



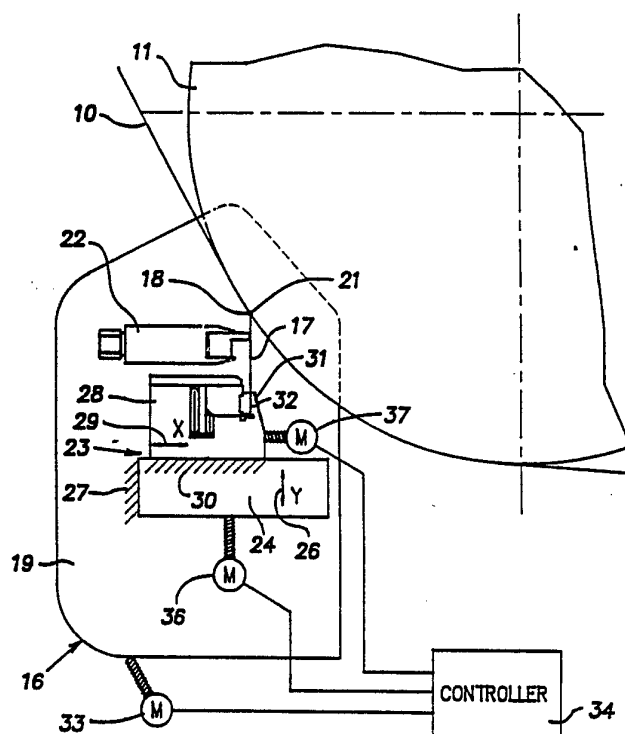
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |                                                                                                                                                                                                                                                                |
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| (51) International Patent Classification <sup>5</sup> :<br><br>B05D 1/28                                                                                                                                                                                                                                                                                                                                                                                                           | A1 | (11) International Publication Number: WO 94/03282<br><br>(43) International Publication Date: 17 February 1994 (17.02.94)                                                                                                                                     |
| (21) International Application Number: PCT/US93/07278<br>(22) International Filing Date: 3 August 1993 (03.08.93)<br><br>(30) Priority data:<br>07/924,838 4 August 1992 (04.08.92) US<br><br>(71) Applicant: KOHLER COATING MACHINERY CORPORATION [US/US]; 9701 Cleveland Avenue NW, Greentown, OH 44630 (US).<br><br>(72) Inventors: KOHLER, Herbert, B. ; 10995 Wright Road, Uniontown, OH 44685 (US). SCHMIDT, Michael, L. ; 1316 Willoway, S.E., North Canton, OH 44720 (US). |    | (74) Agent: SOPKO, Jeffrey, J.; 1200 Leader Building, Cleveland, OH 44114 (US).<br><br>(81) Designated States: CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).<br><br>Published<br>With international search report. |

(54) Title: ADJUSTABLE BLADE COATER

## (57) Abstract

A web coater is provided with a doctor blade (17) having an active edge (18) or tip engaging the web (10) at a predetermined position. The force applied by such active edge is adjusted by movement of jaws (31) gripping the opposite edge of the blade. The jaws are moved along a curve empirically established to maintain the active edge of the blade (17) in a predetermined fixed position during the adjustment. The angle of incidence of the active edge (18) of the blade (17) relative to the web (10) is also maintained constant by pivoting a blade supporting frame (16) about an axis coincident with the active edge (18). A controller (34) is supplied with empirically established data developed by utilizing test blades to establish polynomial formulas having constants corresponding to each of the various blades intended to be used by the coater. The controller (34) also automatically compensates for blade wear.



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1                                    ADJUSTABLE BLADE COATER

2                                    BACKGROUND OF THE INVENTION

3                    This invention relates generally to the coating  
4    of web materials, such as paper, and more particularly, to  
5    a novel and improved adjustable blade coater providing a  
6    constant blade angle and tip position and method of  
7    programming such coaters.

8                                    Prior Art

9                    The pressure of the tip or active edge of a  
10   coater blade should be adjustable to produce a desired web  
11   coating. Further, a stable condition is required for high  
12   quality coatings.

13                   If changes of the blade pressure result in  
14   changes of the tip angle or the location of the tip  
15   relative to the web, an unstable condition occurs. The  
16   blade will run either on its heel or tip. Such unstable  
17   condition continues until the blade edge is honed by its  
18   contact with the web back to a matching condition with  
19   respect to the web causing a return to a stable condition.  
20   The quality of the coating is inferior until a stable  
21   condition returns.

22                   In order to eliminate such unstable conditions  
23   with its resulting inferior coatings, systems have been  
24   devised which attempt to maintain the constant blade tip  
25   angle and position even when the tip pressure of the blade  
26   is adjusted.

27                   One such system is described in the United States  
28   Letters Patent No. 4,220,113. Such system provides a  
29   fulcrum which engages the blade at a location close to but

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1 spaced from the active edge of the blade in combination  
2 with jaws which clamp the other edge of the blade.

3 The jaws are moveable relative to the fulcrum  
4 with translating movement to adjust the pressure exerted by  
5 the active edge of the blade on the web to modify the  
6 coating produced. Such movement of the jaws deforms the  
7 blade to an "S" shape. In an attempt to maintain the  
8 location and tip angle constant during the jaw movement,  
9 such patent discloses the deflection of blade by linear  
10 movement of the jaw in a direction which extends at an  
11 acute angle with respect to the plane of the undeflected  
12 blade. The angle of this linear or straight line movement  
13 of the jaws is intended to compensate for changes in the  
14 effective blade length as it is deflected to the "S" shape  
15 by the jaw movement. Such patent is incorporated herein in  
16 its entirety to illustrate at least one prior art attempt  
17 to maintain a constant blade tip position and angle.

18 Because the jaw movement is linear rather than  
19 along a curve, the system of such patent only approximates  
20 correct adjustment movement and is effective only when  
21 small jaw movements are provided. Therefore, such system  
22 is optimized for only one, or at most, a small number of  
23 blade tip lengths. Further, such system required the use  
24 of relatively stiff and short blades so that the required  
25 range of pressure adjustment can be accomplished with a  
26 small amount of jaw movement.

27 Such stiff blades are undesirable since they tend  
28 to cause web breakage if web imperfections, such as holes  
29 in the web, are encountered.

30

#### SUMMARY OF THE INVENTION

31 There are a number of aspects to the present  
32 invention. In accordance with one important aspect of the  
33 present invention, an apparatus includes a fulcrum which

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1 engages the coating blade at a location spaced from the tip  
2 or active edge of the blade in combination with blade  
3 clamping jaws which grip the opposite edge of the blade.  
4 The jaws are moveable during blade pressure adjustment to  
5 deflect the blade to a "S" shape and adjust the pressure  
6 exerted at the active edge of the blade. The jaw movement  
7 is along a curve which is selected to precisely compensate  
8 the changes of the effective length of the blade so as to  
9 maintain the active edge of the blade in a precisely  
10 constant position. Further, the adjustment is arranged to  
11 also maintain a constant angle of the blade relative to the  
12 web at the active edge or tip. When a blade of different  
13 dimensions is used, the jaw movement curve is changed to  
14 again provide precise compensation for the change in  
15 effective blade length so as to maintain the operative edge  
16 location and angle constant.

17           With this invention, empirically established  
18 curves are provided for the adjustment of each type of  
19 blade intended to be used. Because the adjustment of the  
20 pressure of the blade tip is accurately matched to a  
21 particular blade then in use, a greater range of adjusting  
22 movements is possible. Therefore, wider and thinner blades  
23 can be used. Such thinner blades are more flexible and  
24 less likely to break or otherwise damage a web when a flaw  
25 in the web passes the blade. Further, thinner blades have  
26 a smaller cross-sectional area in contact with the coated  
27 web. For a given blade load, this provides higher unit  
28 shear forces and results in improved coated surface  
29 properties.

30           In the illustrated embodiment, the blade is  
31 installed while undeflected with the active edge or tip  
32 against the web, one side of the blade is against the  
33 fulcrum spaced from the active edge, and the other edge is  
34 clamped between the jaws. The jaws are mounted for  
35 movement in two directions extending at an angle relative  
36 to each other. In the illustrated embodiment, one

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1 direction of jaw movement is perpendicular to the plane of  
2 the undeflected blade, and the other direction of blade  
3 movement is parallel to such plane. A controller is provided  
4 to control the relationship between the two movements so  
5 that the jaws move along a curve which accurately  
6 compensates for the changes in effected blade length caused  
7 by deflection of the blade to an "S" shape. The curve of  
8 jaw movement causes the active edge of the blade to remain  
9 in exactly the same position as the jaws move to adjust the  
10 blade pressure. Further, the fulcrum and the jaws are  
11 mounted on a frame pivoted for movement about an axis  
12 coincident with the point of engagement of the active blade  
13 edge and the web. This frame is pivoted about such axis to  
14 maintain the angle of incidence of the active end of the  
15 blade constant as the adjustments occur. Here again, the  
16 controller operates to control this pivoted movement based  
17 on empirically established data.

18 Another aspect of this invention is the provision  
19 of automatic compensation for blade wear. The amount of  
20 blade wear tends to be a function of the length of the web  
21 which is moved past the blade during the coating operation.  
22 In accordance with the present invention, means are  
23 provided to establish the length of web passing the blade  
24 and to advance the blade as the coater is running as a  
25 function of the linear footage passing the blade.  
26 Depending upon tip length, blade wear compensation from  
27 0.08 inches to 0.18 inches is easily accomplished. In most  
28 cases, this means the doubling or tripling of blade life.

29 In accordance with still another aspect of this  
30 invention, a method has been developed to empirically  
31 establish the curve of movement of the jaws which will  
32 maintain each blade in a constant position. These curves  
33 have been established by extensive testing with full scale  
34 models and field testing.

35 It has been determined that a blade loaded in a  
36 first direction against a fulcrum point can be compensated

1 for by curved movement created by jaw movement in such  
2 first direction combined with movement in a second  
3 direction perpendicular to such first direction when the  
4 relationship of the first and second movements is best  
5 described by a third, or in some cases, fourth order  
6 polynomial. These polynomials take the following form:

7  $Y = AX^3 + BX^2 + CX + D$  for a third order polynomial

8 and

9  $Y = AX^4 + BX^3 + CX^2 + DX + E$  for a fourth order polynomial  
10 when X and Y represent the amounts of the first and second  
11 movements.

12 A different loading curve is required whenever:

- 13 a. The blade extension (the distance  
14 between the fulcrum and active edge) is  
15 changed;
- 16 b. The distance between the jaws and active  
17 edge of an unstressed blade is changed;
- 18 c. The blade thickness is changed; or
- 19 d. The blade wears.

20 After points along each curve are empirically  
21 plotted, the points are supplied to a computer programmed  
22 to establish the corresponding curve formula and constants.  
23 The constants are then stored within a controller computer.  
24 The controller is programmed to apply the proper curve  
25 constants for the controlling of the jaw movement in the X  
26 and Y directions for the particular blade being used.

27 With the present invention, a method and  
28 apparatus is provided for adjusting a variety of different  
29 blades so as to maintain the tip or active edge of the  
30 blade in a constant position and at a constant angle with  
31 respect to the web being coated.

32 These and other aspects of this invention are  
33 illustrated in the accompanying drawings and are more fully  
34 described in the following specification.

1                    BRIEF DESCRIPTION OF THE DRAWINGS

2                    FIG. 1 is a fragmentary schematic view of a  
3                    coating machine incorporating the present invention with  
4                    parts removed for purposes of clarity;

5                    FIG. 2 is a schematic view illustrating the blade  
6                    support structure and the manner in which the blade is  
7                    adjusted;

8                    FIG. 3 schematically illustrates a curvature the  
9                    blade assumes as it is progressively adjusted to higher tip  
10                   pressures; and

11                   FIG. 4 illustrates one of the curves empirically  
12                   established for controlling the movement of the jaws when  
13                   adjusting a specified coater blade.

14                   DETAILED DESCRIPTION OF THE DRAWINGS

15                   FIG. 1 schematically illustrates a web coating  
16                   machine, in accordance with the present invention. In such  
17                   machine a web 10, such as a web of paper, is carried around  
18                   a back-up roll 11. Before reaching the back-up roll 11,  
19                   the web 10 passes over a positioning roll 12 and an  
20                   applicator roll 13. Located below the applicator roll is a  
21                   reservoir 14 containing the coating material which is  
22                   applied to the web 10 by the applicator roll 13.

23                   Positioned on the side of the web opposite the  
24                   back-up roll 11 is a doctor or coating blade assembly 16.  
25                   This assembly provides a doctor or coater blade 17 having a  
26                   tip or an active edge 18 engaging the side of the web 10  
27                   opposite the back-up roll 11. The active edge 18 of the  
28                   blade presses against the adjacent surface of the web and  
29                   functions to press the coating material into the web and

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1 remove any excess coating material so that the web is  
2 provided with a desired coating and finish as it passes the  
3 blade 17. Excess coating material is returned to the  
4 reservoir 14 by an inclined pan 20.

5 The blade assembly 16, in accordance with the  
6 present invention, provides means for adjusting the force  
7 applied by the active edge 18 to the coating and web while  
8 maintaining the active edge in a precisely constant  
9 position with respect to the web and backing roll.  
10 Further, the adjusting means provided by this invention  
11 function to automatically maintain the constant angle  
12 between the active edge and the backing roll and web. In  
13 addition, the present invention provides automatic  
14 compensation for wear of the blade 17.

15 The blade assembly 16 includes a frame 19 mounted  
16 for pivotal movement about an axis 21 which is coincident  
17 with the point of contact between the active edge 18 of the  
18 blade and the web 10. Mounted on the frame 16 is a fulcrum  
19 22 which engages one side of the blade 17 at a location  
20 spaced from the active edge 18. Also mounted on the frame  
21 19 is an adjusting assembly 23 for adjusting the pressure  
22 exerted by the active edge 18 of the blade 17 against the  
23 web 10. This assembly includes a first slide 24 mounted  
24 for movement relative to the frame 19 in a first direction  
25 indicated by the arrow 26. In the illustrated embodiment,  
26 this is the "Y" direction and is parallel to the plane of  
27 the blade in its unstressed condition. Bearings 27  
28 schematically indicated by the inclined hash lines at 27  
29 confine the movement of the first slide 24 relative to the  
30 frame to linear movement in the direction of the arrow 26.

31 A second slide 28 is carried by the first slide  
32 26 by bearings schematically illustrated at 30 for movement  
33 relative to the first slide in a second direction indicated  
34 by the arrow 29. In the illustrated embodiment, the  
35 direction of the movement of the second slide 28 relative  
36 to the first slide is perpendicular to the direction of the

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1 movement of the first slide 24 relative to the frame 19 and  
2 is the "X" direction of movement.

3 The second slide 28 provides jaws 31 which clamp  
4 the edge 32 of the blade 17 remote from the active edge 18.

5 A first servo actuator 33 is connected to the  
6 frame 19 and is operable to pivot the frame 19 about the  
7 axis 21 in response to control signals supplied by a  
8 computer-type controller 34. A second servo actuator 36 is  
9 connected between the frame 19 and the first slide 24 and  
10 is operable to move the first slide back and forth relative  
11 to the frame 19 in the direction of the arrow 26. Here  
12 again, the operation of the second servo actuator is  
13 controlled by the controller 34.

14 A third servo actuator 37 is mounted between the  
15 first slide 23 and the second slide 28 and is operable to  
16 move the second slide 28 relative to the first slide 24  
17 back and forth in the direction of the arrow 29. Here  
18 again, the operation of the third servo actuator is  
19 controlled by the controller 34.

20 Although various types of servo actuators can be  
21 utilized, it is preferred that each of the servo actuators  
22 33, 36 and 37 include a motor-driven screw and nut device,  
23 such as a precision ball screw, in which the motor is  
24 controlled by the controller 34, both as to the direction  
25 of the motor drive and the amount of movement provided by  
26 the motor in response to a given signal. Preferably, the  
27 servo actuators are capable of increments of movement in  
28 the order of 0.00025 inches. Typically, such servo unit  
29 also provides a feedback to the controller 34.

30 Because the first direction of movement 26 is  
31 angulated with respect to the second direction of movement  
32 29 (perpendicular in the illustrated embodiment), the  
33 controller 34 is capable of causing the movement of the  
34 jaws along substantially any curve or path of movement  
35 within the limits of travel of the two slides 24 and 28.

1           In the illustrated embodiment, the unstressed  
2 blade 17 is installed in the jaws so that the active edge  
3 18 engages the web 10 at the desired location which is  
4 coincident with the pivot axis 21 of the frame 19. In such  
5 position in the illustrated embodiment, the first or "X"  
6 direction of movement 29 is in the direction perpendicular  
7 to the plane of the blade 17 when the blade is unstressed  
8 and flat, and the second or "Y" direction of movement 26 is  
9 parallel to such plane. Further, the fulcrum 22 is  
10 adjusted to engage the side of the blade 17 at a point  
11 spaced from the active edge 18. This distance is normally  
12 referred to as the distance of tip extension and is  
13 indicated in FIG. 3 by the bracket 38.

14           FIG. 3 indicates the manner in which the pressure  
15 of the blade 17 is adjusted, in accordance with the present  
16 invention. Referring to FIG. 3, the jaws 31 are moved in a  
17 curved direction which operates to maintain the active edge  
18 18 of the blade 17 in a fixed position against the web 10  
19 on the side thereof opposite the back-up roll 11. The  
20 controller 34 (illustrated in FIG. 2) coordinates the  
21 distance the jaws 31 move in the "X" direction 29 with the  
22 distance of simultaneous movement of the jaws in the "Y"  
23 direction 26 so as to maintain the active edge 18 in a  
24 fixed location. Because the jaws 31 remain in a fixed  
25 orientation with respect to the frame 19 and the fulcrum  
26 22, the blade assumes a generally "S" shape as the  
27 adjustment operates to increase the pressure of engagement  
28 between the active edge 18 and the web 10.

29           FIG. 3 progressively illustrates the deformation  
30 of the blade 17 as the servo actuators 36 and 37 are  
31 operated to increase the pressure. During the first  
32 portion of adjustment illustrated by the blade curvature  
33 17a, the "S" shape is shallow, but as the adjustment  
34 proceeds through the positions indicated by the curves 17b  
35 to the position of the curves 17c, the "S" curvature

1 increases. As a consequence, the effective length of the  
2 blade decreases as the adjustment proceeds.

3 As used herein, the effective length of the blade  
4 in any given position of adjustment is equal to the  
5 distance between the inner ends of the jaws at 41 and the  
6 active edge 18 of the blade, taken along the "Y" direction  
7 26 parallel to the unstressed plane of the blade 17 before  
8 adjustment. The initial effective length is indicated in  
9 FIG. 3 by the distance "A". The effective length when the  
10 blade has been deflected to the position indicated by the  
11 curve 17c is indicated in FIG. 3 by the distance "Ac",  
12 which is substantially smaller than the initial effective  
13 length "A".

14 If it were not for the movement of the jaws in  
15 the direction 26 as the movement of the jaws in the  
16 direction 29 progresses, the location of the active edge 18  
17 against the web 10 would not remain constant. Therefore,  
18 in the illustrated embodiment, the jaws move along a curved  
19 path in which the movement in the "Y" direction 26 is equal  
20 to and fully compensates for the change in effective length  
21 of the blade so as to maintain the active edge in a fixed  
22 location.

23 In FIG. 3, the condition of the blade as it is  
24 progressively adjusted to higher loading conditions is  
25 illustrated without corresponding adjustments to maintain  
26 the angle of the blade active edge 18 with respect to the  
27 web 10 constant. As illustrated in FIG. 3, the portion of  
28 the blade extending from the fulcrum 22 to the active edge  
29 24 is also deformed from its unstressed condition and would  
30 cause a change in the angle of the active edge 18 with  
31 respect to the web if angular adjustment were not provided.  
32 This would create an unstable condition in which the active  
33 edge would run on its heel until such edge were honed by  
34 the engagement with the web 10 to an edge shape  
35 corresponding to the new angular position. This would  
36 again re-establish a stable condition. However, the

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1 coating on the web produced while the unstable condition  
2 existed would be an inferior coating. Therefore, the  
3 controller also operates the servo actuator 33 to pivot the  
4 frame 19 around the pivot axis 21 to maintain the angle of  
5 the active edge 18 of the blade constant as the jaws are  
6 moved to various adjusted positions. By providing the  
7 active edge 18 in exact coincident with the pivot axis 21,  
8 adjustment of the frame around the pivot axis 21 does not  
9 result in movement of the active edge toward or away from  
10 the backing roll. If, as in other designs, active edge 18  
11 and pivot axis 21 are no longer coincident, the effect of  
12 rotation about pivot axis 21 causes the tip 18 to either  
13 dig the blade tip 18 into backing roll 11, or pull it away  
14 from backing roll 11. In either case, the net effect is an  
15 undesirable blade angle change coupled with a load change  
16 that is more or less than expected.

17 FIG. 4 illustrates a typical jaw movement curve  
18 which functions to maintain the active edge of a blade in a  
19 fixed position as the jaws are moved to increase the  
20 pressure of the active edge 18 on the web 10. The  
21 horizontal scale on the curve represents the movement in  
22 the "X" direction 29, and the vertical scale represents the  
23 movement in the "Y" direction of jaw movement in the  
24 direction 26. The "X" indicates measured points which  
25 result from actual tests conducted on full-sized models and  
26 machines.

27 The particular curve illustrated is a loading  
28 curve of a 4-inch wide blade 0.018 inches thick having a  
29 45° bevel at the active edge 18, and a 0.875 inch tip  
30 extension.

31 The points represented by the "X" are determined  
32 experimentally in the following manner. A magnified scope  
33 46 is positioned so that the active edge 18 of the  
34 undeflected blade 17 is located in the cross hairs of the  
35 scope. This permits the optical determination of the  
36 position of the active edge 18 of the blade during

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1 adjustment. The servo actuator 37 is then operated to move  
2 the jaws in the direction 29 a small, predetermined  
3 distance. This results in the initial movement of the  
4 active edge 18 in a downward direction, as viewed in FIG.  
5 3. The servo actuator 36 is then operated in the direction  
6 26 to return the active edge 18 to its previous position as  
7 established by the cross hairs within the scope 46. This  
8 distance is then determined, and the first plotted point  
9 "X" is established. The process is repeated to  
10 sequentially establish the remaining points which result in  
11 maintaining the active edge 18 in a fixed position as the  
12 blade 17 is progressively deformed by the operation of the  
13 two actuators.

14 The referenced points are then supplied to a  
15 computer programmed to establish a curve which matches the  
16 plotted points as close as possible. It has been  
17 determined that such curve can best be described by a  
18 third, or in some cases, fourth order polynomial. These  
19 polynomials take the following form:

20  $Y = AX^3 + BX^2 + CX + D$  for a third order polynomial  
21 and

22  $Y = AX^4 + BX^3 + CX^2 + DX + E$  for a fourth order polynomial  
23 when X and Y represent the amounts of the first and second  
24 movements. It is also possible to develop the curves using  
25 finite element analysis software.

26 The constants thus developed for a given blade  
27 are then loaded into the controller and are programmed to  
28 move the jaws 31 along the proper curve for the particular  
29 blade being used.

30 At the same time the measurements are being taken  
31 to establish the proper curve, the corresponding change in  
32 angle of the tip 18 of the blade at the active edge can  
33 either be measured or calculated by a person skilled in the  
34 art. This information is also supplied to the controller  
35 so that as the jaws are moved, the controller functions to

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1 operate the servo actuator 33 to pivot the entire frame  
2 about the pivot axis 21 which is coincident with the fixed  
3 location of the active edge of the blade. This ensures  
4 that a stable operation continues, even as adjustments of  
5 the pressure are changed, and a high quality coating is  
6 applied to the web 10, even when adjustments are being  
7 made.

8 In accordance with the present invention,  
9 automatic compensation for blade wear is also provided. It  
10 has been established that the blade wear of a particular  
11 blade is a function of the length of the web which passes  
12 the active edge 18. Therefore, a measuring device  
13 schematically illustrated at 47 is provided to determine  
14 the length of the web which moves past the blade 17. This  
15 measuring device can measure either the actual length of  
16 web which moves by the blade 17, or the rate of movement  
17 which can then be multiplied by time to give the actual  
18 length. The information generated by the measuring device  
19 47 is also supplied to the controller which then makes  
20 appropriate changes in the curve of movement of the jaws to  
21 compensate also for the wear occurring in the blade. With  
22 this invention, it is possible to compensate for blade wear  
23 from 0.080 inches to 0.18 inches. In most cases, this  
24 means doubling or tripling existing blade life.

25 The formula used by the controller to establish  
26 the curve of movement of the jaws during blade adjustment  
27 must be modified whenever:

- 28 a. The blade extension is changed;
- 29 b. The effective length (A) of the
- 30 unstressed blade is changed;
- 31 c. The blade thickness is changed; or
- 32 d. The blade wears.

33 The number of different formulas which must be  
34 supplied with a given machine varies with the number of  
35 different types of webs and coatings that are produced and

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1 the number of different blade sizes which are expected to  
2 be used. Typically, it is necessary to establish from five  
3 to twenty sets of curves for a given machine.

4 With the present invention, a method and  
5 apparatus is provided to maintain the exact position and  
6 angle of incidence of the active edge 18 of a blade so as  
7 to maintain a high quality coating output, even when blade  
8 adjustments are required. Further, with the present  
9 invention, automatic adjustment is provided to compensate  
10 for blade wear. Further, since substantial adjustment  
11 movements can be made wider and thinner, more flexible  
12 blades can be used which reduce damage to the web when  
13 holes or other imperfections in the web pass the blade.  
14 Also, this invention can be applied to flooded nip coaters  
15 and jet fountain coaters.

16 Although the preferred embodiment of this  
17 invention has been shown and described, it should be  
18 understood that various modifications and rearrangements of  
19 the parts may be resorted to without departing from the  
20 scope of the invention as disclosed and claimed herein.

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## WHAT IS CLAIMED IS:

1           1. A method of adjusting a beveled edge coating  
2 blade in a web coating machine comprising positioning the  
3 active edge of said blade in a predetermined position for  
4 controlling the application of a coating to a web,  
5 positioning a fulcrum against said blade at a location  
6 spaced from said active edge, and clamping the other edge  
7 of said blade in jaws, and moving said jaws with  
8 translating movement to cause a "S" shaped deflection in  
9 said blade while moving said jaws along an established  
10 curve which maintains said active edge in said  
11 predetermined position.

1           2. A method as set forth in claim 1, including  
2 moving said jaws in two directions angulated relative to  
3 each other, and coordinating the movement of said jaws in  
4 said two directions so that said jaws move along said curve  
5 and adjust the pressure of said active edge on said web  
6 while maintaining said active edge in said predetermined  
7 position.

1           3. A method as set forth in claim 2, including  
2 establishing said two directions perpendicular to each  
3 other.

1           4. A method as set forth in claim 2, including  
2 supporting said fulcrum and said jaws on a frame pivoted  
3 for movement about an axis through said predetermined  
4 position, and moving said frame around said axis to  
5 maintain a constant angle between said active edge and a  
6 web passing said active edge.

1           5. A method as set forth in claim 2, including  
2 establishing said curve by deflecting a test blade having  
3 the same dimensions as said blade in a full scale model of

4 said coating machine to obtain a plurality of points along  
5 said curve.

1           6. A method as set forth in claim 5, including  
2 establishing a polynomial formula substantially fitting  
3 said points.

1           7. A method as set forth in claim 6, including  
2 deflecting a series of test blades having different  
3 dimensions to establish a polynomial formula having a set  
4 of constants for each test blade, and supplying said set of  
5 constants to a controller operating to regulate the  
6 relationship between said movements in said two directions  
7 required by said blade.

1           8. A method as set forth in claim 7, including  
2 establishing the rate of wear per unit length of web  
3 passing said blade, supplying said controller with said  
4 rate of wear information, and supplying said controller  
5 with a measurement of length of web passing said blade  
6 causing said controller to modify said curve to compensate  
7 for said wear.

1           9. A method as set forth in claim 6, including  
2 establishing a constant for a polynomial which is at least  
3 a third order polynomial.

1           10. A web coater comprising a backing roll,  
2 means for positioning a moving web against said roll,  
3 applicator means for applying a coating material to said  
4 web, a coating blade having an active edge located at a  
5 predetermined position against said coated web for pressing  
6 said web against said back-up roll and producing a uniform  
7 coating on said web, a fulcrum engaging the side of said  
8 blade at a location spaced from said active edge, jaws  
9 gripping the other edge of said blade at a location spaced

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10 from said fulcrum, power means operable to move said jaws  
11 with translating movement in two directions angled with  
12 respect to each other to deform said blade to an "S" shape,  
13 and a controller connected to control said movement of said  
14 jaws and coordinate the relationship of said two movements  
15 to cause said jaws to move along a curve maintaining said  
16 active edge in said predetermined position.

1 11. A web coater as set forth in claim 10,  
2 wherein said fulcrum and said jaws are supported on a  
3 frame, and said movement of said jaws in said two  
4 directions are relative to said frame without changing the  
5 angular position of said jaws relative to said frame.

1 12. A web coater as set forth in claim 11,  
2 wherein said two directions are substantially perpendicular  
3 to each other.

1 13. A web coater as set forth in claim 11,  
2 wherein said frame is pivoted for rotation about an axis  
3 coincident with said predetermined position, and said power  
4 means operates to pivot said frame around said axis to  
5 maintain the angle of said active edge relative to said  
6 coated web constant as said jaws are moved in said two  
7 directions.

1 14. A web coater as set forth in claim 12,  
2 wherein said coater provides a controller operable to  
3 coordinate said two movements, and said controller is  
4 provided with empirically established data to control said  
5 relationship of said two movements.

1 15. A web coater comprising a back-up roll,  
2 means for positioning a moving web against said roll,  
3 applicator means for applying a coating material to said  
4 web, a frame pivoted for rotation about an axis extending

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5 along the surface of said web at a predetermined position,  
6 a fulcrum mounted on said frame at a location spaced from  
7 said predetermined position, a first slide mounted on said  
8 frame for movement in a predetermined direction, a second  
9 slide mounted on said first slide for movement relative  
10 thereto in a second direction perpendicular to said first  
11 direction, jaws mounted on said second slide, a blade  
12 having an active edge positioned against the surface of  
13 said web at said predetermined position, said fulcrum  
14 engaging one side of said blade, said jaws clamping the  
15 edge of said blade remote from said active edge, a first  
16 servo actuator connected to control pivotal movement of  
17 said frame around said axis, a second servo actuator  
18 connected to control the movement of said first slide  
19 relative to said frame, a third servo actuator connected to  
20 control the movement of said second slide relative to said  
21 first slide, and a controller for controlling the operation  
22 of said servo actuators, said controller operating to cause  
23 said second and third servo actuators to move said jaws to  
24 deform said blade to an "S" shape and adjust the pressure  
25 of said active edge applied to said web while maintaining  
26 said active edge at said predetermined position, said  
27 controller also operating to control said first servo to  
28 pivot said frame to maintain a constant angle between said  
29 active edge of said blade and said web.

1 16. A web coater as set forth in claim 15,  
2 wherein said controller also operates to compensate for  
3 wear of said blade and maintains said active edge in said  
4 predetermined position.

1 17. A web coater as set forth in claim 16,  
2 wherein said controller is supplied with empirically  
3 established data to control the operation of said servo  
4 actuators.

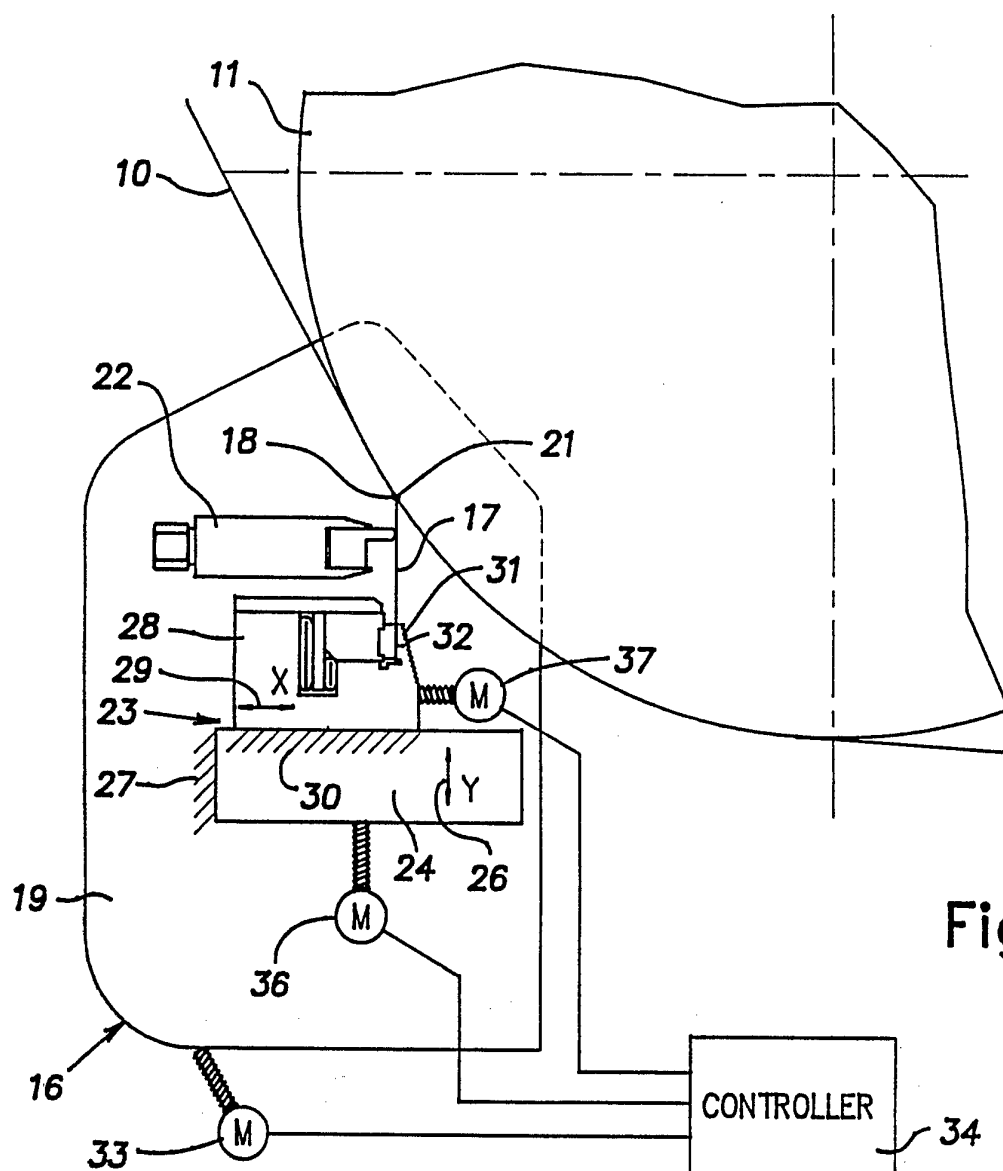
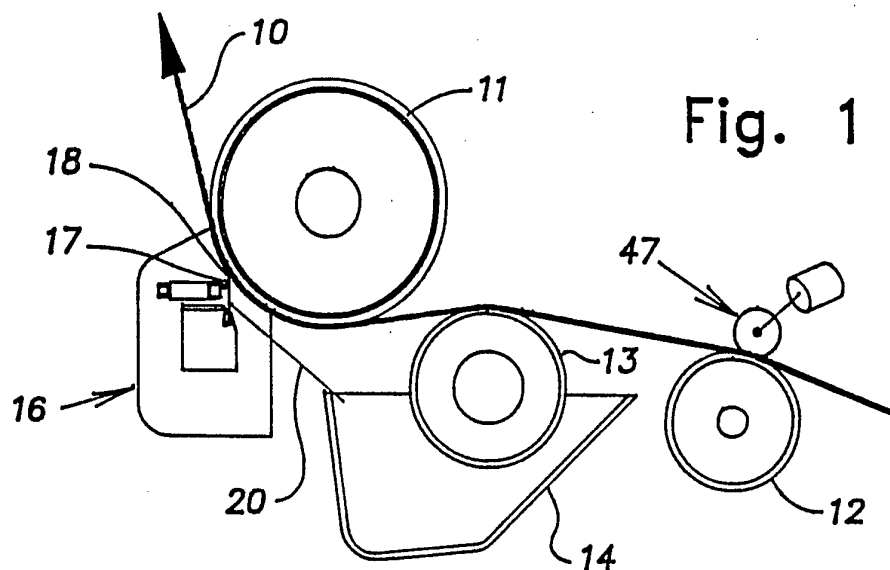


Fig. 3

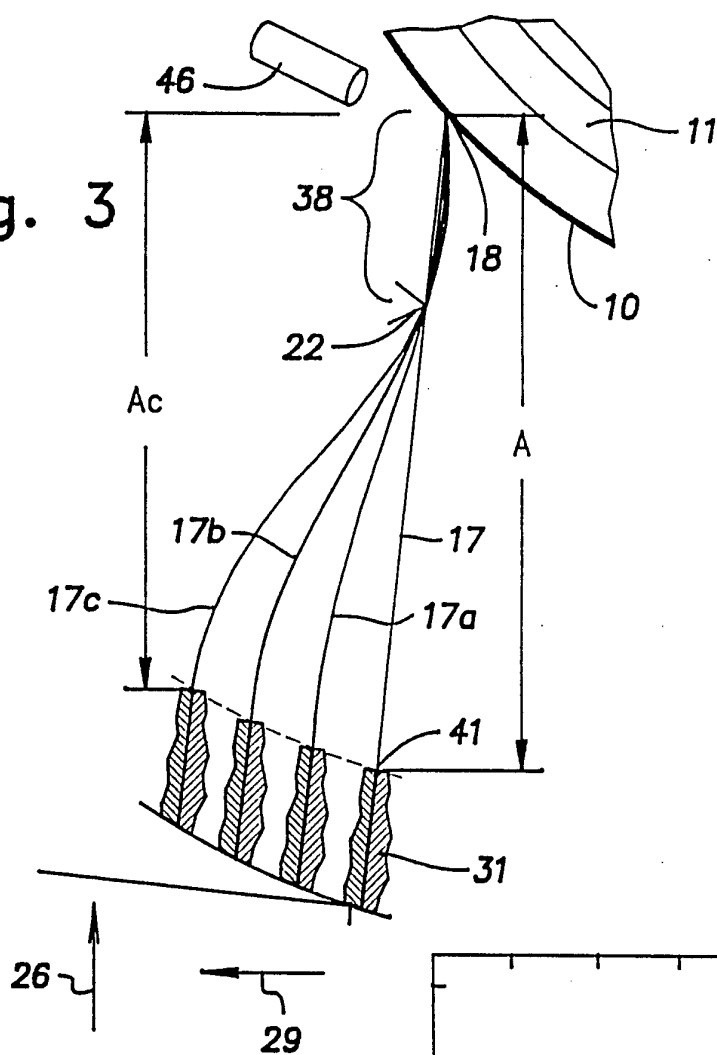
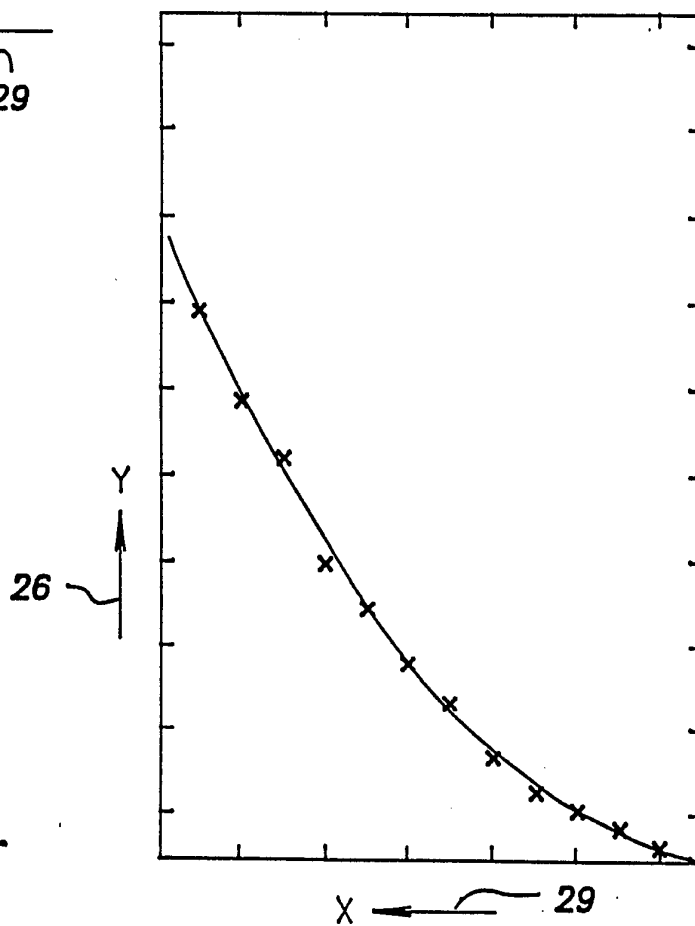


Fig. 4



## INTERNATIONAL SEARCH REPORT

 International application No.  
 PCT/US93/07278

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) : BO5D 1/28

US CL : 118/663; 427/356

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 427/361,356; 118/663,672,674,679,680,681,121,122,123,126

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                   | Relevant to claim No.  |
|-----------|------------------------------------------------------------------------------------------------------|------------------------|
| X<br>Y    | US,A, 4,375,202, (Miller), 01 March 1983, pg. 1, lines 44-47; pg 3, lines 2-10, 5-66; also Figure 3. | <u>1-4</u><br>5,7,8,10 |
| Y         | US,A, 4,966,093, (Sommer), 30 October 1990, see above reference cites, also pg. 3, lines 20-33.      | 8,10,11                |
| Y         | US,A, 3,220,377, (Good), 30 November 1965, see Figure 1                                              | 10,11                  |
| A         | US,A, 4,220,113, (Wohlfell), 02 September 1980, see entire document.                                 | 1-5,7,8,10,12          |
| A         | US,A, 4,930,440, (Shirono), 05 June 1990, see entire document.                                       | 1-5,7,8,10,12          |

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

|                                                                                                                                                                        |                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                               | *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                                              |
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| Date of the actual completion of the international search | Date of mailing of the international search report |
| 07 OCTOBER 1993                                           | 22 NOV 1993                                        |

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