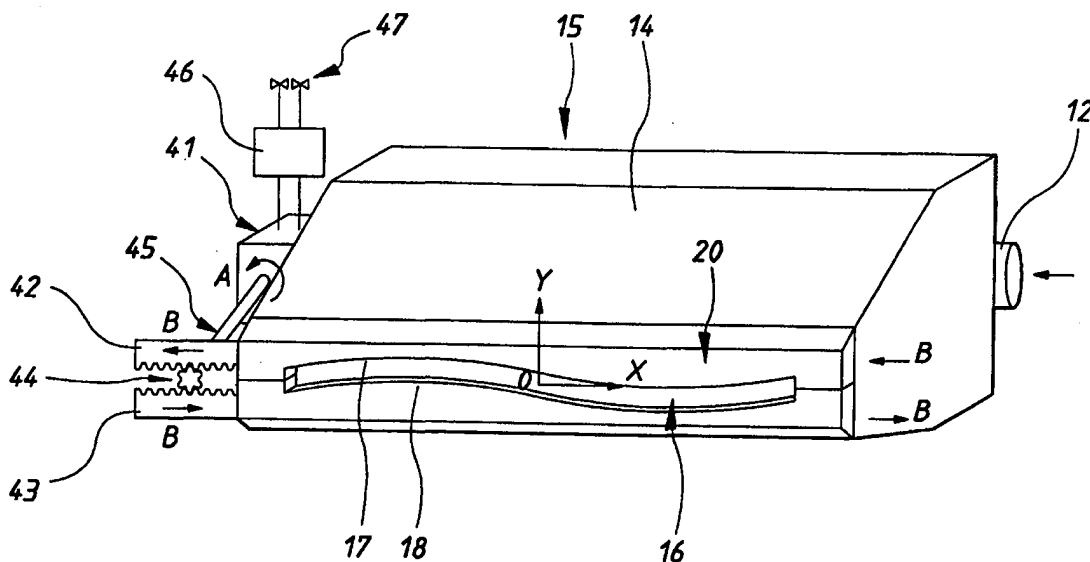




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>C23C 2/20, B05C 11/06, D21H 25/16</b>	<b>A1</b>	(11) International Publication Number: <b>WO 98/32890</b> (43) International Publication Date: 30 July 1998 (30.07.98)
<p>(21) International Application Number: PCT/AU98/00030</p> <p>(22) International Filing Date: 22 January 1998 (22.01.98)</p> <p>(30) Priority Data: PO 4732 22 January 1997 (22.01.97) AU</p> <p>(71) Applicant (for all designated States except US): INDUSTRIAL AUTOMATION SERVICES PTY. LTD. [AU/AU]; 71 York Street, Teralba, NSW 2284 (AU).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): WALLACE, Glen [AU/AU]; 1 Acorn Place, Mount Colah, NSW 2079 (AU).</p> <p>(74) Agent: SHELSTON WATERS; 60 Margaret Street, Sydney, NSW 2000 (AU).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> With international search report.</p>

(54) Title: COATING THICKNESS CONTROL



## (57) Abstract

This invention relates to the control of thickness of a coating applied to the surface of a sheet material. The invention provides an air knife assembly (15) including a body (14) for mounting adjacent to a sheet material which in use is moved past the body in a longitudinal direction, and a mouth (16) facing the sheet material and extending laterally with respect to the direction of movement of the sheet. The mouth (16) is defined by a pair of facing lips (17, 18) which are movable relative to the body (14). A moving means (41) is operable to move the lips (17, 18) relative to the air knife body (14). The assembly further includes a means for distributing a fluid under pressure through the body to enter and emerge from the mouth whereby pressurised fluid emerging from the mouth operates on a coating applied to a surface of the sheet material passing the air knife to thereby control the thickness of the coating.

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**TITLE: COATING THICKNESS CONTROL****FIELD OF THE INVENTION**

This invention relates to the control of thickness of a coating applied to the surface of a sheet material.

**5 BACKGROUND TO THE INVENTION**

The accurate and continuous control of the thickness of a coating being applied to the surface of a sheet material is required in a number of industries. For example, it is often necessary to control the thickness of coatings applied to paper or other similar materials in the form of a continuous travelling web. Another field in which the control  
10 of thickness of a continuously applied coating is required is in hot dip galvanising of metal sheet. The present invention has been particularly developed for controlling the coating thickness in a hot dip galvanising operation and it will be convenient to particularly describe the invention in relation to this field of application. However it should be appreciated that the apparatus and process of the present invention is  
15 applicable to other coatings and to other sheet materials being coated.

The hot dip galvanising process aims to apply a controlled amount of a protective coating, typically zinc and/or zinc alloy, to the surface of a metal item in order to produce a reasonable corrosion service life for the coated component. In the case of sheet metal for use in automobiles, roofing and similar applications a continuous hot dip  
20 galvanising line is employed to coat the sheet. The basic elements of such a galvanising line are depicted in Fig. 1. The galvanising line 1 includes input coils 2 which carry a roll of metal sheet 3. The metal sheet 3 is fed into an accumulator 4 and then passed through a furnace 5 (not shown). Upon leaving the furnace the metal sheet is passed

through a bath of protective coating 6, such as molten zinc. The coated sheet 11 then passes between a pair of air knives 15 located on opposing sides of the sheet. Scanning X-ray gauges 47 are located down the line beyond the air knives 15 to monitor the resulting thickness of the protective coating.

5           For metal sheet processed upon such a line the corrosion service life of the final product is dictated by the thickness of the applied coating, and in particular by the thinnest coating at any point of the applied coating. This is reflected in the standard measures which are used to classify coated sheet, which focus upon the minimum single spot thickness in the coating. Due to such standards specifying a minimum coat  
10       requirement, the producers of galvanised sheet must ensure that at all points over the sheet the coat thickness is above the minimum required for the product in question.

          The coating thickness is controlled by the application of a high pressure wiping jet which issues from an air knife adjacent to each surface of the metal sheet as the sheet is withdrawn from a molten zinc bath. A typical air knife 15 is depicted schematically in  
15       Fig. 2. The amount of coating which remains upon the surface of the sheet after passing through the wiping jet is mainly determined by the following parameters:

- line speed,
- distance from the air knife mouth to the sheet surface,
- pressure within the air knife header, and
- 20   • dimensions of the mouth.

          The distance from the air knife mouth to the sheet surface is controlled by horizontal positioning of the air knife assembly and is dependent also on the profile which the sheet adopts as it passes the air knives. Referring to the horizontal section

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shown in Fig. 3a, a bowed sheet profile can occur as the sheet exits the molten zinc bath and passes the air knives. This reduces the knife mouth to sheet distance in the centre section of the upper or distal sheet surface 31 relative to the knife mouth to sheet distance in the edge regions of sheet surface 31. The reverse is true for the lower or proximal sheet surface 32. This has the effect of introducing a variation in the thickness of the coating across the sheet. Fig 3b illustrates a typical coating profile on the upper or distal sheet surface 31 whilst Fig. 3c illustrates a typical coating profile on the lower or proximal sheet surface 32. This coating defect is known as "crossbow".

The crossbow defect in the coating profile forces line operators to increase the average amount of coating material which is applied to the sheet surfaces in order to ensure that the minimum single spot requirements are satisfied across the entire width of the sheet. Typical magnitudes of crossbow defect are of the order of 10% of the average coating being applied. As such, the over-coating required in order to avoid crossbow induced violations of minimum single spot coating requirements represents a significant cost to continuous galvanising line operators.

There have been many systems proposed or implemented for controlling the coating thickness, particularly in circumstances where bowing of the sheet material causes variations in coating thickness across the width of the sheet. Such systems have typically involved modifying the configuration or other parameters of the air knife. For example, there have been proposed systems for changing the shape of the mouth of the air knife through which the pressurised gas emerges by deforming one of the lips defining the mouth; the deformation of the lip being non-uniform along its length so that the width of the mouth opening varies at different points along its length. Constricting

the width of the mouth reduces the gas flow at that point thus reducing the wiping effect at that point and thereby producing an increased coating thickness, and vice versa.

Examples of such systems involving selective opening and closing of the width of the mouth are shown in the published patent specifications US-5423913 and AU-37005/93.

5 In patent specification AU-50750/85 there is proposed a system of modifying the gas flow through the mouth of the air knife by selectively opening fluid escape passages which open into the mouth to thereby locally reduce the flow rate through the mouth.

US-4524716 discloses an air knife in which movable obstructions are provided inside the mouth so as to selectively modify the fluid flow through the mouth and  
10 thereby provide different flow rates at different points across the sheet or web being coated.

All of these prior proposed systems are mechanically relatively complex since they require a multiplicity of controllable operating components provided along the length of the mouth. This can make the total air knife assembly and control system  
15 complex in construction and operation and susceptible to mechanical failure or dysfunction, and difficult expensive or time consuming to install, calibrate or repair.

Accordingly, it is an object of the present invention to provide an air knife arrangement for use in coating thickness control which overcomes or ameliorates at least one shortcoming of prior air knife arrangements, or at least provides a useful alternative  
20 to prior air knife arrangements.

Although the terms "air knife", "air knife assembly", and "air knife arrangement" are used throughout the specification and claims such terms are not to be construed as

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limiting the invention to a field of application in which pressurised air is used. Other gases, or even liquids, may be used and are encompassed by the invention.

#### DISCLOSURE OF THE INVENTION

5           Accordingly, the present invention provides an air knife assembly including:  
a body for mounting adjacent to a sheet material which in use is moved past the body in a longitudinal direction;

a mouth facing the sheet material and extending laterally, the mouth being defined by a pair of facing lips, the facing lips movable relative to the body;

10           means for distributing a fluid under pressure through the body to enter and emerge from the mouth whereby pressurised fluid emerging from the mouth operates on a coating applied to a surface of the sheet material passing the air knife to thereby control the thickness of the coating; and

moving means operable to move the lips relative to the air knife body.

15           The present invention also provides an air knife mouth arrangement for use in an air knife assembly having a laterally extending elongated mouth through which pressurised fluid passes to operate on a coating applied to a surface of a sheet material passing relative to the mouth in a longitudinal direction to control the thickness of the coating, the air knife mouth arrangement including a pair of facing lips defining the  
20   mouth, the facing lips adapted to be movable relative to the air knife body.

In one preferred form of the present invention there is provided an air knife assembly including:

a body for mounting adjacent to a sheet material which in use is moved past the body in a longitudinal direction;

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a mouth facing the sheet material and extending laterally, the mouth being defined by a pair of facing lips, the facing lips configured and adapted to co-operate with each other such that upon relative lateral displacement of the lips the separation between the lips is varied along at least part of the length of the mouth;

5 means for distributing a fluid under pressure through the body to enter and emerge from the mouth whereby pressurised fluid emerging from the mouth operates on a coating applied to the surface of the sheet material passing the air knife to thereby control the thickness of the coating; and

moving means for selectively laterally or sideways relative displacement of the  
10 facing lips so as to thereby vary the separation of the lips and hence the widths of the mouth at different points along at least part of the length of the mouth.

The present invention also preferably provides an air knife mouth arrangement for use in an air knife having a laterally extending elongated mouth through which pressurised fluid passes to operate on a coating applied to a surface of a sheet material  
15 passing relative to the mouth in a longitudinal direction to control the thickness of the coating, the air knife mouth arrangement including a mouth defined by a pair of facing lips, said facing lips configured and adapted to co-operate with each other such that upon relative lateral displacement of the lips the separation between the lips is varied along at least part of the length of the mouth.

20 Advantageously, by providing a mouth with a pair of facing lips which are configured and adapted to co-operate with each other, a variation in width of the mouth opening, and hence a variation in fluid flow emerging from the mouth at different points along the length of the mouth, can be achieved by a relative lateral displacement of the



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two lips. This enables, for example, a single linear lateral movement of one lip or simultaneous oppositely directed line in lateral movements to the two lips to achieve a change in profile of the mouth, and in particular predetermined changes in widths of the mouth at different points along the length of the mouth.

5 It is further advantageous that the side shifting motion of the two lips forming the mouth of the air knife can be employed to break free, and hence remove, small lumps of coating material which have deposited upon the nozzle in the liquid state and subsequently become fixed in place. Hence the relative lateral motion of the lips can assist in maintaining the nozzle in a clean state, free of obstructions, thereby reducing the  
10 need to resort to cleaning the nozzle by other means such as mechanical means which may adversely affect the quality of the coating. The ability of the relative lateral displacement of the lips to break frozen obstructions from the nozzle is further enhanced by the use of a superfine surface finish on the inside surfaces of the nozzle.

Preferably each lip of the pair of facing lips has, in front elevation, a curved  
15 shape along at least a part of its length, the curved shapes of the lips facing each other.

Preferably the curved shape of each lip is provided along substantially the entire length of the mouth such that the relative lateral displacement of the lips produces a mouth width variation over substantially the entire length of the mouth.

Preferably the shape of each lip is defined by a mathematical function which,  
20 taking the origin as the mid-point along the length of the mouth as the origin of a co-ordinate system and taking the longitudinal and lateral directions as the axes, defines a shape which is not symmetrical about either of the axes, but has anti-symmetry about the two axes.

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Preferably the shape of each lip, in front elevation, is defined by an odd polynomial function or by a trigonometric function.

Preferably each lip has an identical shape to the other lip, although for some purposes or fields of application an initial non-uniform mouth width along its length may  
5 be required.

Preferably the moving means of the air knife assembly is operable to move both of the lips simultaneously in opposing directions. In this way the mid-point along the length of the mouth defined between the lips can remain substantially in the same position relative to the width of the sheet material passing the air knife.

10 Preferably the moving means is operative in response to signals from control means, the control means including sensing means located past the air knife and operative to sense the coating thickness achieved on the surface of the sheet material.

In a further preferred form of the present invention there is provided an air knife assembly wherein the moving means is operable to move the pair of facing lips fore and  
15 aft relative to the air knife body so as to alter the mean distance between the mouth and the surface of the sheet material.

Advantageously, this form of the present invention can be utilised to control the mean thickness of the coating upon the surface of the sheet material.

In a further preferred form of the present invention there is provided an air knife  
20 assembly wherein the moving means is operable to move the pair of facing lips forward at one end and aft at the other end relative to the air knife body.

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Advantageously this aspect of the present invention can be utilised to compensate for misalignment between the mouth of the air knife and the surface of the sheet material.

In a further preferred form of the present invention there is provided an air knife  
5 assembly wherein the moving means is operable to laterally move a wedge member between one of the lips and the body of the air knife so as to adjust the position of the lip relative to the other lip and thus the average distance between the air knife lips along the length of the lips.

All of the mentioned modes of operation may be controlled by manual and/or  
10 automatic closed loop control by employing a downstream coating feedback measurement device.

#### BRIEF DESCRIPTION OF DRAWINGS

The preferred features of the present invention will now be described with particular reference to the accompanying drawings. However it is to be understood that  
15 the features illustrated in and described with reference to the drawings are not to be construed as being limiting on the scope of the invention. In the drawings:

Fig. 1 is a diagrammatic view of a typical hot dip galvanising line for coating sheet metal in a continuous strip or web;

Fig. 2 is a schematic perspective view of a conventional air knife;

20 Fig. 3a is a horizontal sectional view of a pair of air knives operating on a bowed sheet material passing between the air knives;

Figs. 3b & 3c illustrate a typical profile of the coating thickness resulting from the sheet material being bowed as it passes between a pair of air knives;

Fig. 4 is a schematic perspective view of one preferred embodiment of an air knife assembly according to the present invention;

Fig. 5 graphically depicts the mouth shape and mouth width variation of a preferred embodiment of air knife according to the present invention, with the lips of the mouth in a central or neutral position;

Fig. 6 graphically depicts the mouth shape and mouth width variation of a preferred embodiment of air knife according to the present invention, with the lips of the mouth in a laterally displaced first position;

Fig. 7 graphically depicts the mouth shape and mouth width variation of a preferred embodiment of air knife according to the present invention, with the lips of the mouth in an opposite, laterally displaced second position;

Figs. 8a to 8c schematically depict plan views of a further preferred embodiment of air knife according to the present invention, illustrating the fore and aft movements of the air knife mouth relative to the body of the air knife; and

Fig. 9 schematically depicts a further preferred embodiment of air knife according to the present invention, illustrating a wedge arrangement for adjusting the mean distance between the lips of the air knife mouth.

#### PREFERRED EMBODIMENT OF THE INVENTION

Figs. 1, 2 and 3 have been referred to in the introductory part of this specification and depict a known hot dip galvanising line, air knife configuration and arrangement, and coating defects caused by bowing of the sheet metal (the crossbow defect).

Referring to Fig. 4, the present invention relates to an air knife mouth arrangement 20 for use in an air knife assembly 15 having a laterally extending mouth

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16 through which pressurised fluid passes to operate on a coating applied to a surface of a sheet material 11 passing the mouth in a longitudinal direction to control the thickness of the coating. In the preferred form of the invention shown the air knife mouth arrangement 20 comprises a mouth 16 defined by a pair of facing lips 17, 18, each lip  
5 having in front elevation a curved shape along its length. The curved shapes of the two lips 17, 18 face each other. The lips 17, 18 of the air knife mouth arrangement are selectively laterally displaceable relative to each other by a moving means 41 so as to thereby vary the separation of the lips and hence the width of the mouth along the length of the mouth 16. It is to be noted that the term "length" refers to the dimension of the  
10 mouth in the lateral direction (indicated by the X axis), whilst the term "width" refers to the dimension of the mouth in the longitudinal direction (indicated by the Y axis).

The present invention also provides an air knife assembly 15, the assembly comprising a body 14 for mounting adjacent to the sheet material 11 which in use is moved past the body 14 in a longitudinal direction. To the body 14 is mounted the  
15 mouth arrangement 20 with the mouth 16 defined by the pair of facing lips 17, 18 of curved shape. Means 12 are provided for distributing a fluid under pressure through the body 14 to enter and emerge from the mouth 16 whereby pressurised fluid emerging from the mouth operates on a coating applied to the surface of the sheet material 11 passing the air knife to thereby control the thickness of the coating. The moving means  
20 41 selectively laterally or sideways displaces the facing lips 17, 18 so as to thereby vary the separation of the lips and hence the width of the mouth at different points along the length of the mouth.

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In the preferred embodiment for achieving a mouth width variation to counteract or compensate for crossbow defect in coating profile, the shape of each lip 17, 18 is preferably defined by a mathematical function which, taking the mid-point along the length of the lip as the origin of the co-ordinate system and taking the lateral and longitudinal directions as the X and Y axes respectively, defines a shape which is not symmetrical about either of the axes, but has anti-symmetry about the two axes. In a particularly preferred embodiment as illustrated, the shape of each lip in front elevation is defined by an odd polynomial function or by a trigonometric function.

The mathematical function defining the shape or profile of the lips 17, 18 may be an odd polynomial function or a trigonometric function such as:

$$y = Ax + Bx^3 + Cx^5 + Dx^7,$$

or

$$y = A \sin(B\pi x)$$

where:

15            y            =       longitudinal (vertical) coordinate  
              x            =       lateral (transverse) coordinate, with origin as shown in Fig. 4  
              A,B,C,D    =       tuning constants chosen appropriately to achieve desired gap variation and minimise total gap variation.

As shown in Fig. 5, (with the scales of the axes being chosen to exaggerate the amplitude of the curvature of each lip), it is preferable that when the upper and lower lips are in a central or neutral position they define a mouth having a constant width along its entire length, as illustrated by the line 50 representing a constant width of 0.001m.

Although the shape of the mouth is not a straight line, and hence the shape of the

emerging pressurised fluid does not lie in a flat plane, the wiping blade effect of the emerging pressurised fluid nevertheless is substantially uniform across the entire width of the mouth. If the surface of the sheet material passing the mouth is perfectly flat, the wiping effect and hence the achieved thickness of coating will be substantially uniform  
5 across the entire width of the sheet material.

However, if the sheet material is bowed as shown in Fig 3a, the thickness of the coating applied to one surface will be concave in profile across the width of the sheet and convex in profile across the width on the other surface of the sheet as previously described with reference to Figs. 3b & 3c. By sensing variations in coating thickness  
10 across the width of the sheet at a point beyond (downstream of ) the air knives, a control system can be utilised to produce appropriate control signals to vary the shape of the mouth of each air knife by lateral or sideways displacement of the respective facing lips. Lateral or sideways displacement of the lips in the direction shown by the arrows B in Fig. 4 and Fig. 6 will narrow the width of the mouth midway along the length of the  
15 mouth and will likewise increase the width of the mouth at its ends. Thus over the length of the mouth, the width of the mouth opening will vary as shown by the curve 60 in Fig. 6. This will reduce the pressurised fluid flow in the centre of the mouth and increase the fluid flow at the opposite ends of the mouth thus enabling compensation for crossbow defect producing a concavity in the coating thickness across the width of the  
20 coating.

Conversely, as shown in Fig. 7, lateral or sideways displacement of the upper and lower lips in the direction of arrows C produces a widening of the mouth at the mid region along its length, and narrowing of the width of the mouth at the opposite ends, as

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shown by the curve 70. This produces increased pressurised fluid flow in the centre with a greater wiping effect or wiping power in the central region, thus enabling compensation for crossbow defect with a convex profile of the coating thickness across the width of the sheet material.

5           The amplitude of the variation in width of the mouth will vary dependent on the extent of lateral or sideways displacement of the lips. Careful selection of the particular odd polynomial function or the trigonometric function and careful selection of the tuning constants in the formula defining the shape or profile of each lip will allow the particular form of the mouth width variation to closely match the typical sheet material strip or  
10 web deflection. The typical strip deflection caused by bowing of the sheet material in the vicinity of the air knives has been studied or can be studied empirically. And, as a result, the selection of the particular mathematical function and tuning constants can be estimated from such studies and/or effective lip profiles can be determined by empirical methods of testing different lip profiles.

15           The moving means 41 for displacing the lips laterally can be any suitable means. For example, a mechanical arrangement such as gears may be used. Alternatively a hydraulic or pneumatic actuator may be employed. The moving means 41 illustrated in Fig. 4 is operative to simultaneously move both lips in opposite lateral directions. In the embodiment depicted, the moving means comprises racks 42, 43 connected to the  
20 respective upper and lower lips 17, 18, the lips in turn being mounted to the body 14 of the air knife for lateral sliding movement. Co-operating with the racks 42, 43 is a pinion 44 on a drive shaft 45. The arrangement is such that rotation of the drive shaft 45 in the direction of arrow A produces lateral or sideways movement of the upper and lower lips



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in opposite directions as shown by the arrows B. The moving means 41 may be operative in response to signals from control means 46, the control means including sensing means 47 located past the air knife and operative to sense the coating thickness achieved on the surface of the sheet material 11.

5           It will be seen this preferred embodiment of the air knife mouth arrangement and air knife assembly, enable the selective control of the width of the mouth at different points along the entire length of the mouth. This enables adjustment of the wiping effect in a controlled manner. The mouth arrangement can be relatively simple in construction and operation so that it can be reliable in operation. It is believed that the air knife  
10   mouth arrangement may be capable of being retro fitted to existing air knives so that the air knife mouth arrangement per se is a novel and valuable article of manufacture, as well as the total assembly with the air knife mouth arrangement installed and in use in an air knife.

Referring to Figs. 8a to 8c, a further preferred embodiment of the present  
15   invention provides for the adjustment of the mean distance between the mouth of the air knife and the sheet, and for adjustment of the alignment between the mouth of the air knife and the plane of the sheet. The air knife 15 is schematically depicted in plan view. At each end of the air knife mouth arrangement 20 there is provided a moving means 86 for moving the lips of the mouth in fore and aft directions with respect to the body 14 of  
20   the air knife. Fig 8a depicts the air knife 15 with the lips of the air knife mouth 20 in a retracted position with respect to the air knife body 14. In Fig 8b the lips of the air knife mouth have been extended from the body 14. In this way the mean distance between the mouth of the air knife and the surface of the coated sheet can be adjusted. In Fig. 8c the

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moving means 86 can be utilised to move one end of the mouth forward and the opposing end aft. In a particularly preferred arrangement the opposing ends of the mouth can be moved in equal but opposite directions so as to alter the alignment of the air knife mouth with respect to the surface of the sheet. In this way it is possible to  
5 compensate for skewing of the sheet as it passes the mouth of the air knife.

Referring to Fig. 9, in a further preferred embodiment of the invention adjustment of the mean distance between the lips 17, 18 of the air knife mouth 16 can be achieved by utilising a laterally displaceable wedge member 92. The wedge member 92 is located between and acts upon the upper lip 17 and the body of the air knife 14 such  
10 that when the wedge is moved laterally in the directions shown by the arrow 94 the upper lip is caused to move either towards or away from the lower lip 18. It should be appreciated that a wedge member 92 may be located to act upon either or both of the lip members 17, 18. In this way the average distance between the lips of the mouth can be modified either independently or in conjunction with the other position options  
15 mentioned.

Control over the mean distance between the mouth of the air knife and the surface of the coated sheet, the average air knife gap, and the degree of misalignment between surface of the coated sheet and air knife mouth, either individually or when coupled with the lateral motion of the lips defining the mouth of the air knife, allow all  
20 of the major coating defects to be corrected by fine adjustments of the air knife mouth. With this capability the air knife supporting structure can be used to position the air knife in a coarse fashion whilst the fine motion required to accurately control the coating can then be achieved by movement of the air knife mouth alone. This is considered

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highly desirable when compared to the current practice of attempting to precisely position the entire air knife supporting structure as the components being moved have a far more direct relation to the strip surface being controlled.

It is to be understood that various alterations, modifications and/or additions may  
5 be made to the features of the possible and preferred embodiment(s) of the invention as herein described without departing from the spirit and scope of the invention.

## CLAIMS

1. An air knife assembly including:
  - a body for mounting adjacent to a sheet material which in use is moved past the body in a longitudinal direction;
  - 5 a mouth facing the sheet material and extending laterally, the mouth being defined by a pair of facing lips, the facing lips movable relative to the body;
    - means for distributing a fluid under pressure through the body to enter and emerge from the mouth whereby pressurised fluid emerging from the mouth operates on a coating applied to a surface of the sheet material passing the air knife to thereby
    - 10 control the thickness of the coating; and
    - moving means operable to move the lips relative to the air knife body.
2. The air knife assembly as claimed in claim 1, wherein the pair of facing lips are laterally displaceable relative to each other;
  - the facing lips configured and adapted to co-operate with each other such that
  - 15 upon relative lateral displacement of the lips the separation between the lips is varied along at least part of the length of the mouth;
  - the moving means operable to laterally displace the lips relative to each other so as to vary the separation of the lips and hence the width of the mouth at different points along at least part of the length of the mouth.
- 20 3. The air knife assembly as claimed in claim 2, wherein each lip of the pair of facing lips has, in front elevation, a curved shape along at least a part of its length, the curved shapes of the lips facing each other.

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4. The air knife assembly as claimed in claim 3, wherein the curved shape of each lip is provided along substantially the entire length of the mouth, such that the relative lateral displacement of the lips produces a mouth width variation over substantially the entire length of the mouth.
- 5 5. The air knife assembly as claimed in claim 3, wherein the shape of each lip is defined by a mathematical function which, taking the origin as the mid-point along the length of the mouth as the origin of the co-ordinate system and taking the longitudinal and lateral directions as the axes, defines a shape which is not symmetrical about either of the axes, but has anti-symmetry about the two axes.
- 10 6. The air knife assembly as claimed in claim 5, wherein the shape of each lip, in-front elevation, is defined by an odd polynomial function or by a trigonometric function.
7. The air knife assembly as claimed in claim 2, wherein the moving means is operable to move both of the lips simultaneously in opposing directions.
8. The air knife assembly as claimed in claim 2, wherein the moving means is  
15 operable in response to signals from control means, the control means including sensing means located past the air knife and operative to sense the coating thickness achieved on the surface of the sheet material.
9. The air knife assembly as claimed in claim 1, wherein the moving means is operable to move the pair of facing lips fore and aft relative to the body so as to alter the  
20 mean distance between the mouth and the surface of the sheet material.
10. The air knife assembly as claimed in claim 1, wherein the moving means is operable to move the pair of facing lips forward at one end and aft at the other end relative to body.

- 20 -

11. The air knife assembly as claimed in claim 1, wherein the moving means is operable to laterally move a wedge member between one of the lips and the body so as to adjust the position of the lip relative to the other lip and thus the average distance between the air knife lips along the length of the lips.

5 12. An air knife mouth arrangement for use in an air knife assembly having a laterally extending elongated mouth through which pressurised fluid passes to operate on a coating applied to a surface of a sheet material passing relative to the mouth in a longitudinal direction to control the thickness of the coating, the air knife mouth arrangement including a pair of facing lips defining the mouth, the facing lips adapted to  
10 be movable relative to the air knife body.

13. The air knife mouth arrangement as claimed in claim 12, wherein the pair of facing lips are laterally displaceable relative to each other;

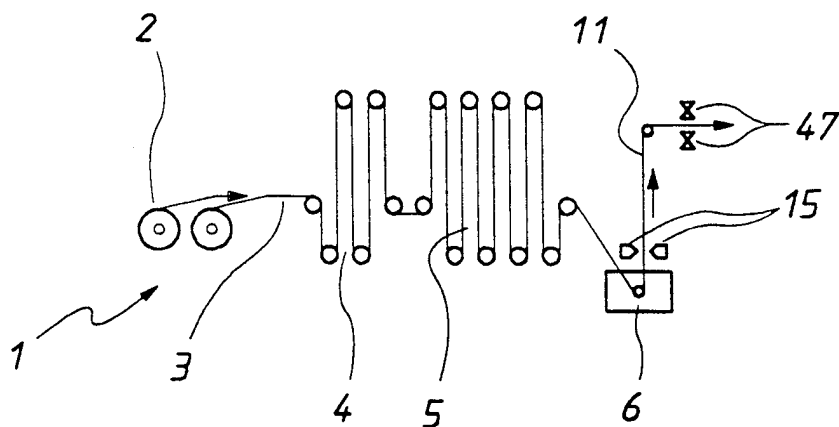
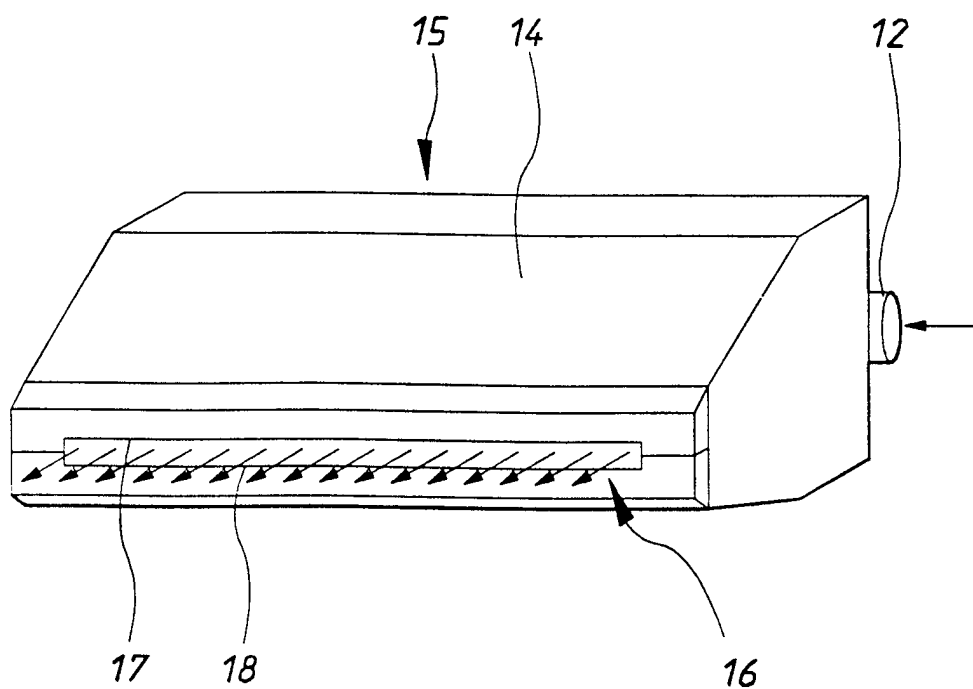
the facing lips configured and adapted to co-operate with each other such that upon relative lateral displacement of the lips the separation between the lips is varied  
15 along at least part of the length of the mouth.

14. The air knife mouth arrangement as claimed in claim 13, wherein each lip of the pair of facing lips has, in front elevation, a curved shape along at least a part of its length, the curved shapes of the lips facing each other.

15. The air knife mouth arrangement as claimed in claim 14, wherein the curved  
20 shape of each lip is provided along substantially the entire length of the mouth, such that the relative lateral displacement of the lips produces a mouth width variation over substantially the entire length of the mouth.

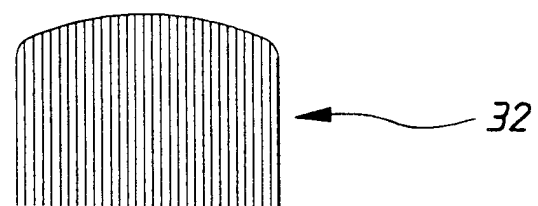
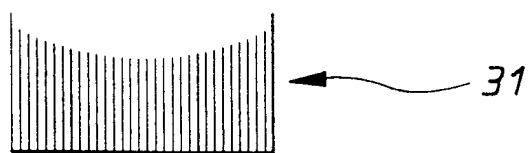
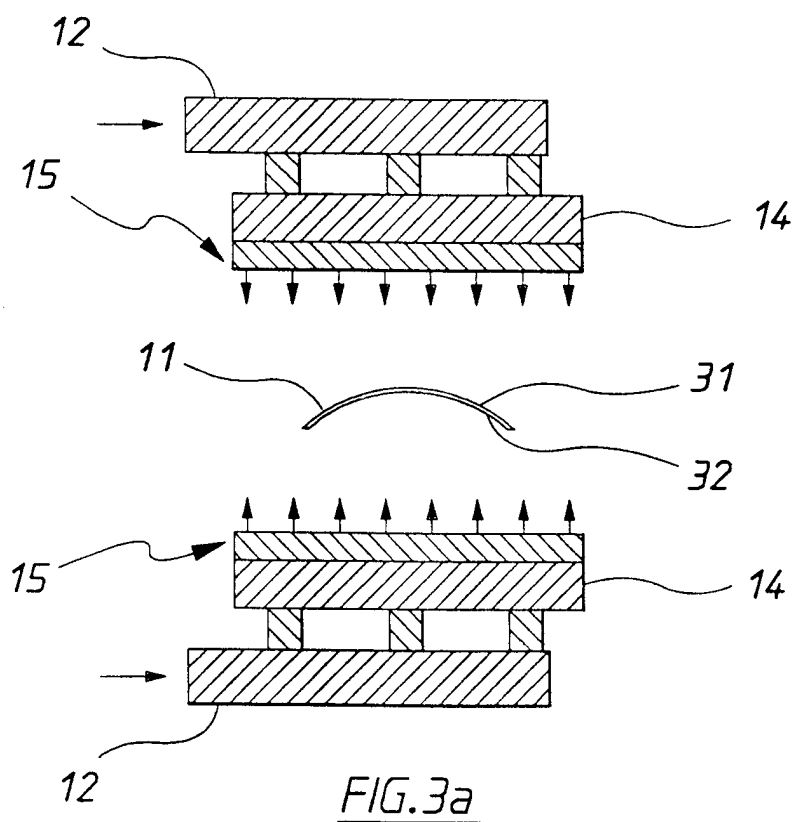
16. The air knife mouth arrangement as claimed in claim 14, wherein the shape of each lip is defined by a mathematical function which, taking the origin as the mid-point along the length of the mouth as the origin of the co-ordinate system and taking the longitudinal and lateral directions as the axes, defines a shape which is not symmetrical
- 5 about either of the axes, but has anti-symmetry about the two axes.
17. The air knife mouth arrangement as claimed in claim 16, wherein the shape of each lip, in-front elevation, is defined by an odd polynomial function or by a trigonometric function.

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FIG. 1FIG. 2



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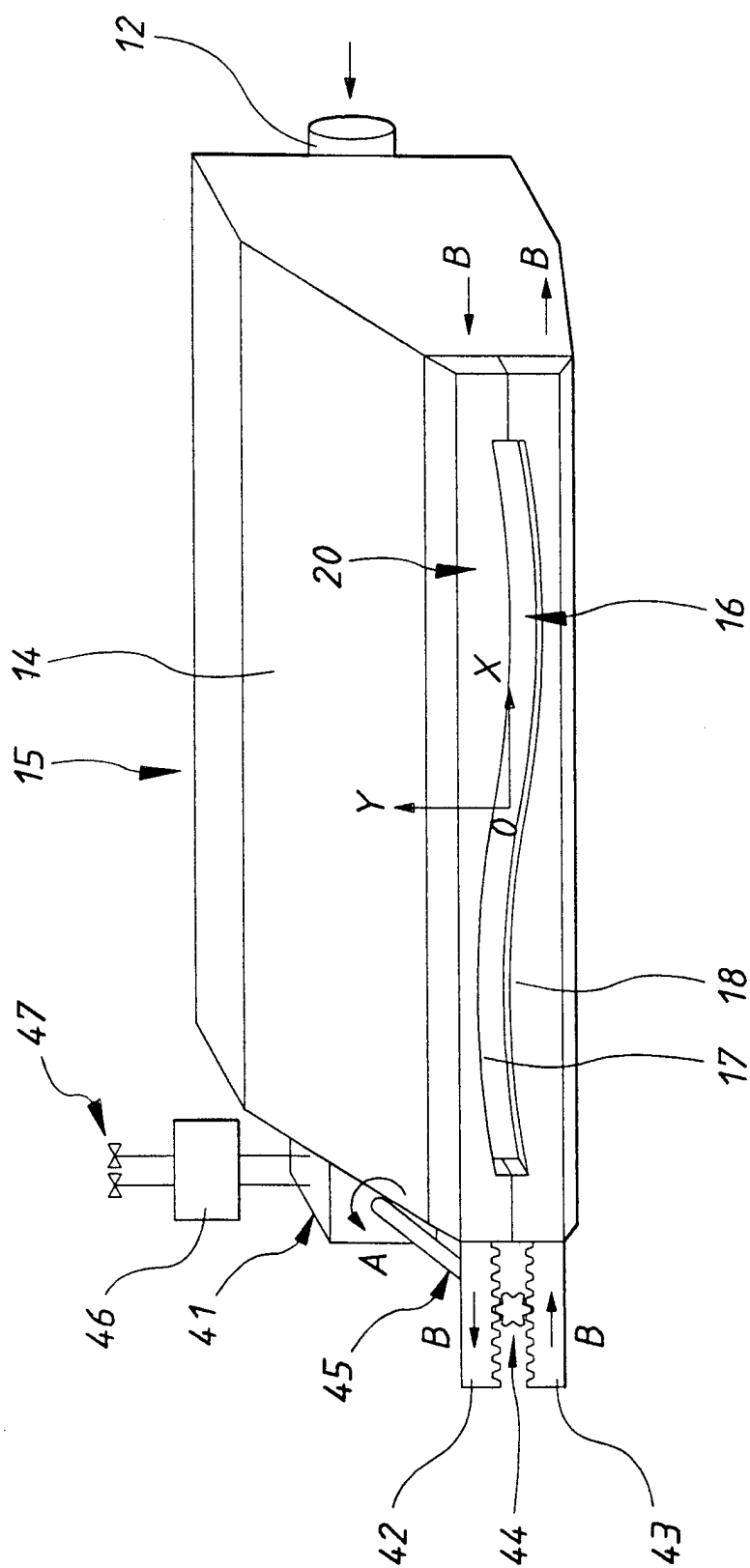


FIG. 4

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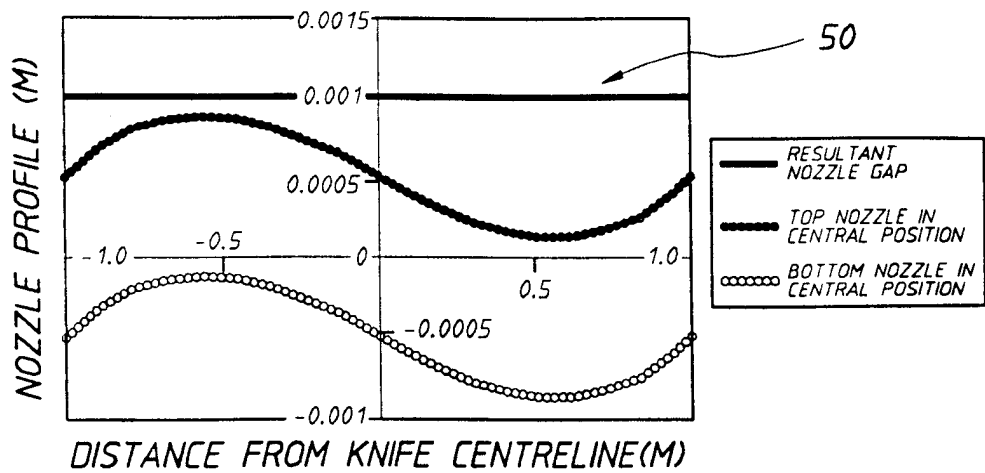


FIG. 5

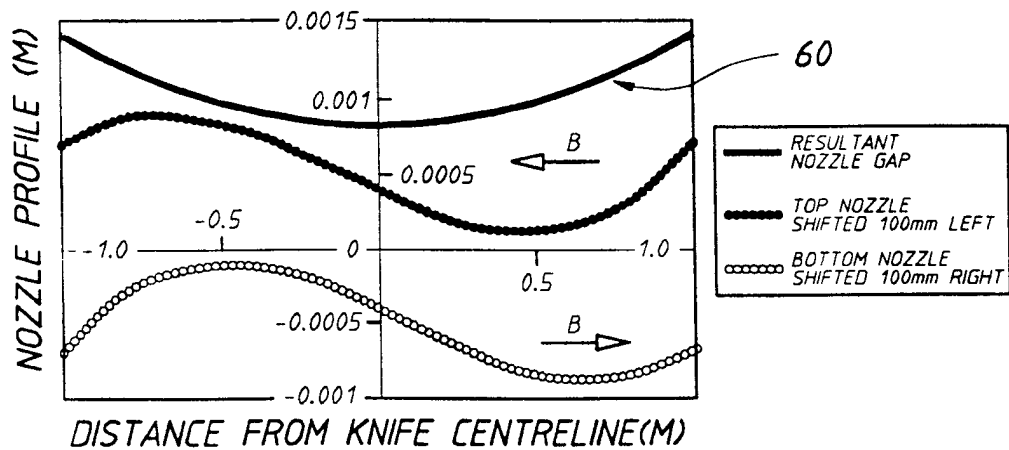


FIG. 6

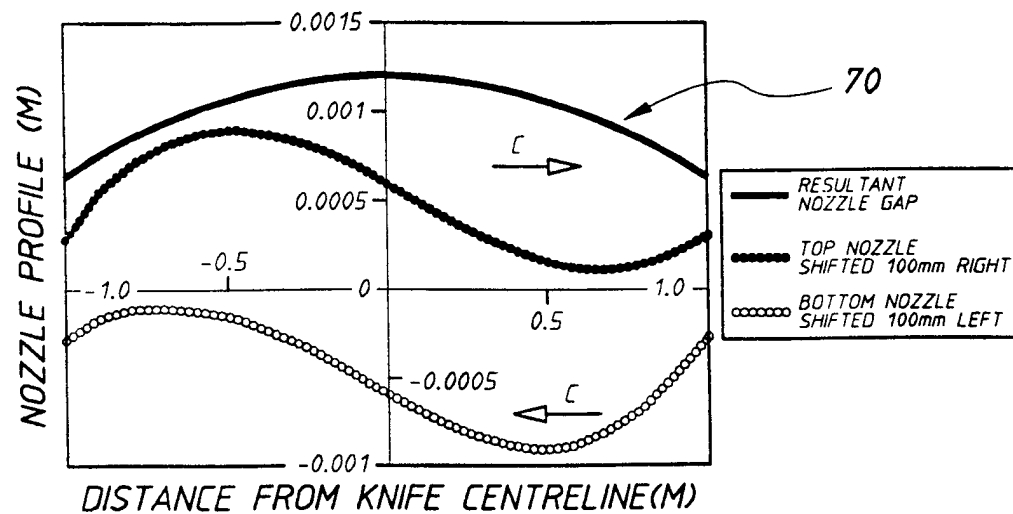


FIG. 7

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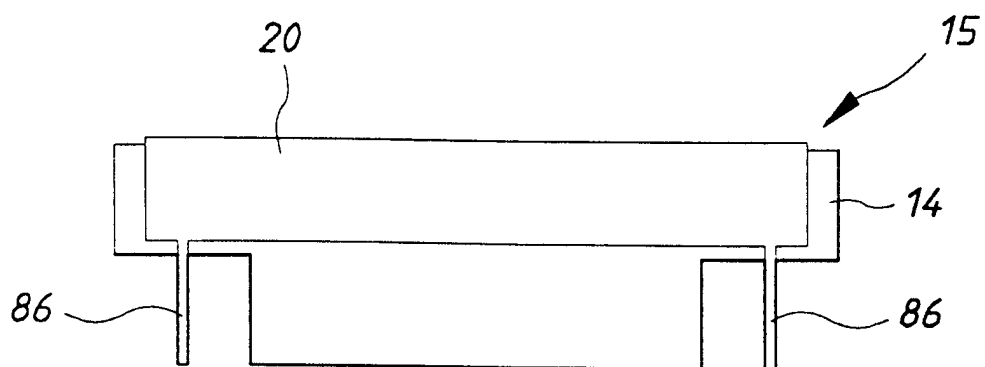


FIG. 8a

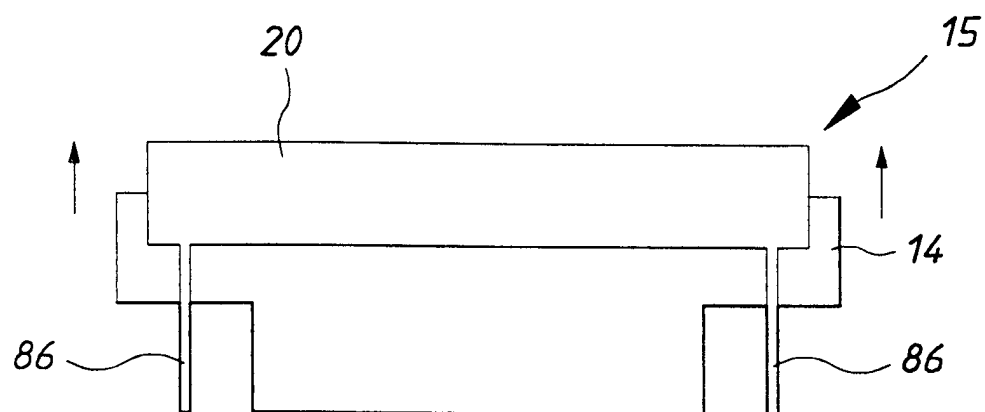


FIG. 8b

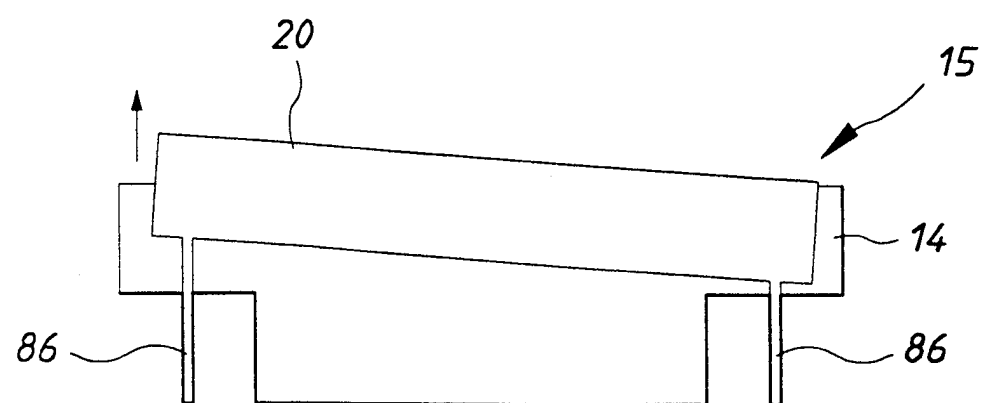
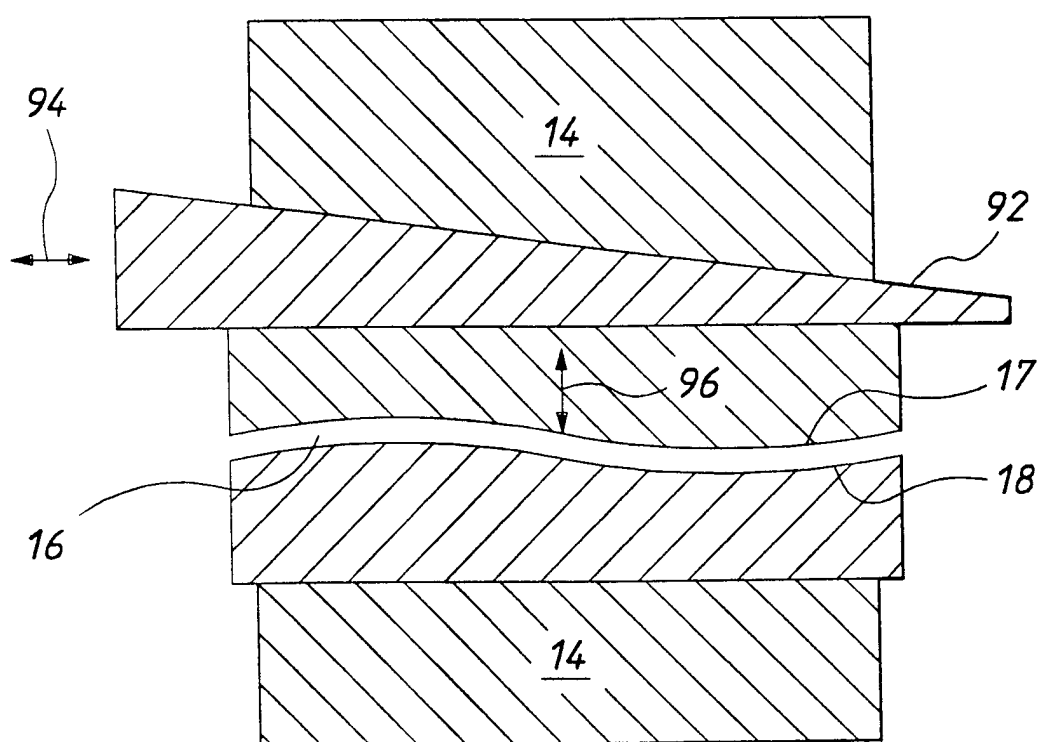


FIG. 8c

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FIG. 9

# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/AU 98/00030

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>																						
Int Cl <sup>6</sup> : C23C 2/20; B05C 11/06; D21H 25/16																						
According to International Patent Classification (IPC) or to both national classification and IPC																						
<b>B. FIELDS SEARCHED</b>																						
Minimum documentation searched (classification system followed by classification symbols) IPC (6): C23C 2/20; B05C 11/06; D21H 25/16																						
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU: IPC as above																						
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)																						
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>																						
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																				
X	US, 3272176 A, (SAYDLOWSKI) 13 September 1966	1, 12																				
X	US, 2568492 A, (GALLICK) 18 September 1951	1, 12																				
X	EP, 249234 A, (DUMA KONSTRUKT) 16 December 1987	1, 12																				
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex																						
<p>* Special categories of cited documents:</p> <table border="0"> <tr> <td>"A"</td> <td>document defining the general state of the art which is not considered to be of particular relevance</td> <td>"T"</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"E"</td> <td>earlier document but published on or after the international filing date</td> <td>"X"</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"L"</td> <td>document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"Y"</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"O"</td> <td>document referring to an oral disclosure, use, exhibition or other means</td> <td>"&amp;"</td> <td>document member of the same patent family</td> </tr> <tr> <td>"P"</td> <td>document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"E"	earlier document but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family	"P"	document published prior to the international filing date but later than the priority date claimed		
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"P"	document published prior to the international filing date but later than the priority date claimed																					
Date of the actual completion of the international search 3 March 1998		Date of mailing of the international search report <b>10 MAR 1998</b>																				
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE IP AUSTRALIA PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929		Authorized officer  <b>DAVID LEE</b> Telephone No.: (02) 6283 2107																				

# INTERNATIONAL SEARCH REPORT

International Application No.  
**PCT/AU 98/00030**

<b>C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB, 2254808 A, (AIR CONTROL INSTALLATIONS) 21 October 1992	1, 12
Y	US, 4106429 A, (PHILLIPS) 15 August 1978	1, 12
Y	AU, 37005/93 A, (CLECIM) 21 October 1993	1, 12
Y	DE, 4024229 C1, (PANNENBECKER) 18 July 1991	1, 12
Y	GB, 2019916 A, (ALBANY INTERNATIONAL) 7 November 1979	1, 12

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.  
PCT/AU 98/00030

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
US	3272176						
US	2568492						
EP	249234	AT	45390	DE	3760425		
GB	2254808						
US	4106429	BR	7802947	CA	1091002	ES	470515
		IT	1095811	JP	54106550	JP	54043012
		MX	146805				
AU	37005/93	EP	566497	FR	2690170	JP	6106500
		US	5332437				
DE	4024229	AT	105339	CA	2088591	EP	542765
		FI	930410	US	5346551	WO	9209656
GB	2019916	AR	218972	AU	45785/79	CA	1095826
		DE	2911812	FI	791203	FR	2424112
		NZ	190189	SE	7903430	US	4270702
		ZA	7902009				
END OF ANNEX							