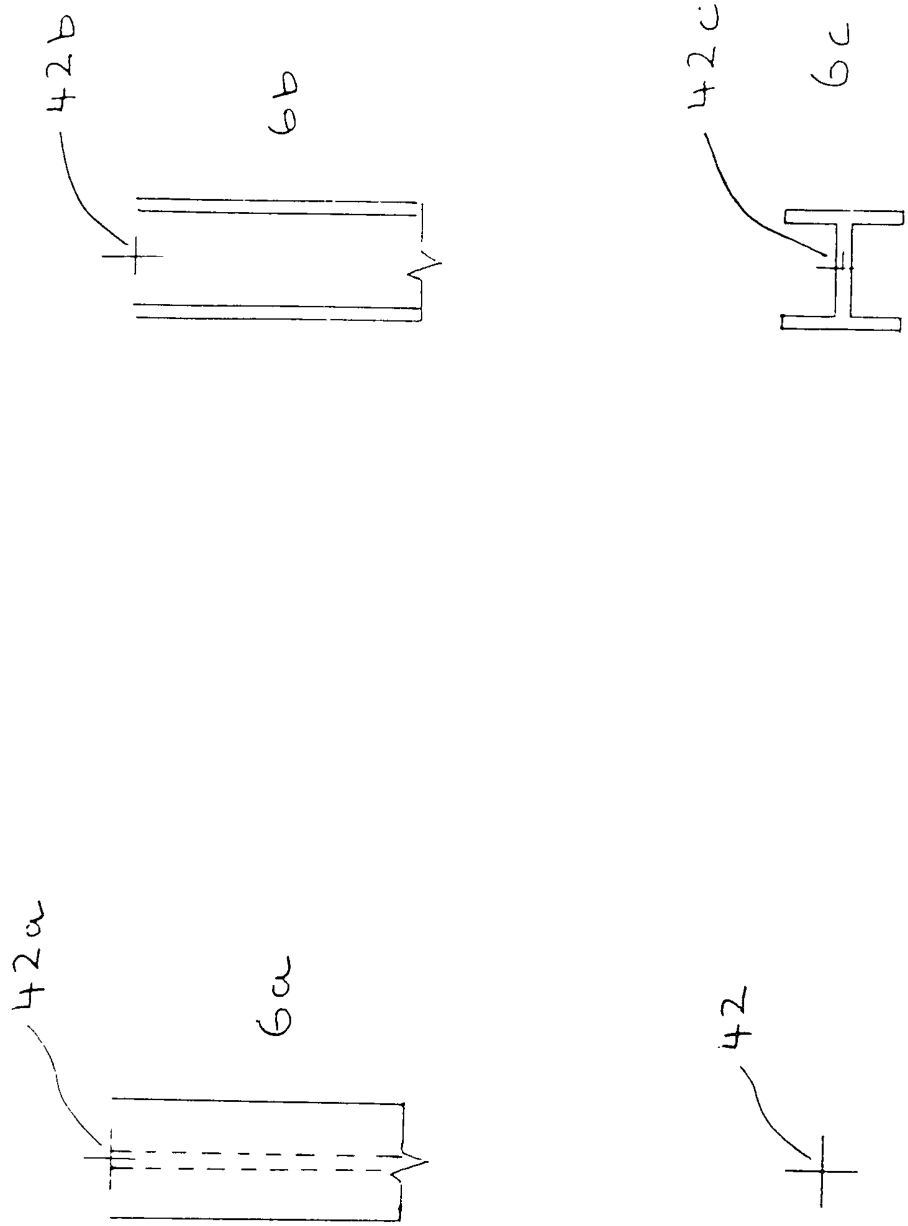



Fig 6

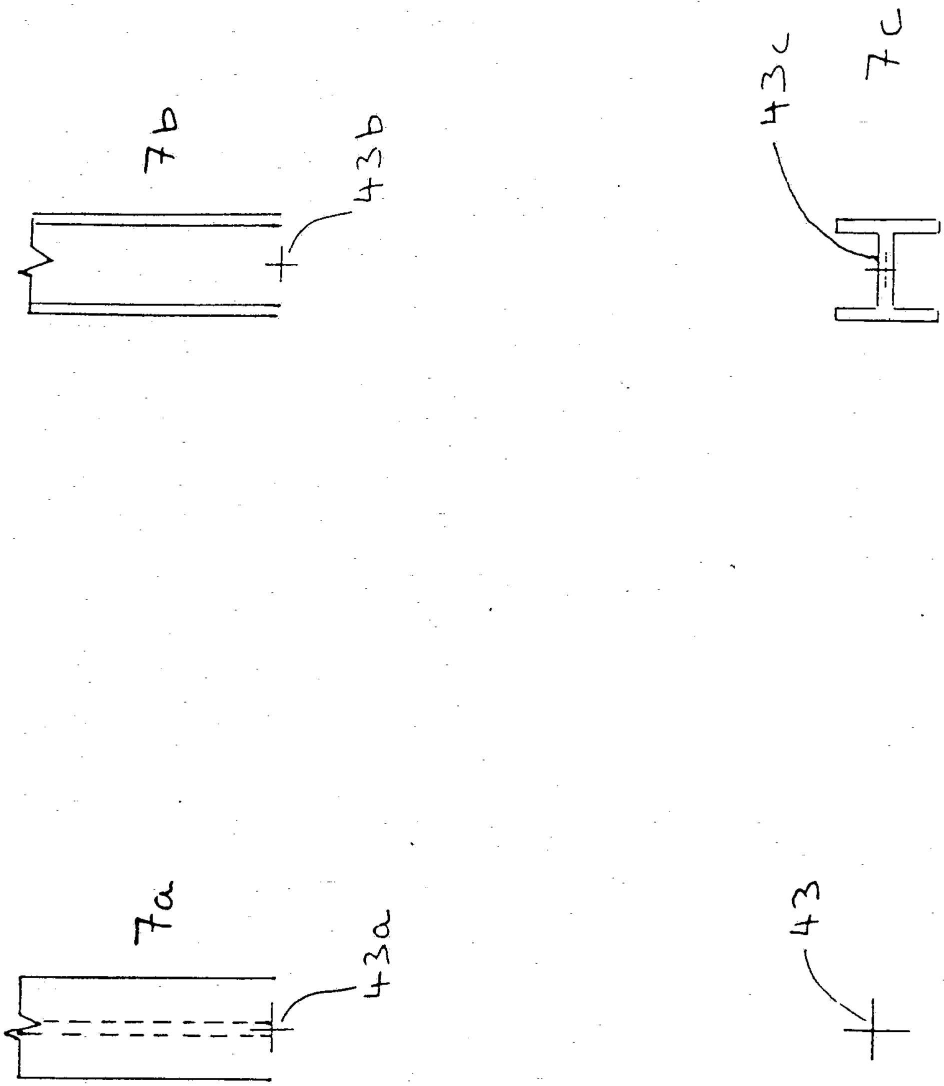
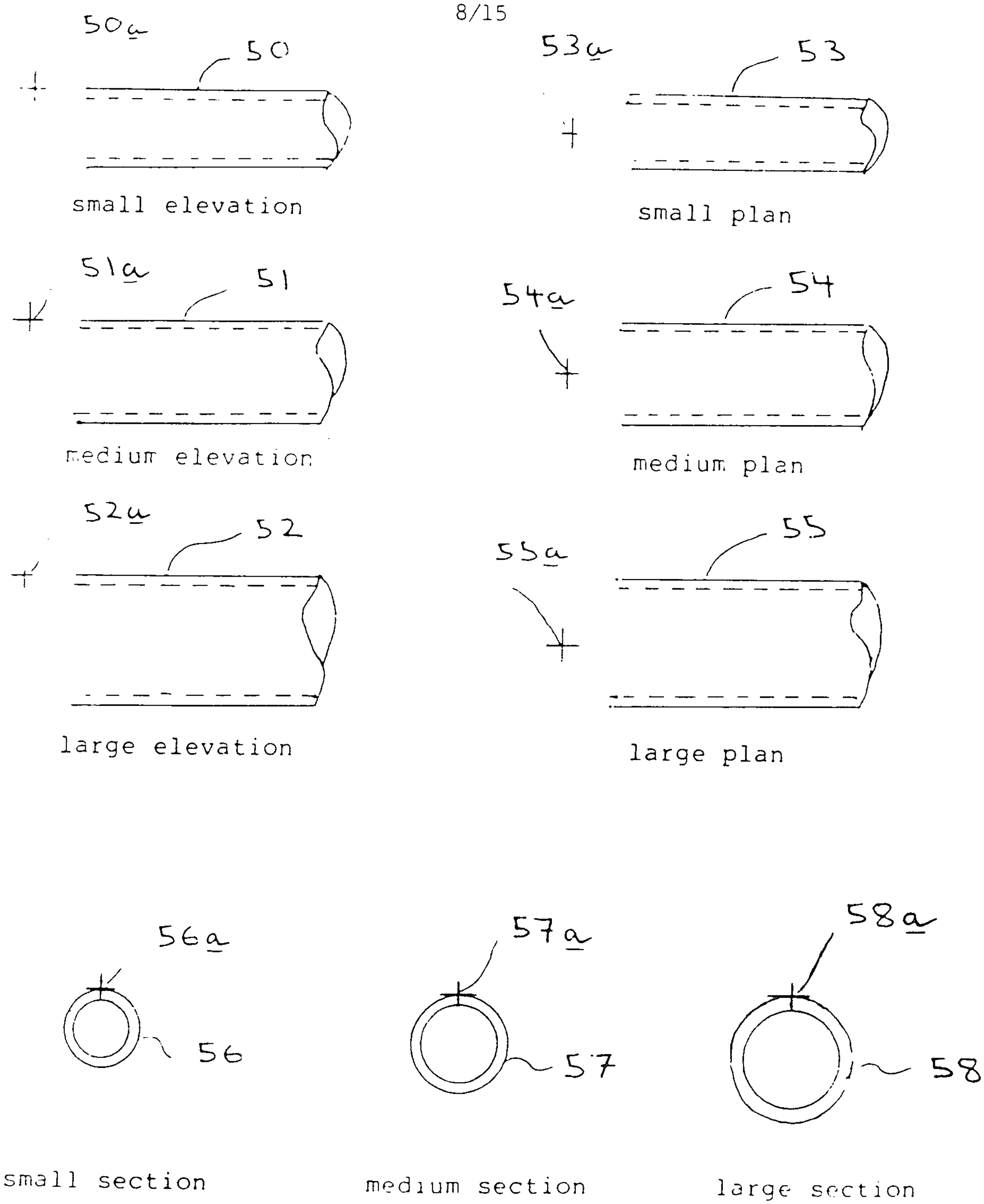



Fig 7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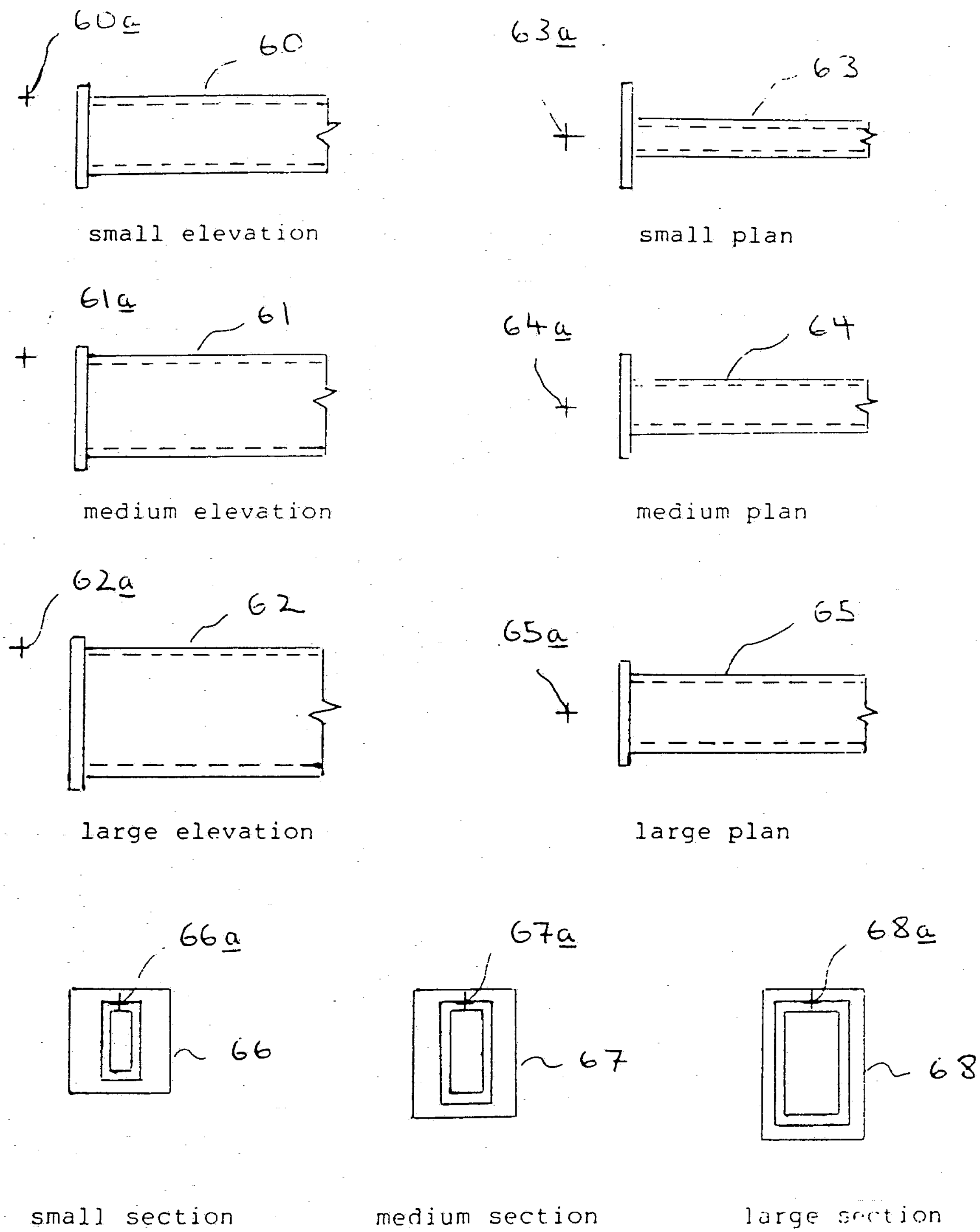
53a
53
small plan
51a
51
medium elevation
54a
54
medium plan
52a
52
large elevation
55a
55
large plan
56a
56
small section
57a
57
medium section
58a
58
large section

Figure 6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medium section
68a
68
large section

Figure 9

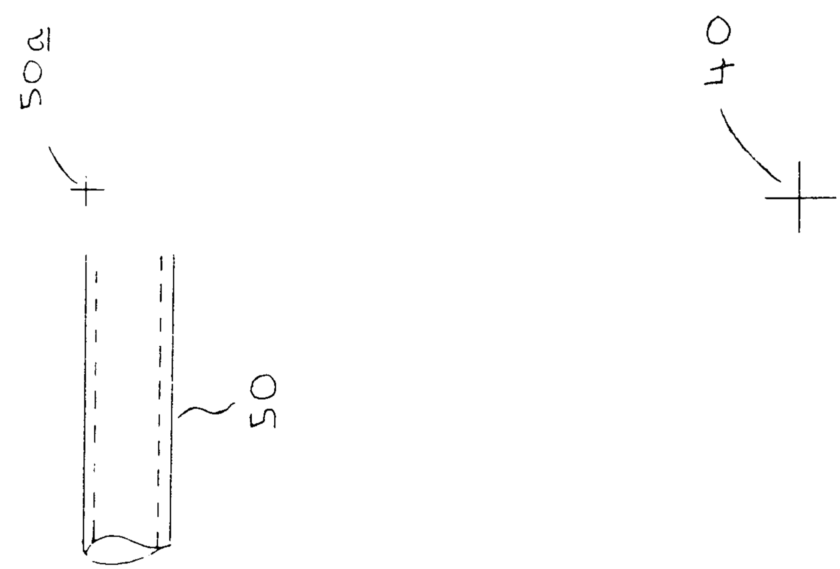


Fig 10


Fig 11

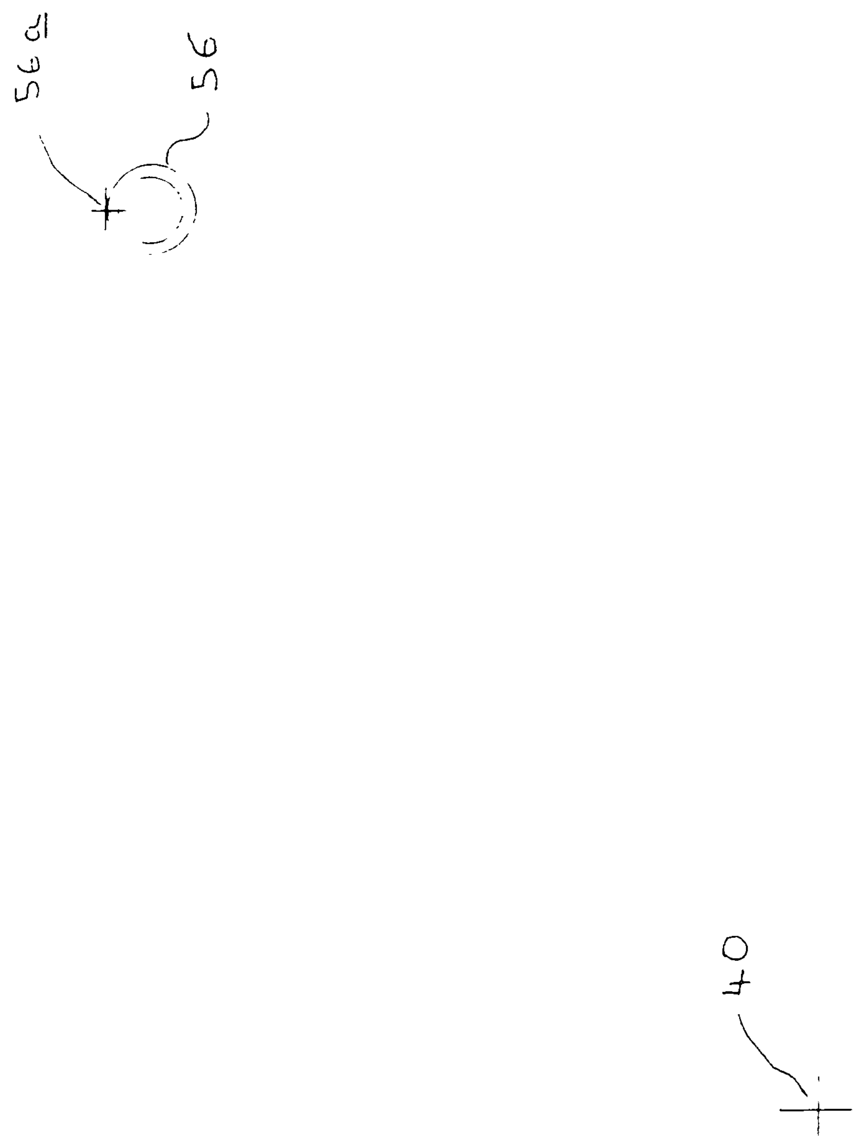


Fig 12

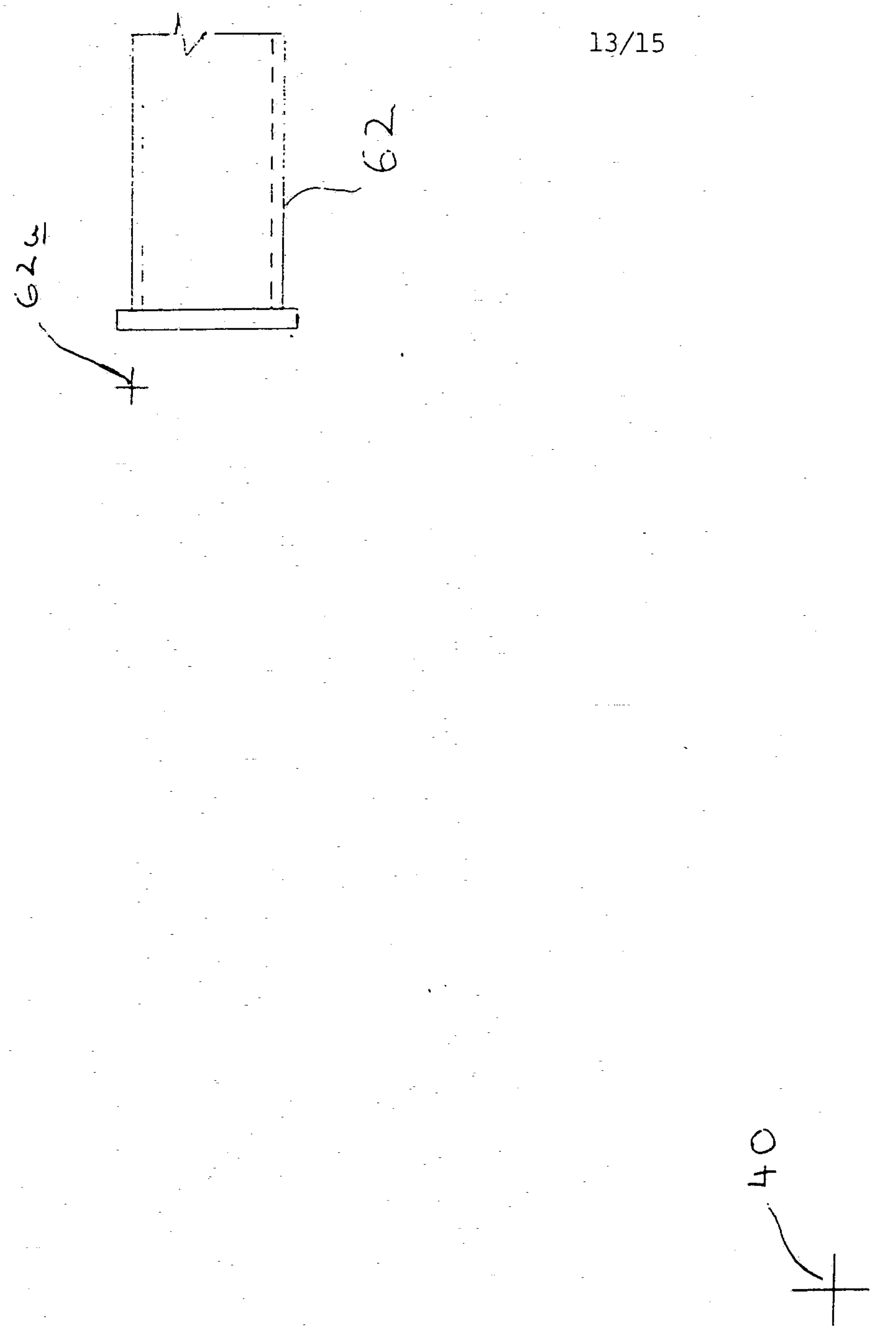


Fig 13


Fig 4

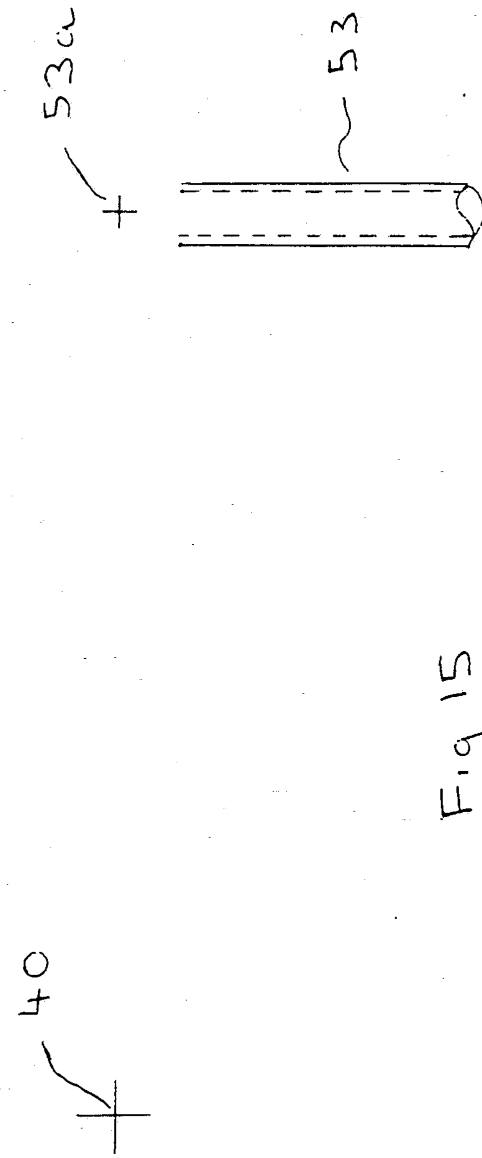


Fig 15

DRAWING AID

This invention relates to the production of drawings, in particular engineering drawings, and has particular application to the production of so-called "engineering details".

In a particularly preferred embodiment, the invention may be implemented utilising an appropriately programmed computer, although the invention also finds application in manual drawing aids, for example using transfers or transparencies.

In particular, the invention is concerned with a drawing aid for producing detailed drawings of structural steel fabrications.

In the production of fabricated steel structures, for example, steel frameworks for buildings, oil platforms, and the like, the path from the original conception of an idea to the production of working drawings or construction is a long one. In general, a three-dimensional description is first formulated by an architect or engineering, and plastics scale models may sometimes be constructed for complex structural systems, to aid visualization in three-dimensions. Perspective and isometric drawings are manually draughted by an architect, until the optimum layout in three-dimensions has been achieved. Finally, a set of general arrangement drawings are produced. These consist of plans, elevations, sections, and architectural details.

These general arrangement drawings are then used by the various disciplines who will be concerned with the production of the structure, as a basis for their design. Each discipline will then produce a set of general arrangement and detailed drawings.

The process is an iterative one, with all the architectural and engineering disciplines interacting.

When the general arrangement has been finalised, a detailed drawing must be produced of each small part of the structure, for use during fabrication. For example, in the production of a steel framework for a building, a drawing must be produced at every point at which steel members intersect, showing the way in which the various members connect to each other.

The production of detailed drawings can typically take many times the time taken to produce the general arrangement drawings.

Various attempts have been made to simplify the production of detailed drawings from general arrangement drawings. For example, when manual drafting methods are used, it is possible to obtain stick-on transfers for some standard details of the interconnection of structural members. Such existing standard details include however all the structural members entering the joint. Structural members can enter a joint from any of a large number of directions, and each of the members can have many forms (for example "I" section, "L" section, circular, box, etc).

For each type and size of structural member, a large number of types of end configuration may be used. For example, joints may be welded, bolted, using various number of bolt holes, etc. It will readily be appreciated that the number of different types of joints which can be constructed is very large indeed, and it is possible to produce using transfers only a very restricted number of standard types of joints.

Recent years have seen the increasing use of computer aided design (CAD) methods to the production of drawings. Numerous attempts have been made to produce computer systems able to generate from a 3-dimensional computer model the necessary detailed drawings of constructional joints between members.

Existing approaches to the problem however fall into two types. In the first type of solution, a library of data relating to the representation of different joint types is stored, for example on computer disk, and extracted when it is desired to produce a representation of a particular type of joint. This method is directly analagous to the manual method described above, using transfers. Substantially the same problems arise, so that although such methods are an improvement upon traditional manual methods, the approach cannot cater for anything except a very small number of possible joint types. Thus, when this approach is employed, a great deal of detailing still has to be done "manually", (even though the "manual" operation may utilise a computer input device such as light pen rather than a draughtsman's pen).

The alternative approach to computer methods has been the use of intersection generally in which surfaces of members intersecting in the three dimensional model are trimmed against each other. Rules need to be established for priority if this is to be done automatically. Most detailing systems use an interactive form of intersection geometry where the designer interactively trims members against each other, adds plates bolts etc. and gradually constructs the detail. As well as being computer intensive, intersection geometry is very limited and only applicable to a small number of "standard" details.

One possible approach is to build up a description of an intersection, using a library of descriptions of member types, and an appropriate scaling factor, taken from the computer model, for the sizes of the members. Although superficially attractive, this approach is very difficult to implement in practice. The main difficulty arises because only certain parts of a joint will vary in size, depending upon the size of the members entering the joint. Thus, for example, when two structural members are joined by a cleat or plate, the size of the cleat or plate bolts will frequently be invariant, for a wide range of member sizes. Also, certain features would require to be scaled in one direction only which is very difficult to achieve in a practical situation. For example, any attempt to scale circular features in one direction only results in the production of an ellipse, which is not only difficult to produce by existing CAD techniques, but is also incorrect. A number of other features give rise to similar problems when scaled, and any attempt to produce detailed drawings of parts by scaling would necessary result in very complex computer programs, which can deal only with a limited number of situations. No practical proposals have been put forward which employ this approach.

The invention is based on the realisation that, in order to produce detailed drawings of member connections which are useful for fabrication purposes and the like, a fully scaled drawing is not in general required, since the actual sizes of members can be indicated separately on the drawing. It is however necessary that a general indication of the relative sizes of the members entering the joint should be shown by the drawing, since otherwise the drawing produced bears no relation to reality, and cannot show the correct juxtaposition of the various members.

In accordance with the present invention, a drawing of the construction of a joint between a plurality of elongate members may be constructed by superimposing representations of each of a plurality of types of members which enter the joints. Representations of a number of different types of standard end configurations of members are provided, for example a "double cleat connection", "a single cleat connection", various types of welded connections etc., each representation showing a single member, and for certain members, showing three orthogonal views of the member. These representations are then superimposed to provide the final detail drawings. Because in general it is required only that the detail drawings should show relative sizes of members along any line passing through the connection, a plurality of standard sizes of representations are provided for each end configuration. In general, three sizes ("small", "medium" and "large") will be required for each view of each type of end configuration.

Accordingly, in a first aspect of the invention, there is provided a method of drawing the construction of a joint between a plurality of members, which method comprises storing for each of a plurality of types of members representations associated with each of a plurality of possible end configurations for each member, such that for each of the said members there are stored representations of at least three standard sizes of the said member for each of the said possible end configurations, each of the said representations having a datum point to enable the plurality of the said representations to be superimposed such that the respective members are correctly orientated with respect to the joint to be drawn, ascertaining for the joint to be drawn the end configurations of the various members constituting the joint, comparing the sizes of the said members entering the joint, and classifying the said members into one of the said at least three standard sizes, in accordance with the result of the said comparison, selecting for each end of a said member entering the joint a corresponding one of the said standard size representations, and combining the selected standard size representations, to produce a drawing of the joint.

In a first and readily comprehensible embodiment of the invention, the representations may be drawings, for example conventional elevational and plan drawings, and may be provided for example on transparent film, or in the form of transfers. In particular, a single sheet of representations may comprise, for one of the three relative sizes, and for one of the possible plurality of types of end configuration, a single elevational or plan view of a single member entering a joint. Similar sheets of representations are provided for each other possible combination of relative size, end configuration, and view. These views are orientated in a fixed position relative to a datum point on the supporting material (e.g. the plastic film on which they are drawn), such that a number of such individual representations of members may be superimposed to produce a representation of the detail construction of joints. Accordingly, in a second aspect of the invention, there is provided a drawing aid for the construction of a drawing of a joint between a plurality of elongate members, comprising, for each of a plurality of types of members, a plurality of representations associated with each of a plurality of end configurations of the member, such that, for each of the said end configurations, there are provided a plurality of representations for each of at least three standard sizes of the member, and for each of at least three views of the member, each representation also including a datum point, and the views on the respective representations being in fixed spatial relation to the datum point for all the plurality of representations, such that a drawing of the joint may be contructed by selecting appropriate representations of the members entering the joint, and superimposing the datum point of the representations, thereby to superimpose the respective views, and produce the desired drawing of the joint.

It will be appreciated however that a directly similar result can be achieved without the physical reduction of the views of the members to a drawing (e.g. on a transparent film). Instead, representations of the various ends configurations may be stored by a computer, for example on a computer disk, and may be combined electronically, to produce on a display device, for example a visual display unit, (VDU) or a plotter a representation of the joint.

Accordingly, in a further aspect of the invention, there is provided apparatus for producing a drawing of a joint between a plurality of elongate members, comprising data processing means, data input means, and display means for displaying the drawing, means for storing, for each of a plurality of types of members, representations associated with each of a plurality of end configurations of the member, such that for each of the said end configurations, means are provided for storing at least three standard sized representations, corresponding to members of different relative sizes, for each of the said possible end configurations, the data input means including means for inputting to the apparatus data indicative of the end configuration and relative sizes of the various members constituting the joint, and the data processing means being arranged and programmed to compare the sizes of the said members, and to classify the said members entering the joint in accordance with the result of the said comparison, and thereby selecting for each said member entering the joint a corresponding one of the said standard sized representations, the apparatus for including means for combining the representations in such a way as to superimpose on the display means the representations of the said end configurations of the members forming the joint, and thus provide a representation of the joint.

In practice, there are a finite number of shapes adopted for structural members, and each of these will be attached to other structural members using only a finite number of end configurations. In accordance with the invention however, if an additional shape of member, or end configuration is required to be represented, it can simply be drawn, and its representation added to the "library" of representations stored. In practice for structural steelwork, almost all joints in common use can be represented using less than a hundred end configurations.

A particular embodiment of the invention will now be illustrated with reference to the following drawings, in which:-

Figures 1*a* to 1*g* illustrate a number of different typical structures joint configurations;

Figure 2 is a hidden line isometric view of an alternative construction of a joint;

Figure 3 shows right elevation, front elevation and plan views of the joint of Figure 2, formed from representations in accordance with the invention;

Figures 4 to 7 are respectively representations of four different column end types, each containing three views;

Figures 8 and 9 illustrate respectively libraries of representations of the member types shown in Figure 2, and

Figures 10 to 15 illustrate the various views of the members used to construct Figure 3, referred to a datum point.

Referring first to Figures 1a to 1g, each of Figures 1a to 1g illustrates a different typical joint configuration. For example, in the configuration of Figure 1c, a column 1, formed of an "I" beam section is connected to two horizontal I beam sections 2 and 3, by angle cleats 4. A further horizontal "I" section 5 is bolted to column 1 at right angles to the two members 2 and 3, using angle cleats 6. Further up the column, braces 8 and 9 are connected to column 1, by means of a gusset plate 10.

In practice, almost all inclined members in structural steelwork are inclined only in one of the three orthogonal planes of the joint (horizontal and two vertical) and thus almost all braces will lie in a vertical or horizontal plane.

The three primary orthogonal planes for which drawings are constructed may be chosen with reference to the orientation of the joint and designated arbitrarily as X, Y and Z. These axes need not necessarily coincide with the main axes of the structures being detailed, but in most cases will do so.

The various types of members entering a joint may therefore be classified into eighteen different types and for convenience the following descriptions are given for a joint where the axis of the joint is vertical:-

(i) Vertical Member (+ve Z direction)

(ii) Verticial Member (-ve Z direction)

(iii) Horizontal Member (+ve X direction)

(iv) Horizontal Member (-ve X direction)

(v) Horizontal Member (+ve Y direction)

(vi) Horizontal Member (-ve Y direction)

(vii) Vertical Brace (at any angle in +ve X, +ve Z Plane)

(viii) Vertical Brace (at any angle in +ve Y, +ve Z Plane)

(ix) Vertical Brace (at any angle in -ve X, +ve Z Plane)

(x) Vertical Brace (at any angle in -ve Y, +ve Z Plane)

(xi) Vertical Brace (at any angle in +ve X, -ve Z Plane)

(xii) Vertical Brace (at any angle in +ve Y, -ve Z Plane)

(xiii) Vertical Brace (at any angle in -ve X, -ve Z Plane)

(xiv) Vertical Brace (at any angle in -ve Y, -ve Z Plane)

(xv) Horizontal Brace (at any angle in +ve X, +ve Y Plane)

(xvi) Horizontal Brace (at any angle in -ve X, +ve Y Plane)

(xvii) Horizontal Brace (at any angle in -ve X, -ve Y Plane)

(xviii) Horizontal Brace (at any angle in +ve X, -ve Y Plane)

In practice when producing a detail of a structural joint, it is rarely required that the relative sizes of inclined members such as braces should be shown, with respect to the other members. Therefore, in accordance with a preferred aspect of the present invention, inclined members such as braces may be added to the drawing as a final stage, after the main vertical and horizontal members have been represented.

Figure 2 provides an illustration of the operation of the invention in practice. Figure 2 is a hidden line isometric drawing of a structural joint between a column 20, a circular tube member 21, and a box section member 22. Tube 21 is welded to column 20 by means of a Butt weld 24, and box section 22 is welded to an end plate 25, which is in turn welded to the two flanges 27 and 28 of column 20.

Figure 3 shows a right elevation (3a), front elevation (3b), and plan view (3c) respectively, which it is desired to produce of the joint of Figure 2.

A library is provided of each type of end configuration contemplated by the systems of members which may enter a joint. Examples of such libraries, showing the representations required for members 21 and 22 in Figure 2 are shown in Figures 8 and 9 respectively.

Columns are arbitrarily chosen as being fixed in size (for example, 30 mm x 30 mm in a typical implementation for drawing of scale 1:10). The four representations required by the library to shown an "I" section column is shown in Figures 4 to 7 respectively. Each of the representations of Figures 4 to 7 shows a right elevation 4a, 5a, 6a, 7a front elevation 4b, 5b, 6b, 7b and plan view 4c, 5c, 6c, 7c respectively of the end of the respective column member. Thus, in Figure 4, 4a represents the upper part of column 20 of Figure 2 viewed in the direction of arrow A, 4b the same member in direction of arrow B, and 4c, in direction of arrow C shown in Figures 2. Figure 5 shows the same representations 5a, 5b and 5c, for the lower part of column 20 in Figure 2.

Figures 6 and 7 are corresponding representations of a column member orientated at 90° to the column member of Figure 2. The representations of Figures 6 and 7 are not required to produce the details of Figures 3a to 3c.

In general, columns will very rarely be orientated at intermediate angles with respect to the main axes of the overall model, and as Figures 4 to 7 will be the only representations of an "I" section column required for almost all practical circumstances.

Each of Figures 4 to 7 includes a primary datum point 40, 41, 42 and 43 respectively with reference to which the three views 4a, 4b and 4c are positioned, and subsidiary datum points 41a, b and c, 42a, b and c, and 43a, b and c, associated with each of the three views 4a, 4b and 4c respectively.

The first step in constructing the detail of Figure 3 is to select the representations appropriate to the column type in use, in the present case that shown in Figures 4 and 5 respectively. The representations 4 and 5 may be provided on a transparent sheet, for example a transfer sheet, or, preferably, as representations stored in a computer. The representations of Figures 4 and 5 are superimposed, such that primary datum points 40 and 41 are superimposed as are secondary datum points 41, 40a and 41a and 40b and 41b and 40c and 41c . Thus, the representation of the column 20 is generated.

Figure 8 shows a library, of the representations 50 to 58 stored for a tubular member, such as member 21, attached by a weld, for each of the three views, in each of three possible sizes. Thus, in Figure 8, 50 represents a "small" size elevation of tube 21, 53 represents "small" size plan view, and 56 represents a "small" sectional view section of a "small" tubular member. Each of views 50 to 58 has a corresponding secondary datum point 50a to 58a respectively.

Figure 9 shows a corresponding library of representations 60 to 68, having secondary datum points 60a to 68a, for member 22.

Each view shown in Figures 8 and 9 can be rotated and/or reflected about an axis passing throught the respective datum point, so as to enable the respective view to be utilised in various orientations. In a computer implementation, this is achieved simply by the computer software. Where the views 54, 55 and 56 are provided in a physical embodiment, for example on a transfer sheet, the transfer sheet may be rotated, or in certain circumstances, separate transfers may be provided for each of the possible orientations.

In the computerised implementation of this invention, the first step in constructing the desired detail is to determine from the computer model of the overall structure, of which the joint of Figure 2 forms a part, what members enter the joint. An eighteen element matrix is constructed, each element representing one of the notional directions in which a member can enter the joint, and a value is assigned to each element of the matrix in accordance with the member, if any, entering the joint from the respective direction. If no member is present in a particular direction, a value of zero is assigned to the matrix.

The first six elements of the matrix refer to members in the major vertical and horizontal directions, and in the example shown in Figure 2, members are present only in the positive and negative z directions, and the positive x and negative y directions.

Thus in this case only four elements of the matrix are assigned non-zero values. These are the two elements representing the vertical column (assigned a value representing an "I" section beam), and the elements representing members 21 and 22 (assigned values representing tubular and box members respectively).

For each of the views 3*a*, 3*b* and 3*c* to be produced, a comparison is carried out along each of the major axes of the relative sizes of the three possible members which might be present. These are classified into "small", "medium", "large" and "absent". This information is derived by comparison of the *actual* sizes of the various members stored in the computer model. Thus, for view 3*a* of Figure 3, member 21 is smaller in depth than member 22, and is thus classified as "small", whereas member 22 is classified as "large". This is repeated for each of the three views, 3*b* and 3*c* in view 3*b*, the comparison is again between the depth of members 21 and 22, and for view 3c, no comparison is required, because, in each direction through the view, only one member enters the joint.

The computer thus ascertains that, to construct view 3a of Figure 3, there must be superimposed on the view of the column already constructed from the representations of Figures 4 and 5 the additional detail 50, from the library of Figure 8, reflected about the vertical axis of the secondary datum point 50a, and sectional view 68 of member 22, from the library of Figure 9. Similarly, view 3b requires sectional view 56 from Figure 8, and elevation 62 from Figure 9, and Figure 3c requires view 64 from Figure 9, and view 54 from Figure 8, rotated about datum point 54a. Figures 10 to 15 illustrate the various views 50, 68, 56, 62, 64 and 54 respectively of members 21 and 22 required to complete views 3a, 3b and 3c in Figure 3, each with its respective main datum point 40, and secondary datum point 50a, 68a, 56a, 62a, 64a and 54a respectively.

In order to produce Figure 3, showing three views, 3a, 3b and 3c, the representations of Figures 10 to 15 are superimposed with the representation of the column already produced, by superimposing respectively the primary datum points 40, and secondary datum points 50a, 68a, 56a, 62a, 64a and 53a respectively.

By the above means, a detailed view can be constructed very simply, for any joint which consists only of members in the x, y and z directions.

As indicated above, it is not usually necessary to indicate on a detail view the relative size of inclined members, because in almost every case, in which two inclined members enter a joint along the same line on opposite sides of the joint, they will be of a similar size. Thus, for each view of each type of end configuration for an inclined member, a representation of a standard size can be employed. Associated with each such representation is a datum line, indicating the line along which the inclined member should be orientated towards the secondary datum point of the joint. Also associated with each such representation is a clearance value between the inclined member and the vertical and horizontal members of the joint in the respective plane, for an inclined member end configuration of that type. Braces are generally offset by a minimum specified clearance from the vertical and horizontal members of the joint, and all that is generally required of the detail is that is should show the type of joint construction, the clearance value, and the angle of the inclined members. The angle of inclination of the inclined member may be derived from the computer model, and the computer is programmed to calculate the optimum position of the inclined member from the secondary datum point, such that the minimum clearance is satisfied. In the non-computerised embodiment of the invention, the same result can be achieved manually by placing a transfer of the inclined member on the correct angle line, and sliding the transfer along the angle line, until the optimum position is reached.

In a preferred embodiment, the computer can be programmed to generate on the detail a representation of a gusset plate, to support an inclined member. The size of the gusset plate can be calculated using trigonometry, from the weld length appropriate for that particular type of inclined member in the joint type in question. The computer may also be arranged to annotate on the detailed drawing produced the weld lengths, plate dimensions, and clearance values etc.

CLAIMS

1. A method of drawing the construction of a joint between a plurality of members, which method comprises storing for each of a plurality of types of members representations associated with each of a plurality of possible end configurations for each member, such that for each of the said members there are stored representations of at least three standard sizes of the said member for each of the said possible end configurations, each of the said representations having a datum point to enable a plurality of the said representations to be superimposed such that the respective members are correctly orientated with respect to the joint to be drawn, ascertaining for the joint to be drawn the end configurations of the various members constituting the joint, comparing the sizes of the said members entering the joint, and classifying the said members into one of the said at least three standard sizes, in accordance with the result of the said comparison, selecting for each end of a said member entering the joint a corresponding one of the said standard size representations, and combining the selected standard size representations, to produce a drawing of the joint.

2. A method as claimed in claim 1, wherein the representations are drawings.

3. A method as claimed in claim 2, wherein the drawings are provided on transparent film, or in the form of transfers.

4. A method as claimed in claim 2 or claim 3 wherein a single sheet of representations comprises for one of the said at least three standard sizes, and for one of the possible plurality of types of end configuration, a single elevational or plan view of a single member entering a joint.

5. A drawing aid for the construction of a drawing of a joint between a plurality of elongate members, comprising, for each of a plurality of types of members, a plurality of representations associated with each of a plurality of end configurations of the member, such that, for each of the said end configurations, there are provided a plurality of representations for each of at least three standard sizes of the member, and for each of at least three views of the member, each representation also including a datum point, and the views on the respective representations being in fixed spatial relation to the datum point for all the plurality of representations, such that a drawing of the joint may be contructed by selecting appropriate representations of the members entering the joint, and superimposing the datum point of the representations, thereby to

superimpose the respective views, and produce the desired drawing of the joint.

6. A method as claimed in claim 1, wherein the said representations of the various end configurations are stored by a computer, and are combined electronically, to produce on a display device a representation of the joint.

7. Apparatus for producing a drawing of a joint between a plurality of elongate members, comprising data processing means, data input means, and display means for displaying the drawing, means for storing, for each of a plurality of types of members, representations associated with each of a plurality of end configurations of the member, such that for each of the said end configurations, means are provided for storing at least three standard sized representations, corresponding to members of different relative sizes, for each of the said possible end configurations, the data input means including means for inputting to the apparatus data indicative of the end configuration and relative sizes of the various members constituting the joint, and the data processing means being arranged and programmed to compare the sizes of the said members, and to classify the said members entering the joint in accordance with the result of the said comparison, and thereby selecting for each said member

entering the joint a corresponding one of the said standard sized representations, the apparatus for including means for combining the representations in such a way as to superimpose on the display means the representations of the said end configurations of the members forming the joint, and thus provide a representation of the joint.

8. A method of drawing a joint, substantially as hereinbefore described with reference to, and as illustrated by, the accompanying drawings.

9. Apparatus in the form of a transparent sheet or transfer for drawing a joint substantially as hereinbefore described with reference to the accompanying drawings.

10. A computer programmed and arranged to produce a drawing, substantially as described herein.

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