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(54) Singulation module/belt for separating sheet material

(57) A singulating module/belt including a conveyor belt (14a,14b,14c) for moving a stack (12) of sheet material toward a pair of take-away rollers in one direction and a singulation belt (20a,20b) moving in an opposing direction for retarding the motion of the upper sheets of the stack (12). The singulation belt (20a,20b) is characterized by a compliant face surface which separates sheet material without damaging or tearing the sheets during singulation. In the described embodiment, the cross section of the belt (20a,20b) includes a plurality of grooves defining a plurality of longitudinal ribs therebetween. The ribs define a cumulative width dimension in contact with the sheet material (12) which is within a range of between about 0.55 to about 0.85 of the width dimension of the belt (20a,20b). Furthermore, the height dimension of each rib is within a range of between about 0.20 to about 0.8 of the height dimension of the belt (20a, 20b). Moreover, each rib thereof defines an aspect ratio (RW/RH) including a width dimension RW in contact with the sheet material and a height dimension RH measured from a core of the singulation belt. The aspect ratio is within a range of between about 0.5 to about 2.0.

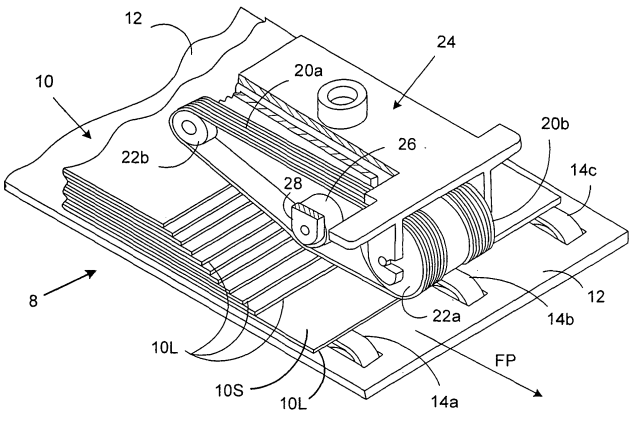

FIG. 2

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Description

[0001] This invention relates to belts for handling/singulating sheet material, and more particularly, to a new and useful singulation belt useful for separating sheet material in automated material handling equipment.

[0002] Material handling apparatus such as mailing machines commonly employ belts for transporting and separating sheet material. Oftentimes, a plurality of belts are employed, one set of belts opposing another set, to separate individual sheets from a stack of sheet material. That is, as a first set of horizontal belts transport a stack of sheet material, e.g., envelopes, postcards or other sheet stock, in one direction, a second set of belts, disposed above the first set, shingles the stack thereby causing a single sheet to pass through a predefined gap or opening between the belts. Oftentimes, the belts are arranged in a V-shaped configuration (i.e., from a side or profile view) to progressively close the gap therebetween. As the stack approaches the neck/throat of the opposing belts, the sheets begin to shingle such that the leading edges of each separate. Finally, a single sheet is caused to pass between the belts, or is "singulated", and taken away by an opposing pair of rollers, e.g., nip rollers.

[0003] A variety of factors associated with the geometry and arrangement of the opposing belts can be difficult to control and/or anticipate the effectiveness regarding singulation of the sheet material. In particular, sheet material used for producing postcards can present unique difficulties due to their relatively thick, single-sheet construction.

[0004] To better understand the problem or difficulty, consider first the singulation of other sheet material, such as a conventional mailing envelope. A mailing envelope inherently presents a fold line, along a leading edge, having fibers which wrap around the edge. Inasmuch as the fibers are substantially continuous, the shear strength of the material is relatively high, i.e., relying upon the strength of the fibers rather than the adhesive resin matrix to provide tensile and shear strength.

[0005] On the other hand, consider a relatively thick sheet stock used for producing postcards. The fibers of the sheet stock are cut and form thick layers of substantially discontinuous fibers, i.e., held together along the edge by the adhesive resin matrix. When opposing belts contact the face surfaces of the postcard stock, the resin matrix, which exhibits relatively low tensile and shear strength, can fail, resulting in delamination along the free edge of the postcard. The resulting damage can render the card unusable for subsequent printing and/or postage. Consequently, the shearing effect due to opposing belt translation must be carefully considered, or precisely controlled, to mitigate delamination damage to card stock having exposed free edges.

[0006] A need, therefore, exists for a singulation module and/or singulation belt which mitigates damage to thick, single sheet card stock such that used in automated material handling apparatus e.g., mailing machines, postage meters, etc.

[0007] The accompanying drawings illustrate presently preferred embodiments of the invention and, together with the general description given above and the detailed description given below serve to explain the principles of the invention. As shown throughout the drawings, like reference numerals designate like or corresponding parts.

[0008] Figure 1 is a side view of a singulation module of a mailing machine incorporating a pair of singulation belts according to the teachings of the present invention for singulating sheet material such as postcard stock.

[0009] Figure 2 is a partially broken-away perspective view of the singulation module shown in Figure 1 illustrating the separation of sheet stock as they approach a throat region of the opposing belts.

[0010] Figure 3 is a cross-sectional view taken substantially along line 3 - 3 of Fig. 1 of the inventive singulation belt including a plurality of grooves disposed along the face or driving surface thereof.

[0011] A singulating module/belt is provided including a conveyor belt for moving a stack of sheet material toward a pair of take-away rollers in one direction and a singulation belt moving in an opposing direction for retarding the motion of the upper sheets of the stack. The singulation belt is characterized by a compliant face surface which separates sheet material without damaging or tearing the sheets during singulation. In the described embodiment, the cross section of the belt includes a plurality of grooves defining a plurality of longitudinal ribs therebetween. The ribs define a cumulative width dimension in contact with the sheet material which is within a range of between about 0.55 to about 0.85 of the width dimension of the belt. Furthermore, the height dimension of each rib is within a range of between about 0.20 to about 0.8 of the height dimension of the belt. Moreover, each rib thereof defines an aspect ratio (RW/RH) including a width dimension RW in contact with the sheet material and a height dimension RH measured from a core of the singulation belt. The aspect ratio is within a range of between about 0.5 to about 2.0.

[0012] The present invention is described in the context of a singulation module for use in mailing machines, though the invention is applicable to any singulation module/belt for separating sheet material. Furthermore, while the invention is described in the context of singulation modules having belts moving in opposite directions, it will be appreciated that the belts need not traverse in opposite directions, but merely move relative to each other, e.g., one belt being stationary while another belt is driven to singulate the sheet material. Moreover, the singulation module is described as having an odd number of conveyor belts and even number of singulation belts disposed in a staggered array. While this configuration is most commonly employed, it should be appreciated that the singulation module may comprise any number or combination of belts, whether the module contains the same number of opposed belts or a multiple array of staggered belts.

[0013] In the broadest sense of the invention, the singulation module incorporates a belt having a compliant face

surface, i.e., the face surface in contact with a stack of sheet material, which opposes/retards the motion of an upper portion of a stack to separate/singulate the lowermost sheet from the stack. In the described embodiment, the compliant face surface includes a plurality of grooves to form a plurality of longitudinal ribs therebetween. In Figs. 1 and 2, a side view of a singulation module 8 for a mailing machine is shown having a stack of sheet material 10, e.g., postcards, disposed on and conveyed along a feed deck 12. A plurality of conveyor belts 14a, 14b, 14c are spaced apart and in-plane with the feed deck 12 to move the stack 10 along a feed path denoted by an arrow FP in Fig. 2. A plurality of skewed rollers 16 may also be incorporated upstream of the conveyor belts 14a, 14b, 14c to direct the sheet material 10 inwardly (normal to the paper plane) toward a registration wall (not shown). That is, by placing these rollers 16 on an angle relative to the feed path FP, a small component of force is developed to direct the stack laterally against the registration wall.

[0014] A pair of singulation belts 20a, 20b is mounted to wrap around forward and aft support rollers 22a, 22b. The support rollers 22a, 22b are mounted to a support fixture 24 disposed above the feed deck 12. Additionally, tensioning rollers 26 (only one can be seen in Fig. 2) are mounted between extended lugs 29 of a clevis which rollers 26 act on the singulation belts 20a, 20b to apply a tensile load to the belt 20a, 20b. As best seen in the side view of Fig. 1, the support rollers 22a, 22b are spatially positioned, i.e., vertically, such that the spacing between the singulation belts 20a, 20b and the underlying conveyor belts 14a, 14b, 14c narrows, i.e., forms a V-shaped neck;/throat, as the sheet material 10 is fed along the feed path FP. Furthermore, the gap between the singulation and conveyors belts 20a, 20b, 14a, 14b, 14c, at the apex of the V-shaped throat, is spaced to permit the passage of a single sheet of material 10. Moreover, the mounting fixture 24 may be spring-biased by a coil spring 25 to urge the singulation belts 20a, 20b downwardly against the sheet material 10, i.e., applying a normal force to the singulation belts 20a, 20b as it acts upon the sheet material 10. The normal force applied to the belts 20a. 20b is between about 1.3 lbs to about 3.0 lbs (590 gm to 1360 gm).

[0015] Operationally, the singulation belts 20a, 20b are driven in a direction opposing the conveyor belts 14a, 14b, 14c by a belt (not shown) which drives the aft roller 22b. As the stacked sheet material 10 is fed along the feed deck 12, the shearing action of the singulation and conveyor belts 20a, 20b, 14a, 14b, 14c causes the material 10 to "shingle", i.e., effects separation of the leading edges 10L. As the sheets spread, a single sheet 10S is caused to separate from the stack 10, passing between the singulation belts 20a, 20b and the underlying conveyor belts 14a, 14b, 14. Take-away rollers (not shown) move the sheet 10S toward subsequent stations, e.g., print station, weigh station, metering station, etc.

[0016] As discussed in the "Background of the Invention", the shingling and separation of certain sheet material, particularly thick sheet material having an exposed edge, presents unique difficulties. That is, the singulation belts of the prior art can tear/cause delamination of the exposed edge. While many factors, particularly those relating to the geometry and normal forces applied to the singulation belts, can mitigate delamination damage, the inventors found that relatively minor modifications to the face surface geometry of the singulation belts can produce certain unexpected/ advantageous results. These modifications are made in the context of a urethane elastomer material, i.e., a rubber material, though the modifications may be made to a belt composed of other materials. In the described embodiment, the singulation belts 20a, 20b are composed of either a microcellular urethane rubber or solid polyurethane elastomer having a Shore A hardness between about 10A to about 50A. Both compositions, in combination with the face surface modifications, provided significant improvement in terms of delamination damage.

[0017] In Figure 3, a cross-section of one of the singulation belts 20a, 20b is shown to more accurately define the face surface modifications. To simplify the discussion, the surface modifications with respect to belt 20a will be discussed, though, it will be appreciated that the modifications apply to both singulation belts 20a, 20b. Specifically, the cross section has a characteristic width dimension W and height dimension H. A plurality of longitudinal grooves 30 are cut, molded or otherwise formed in the face surface 20F the singulation belt 20a i.e., the face surface 20F in contact with the sheet material 10S during singulation. In the preferred embodiment, five (5) grooves 30 are formed to define six (6) ribs 32 which define a cumulative rib width dimension CRW evaluated by the expression 1.0 below:

$$CRW = RW \times NR \qquad (1.0)$$

wherein RW is the width of an individual rib 32 and NR is the number of ribs 32 along the face surface 20F. The cumulative rib width dimension CRW is preferably within a range of between about 0.55 to about 0.85 of the width dimension W of the belt 20a. More preferably, the cumulative rib width dimension CRW is within a range of between about 0.65 to about 0.75 of the width dimension W of the belt 20a. Each rib 32 also defines a height dimension RH, which is within a range of between about 0.20 to about 0.45 of the height dimension H of the belt 20a. More preferably, the height dimension RH is within a range of between about 0.25 to about 0.40 of the height dimension H of the belt 20a.

[0018] While the section may be characterized in terms of the overall width and height dimension, W, H of the singulation belt 20a, the cross-section may also be defined in terms of the aspect ratio of an individual rib 32, i.e., the width/height

RW/RH of an individual rib 32. In the described embodiment, the aspect ratio is preferably within a range of between about 0.5 to about 2.0 and, more preferably within a range of between 0.7 to about 1.5.

[0019] In summary, the singulation module 8 and/or belts 20a, 20b of the present invention provides a compliant face surface geometry for mitigating or eliminating delamination damage. The compliant face surface 20F is particularly useful for mitigating delamination damage with respect to thick sheet material having a free edge which engages the singulation belt(s) of the module. The singulation belt(s) 20a, 20b includes a plurality of grooves to define a plurality of longitudinal ribs. When employing a soft microcellular or solid urethane material i.e., having a Shore A hardness of between about 10A to 50A, the number of grooves is preferably five (5), though four (4) or six (6) grooves may also be employed to provide improvement.

[0020] When fewer than four (4) ribs are employed (i.e., using the dimensional characteristics previously described, higher shear loads are applied to the surface of the sheet material (along the width of each rib 32) resulting in a greater propensity for delamination damage. Furthermore, higher shear loads produce lower wear resistance along the surface of each rib and reduced service life. While a greater number of ribs, i.e., in excess of six (6) ribs, enhances the wear resistance of the face surface 20F, the increase in stiffness produces delamination damage similar to that previously described with respect to prior art belts having no surface modifications, i.e., no longitudinal grooves/ribs.

[0021] Although the invention has been described with respect to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the scope of this invention.

Claims

1. A singulation belt for a mailing machine, comprising:

a belt (20a,20b) having a characteristic cross sectional configuration, the cross section having a width and height dimension;
the cross section, furthermore, having a plurality of grooves (30) defining a plurality of longitudinal ribs (32) therebetween, the ribs operative to reduce the width dimension in contact with sheet material (10) during singulation of a sheet from the stack (10).

2. The singulation belt according to Claim 1, wherein the ribs (32) define an aspect ratio defined by a rib width dimension (RW) divided by a rib height dimension (RH), the aspect ratio being within a range of between about 0.5 to about 2.0.

3. The singulation belt according to Claim 1 or 2, wherein each of the ribs (32) define a height dimension (RH), the height dimension of each rib being within a range of between about 0.20 to about 0.80 of the height dimension of the belt.

4. The singulation belt according to Claim 1, 2 or 3, wherein the ribs (32) define a cumulative width dimension in contact with the sheet material, the cumulative width dimension being within a range of between about 0.55 to about 0.85 of the width dimension (W) of the belt (20a,20b).

5. The singulation belt according to Claim 4, wherein each of the ribs (32) defines a height dimension (RH), the height dimension of each rib being within a range of between about 0.25 to about 0.40 of the height dimension (H) of the belt.

6. The singulation belt according to any preceding claim, wherein the belt (20a,20b) is composed of a solid polyurethane elastomer having a Shore A hardness between about 10A to about 50A.

7. The singulation belt according to any one of Claims 1 to 5, wherein the belt (20a,20b) is composed of a microcellular urethane rubber having a Shore A hardness between about 10A to about 50A.

8. A singulating module (8) for separating sheet material (12), comprising:

a pair of opposing take-away rollers;
a conveyor belt (14a,14b,14c) for moving a stack of sheet material (12) toward the take-away rollers in one direction;
a singulation belt (20a,20b) arranged for moving in a direction opposing the direction of the conveyor belt (14a, 14b,14c) for retarding the motion of the upper sheets of the stack (12), the singulation belt (20a,20b) having a characteristic cross section, the cross section having a width and height dimension;

the cross section, furthermore, having a plurality of grooves (30) defining a plurality of ribs (32) therebetween, each rib (32) defining an aspect ratio including a width dimension (RW) in contact with the sheet material and a height dimension (RH) measured from a core portion of the singulation belt;
the aspect ratio being within a range of between about 0.5 to about 2.0.

9. The singulation module according to Claim 8, wherein the aspect ratio is within a range of between about 0.7 to about 1.5.

10. The singulation module according to Claim 8 or 9, wherein the ribs (32) define a cumulative width dimension in contact with the sheet material, the cumulative width dimension being within a range of about 0.55 to 0.85 of the width dimension (W) of the belt.

11. The singulation module according to Claim 8, 9 or 10, wherein each of the ribs (32) defines a height dimension, the height dimension of each rib being within a range of between about 0.20 to about 0.8 of the height dimension of the belt (20a,20b).

12. The singulation module according to Claim 11, wherein each of the ribs (32) defines a height dimension, the height dimension of each rib (32) being within a range of between about 0.25 to about 0.40 of the height dimension of the belt (20a,20b).

13. The singulation module according to any one of Claims 8 to 12, wherein the belt (20a,20b) is composed of a solid polyurethane elastomer having a Shore A hardness between about 10A to about 50A.

14. The singulation module according to any one of Claims 8 to 12, wherein the belt (20a,20b) is composed of a microcellular urethane rubber having a Shore A hardness between about 10A to about 50A.

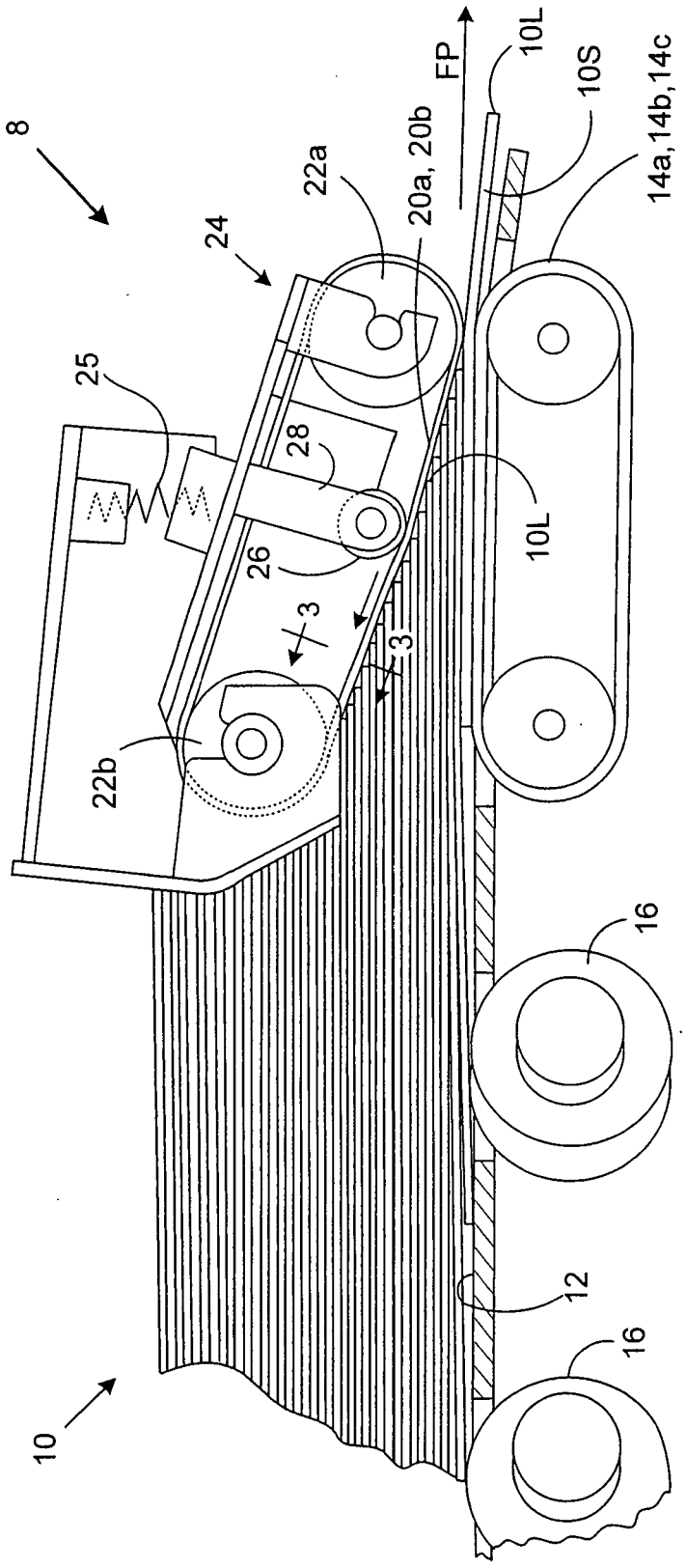
8
24
22a
20a, 20b
FP
10L
10S
14a,14b,14c
25
28
26
10L
3
3
22b
16
12
16
10

FIG. 1

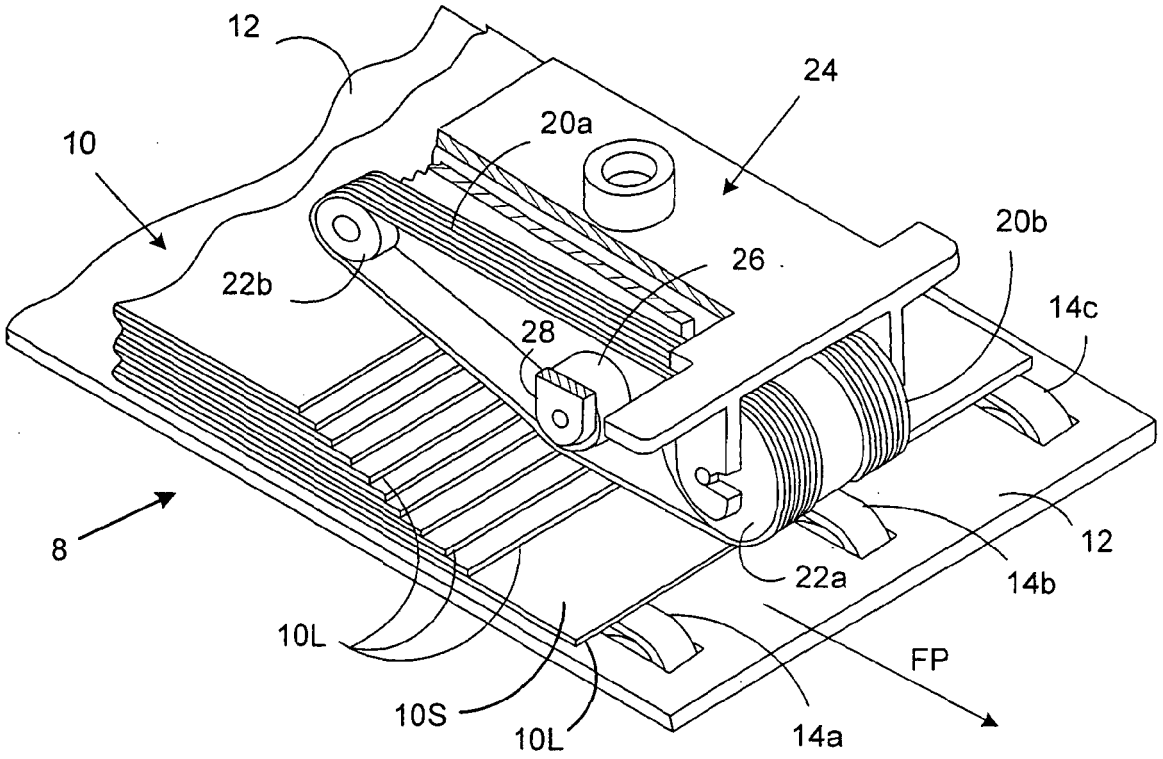
12
24
10
20a
20b
26
22b
14c
28
8
12
22a
14b
10L
FP
10S
10L
14a

FIG. 2

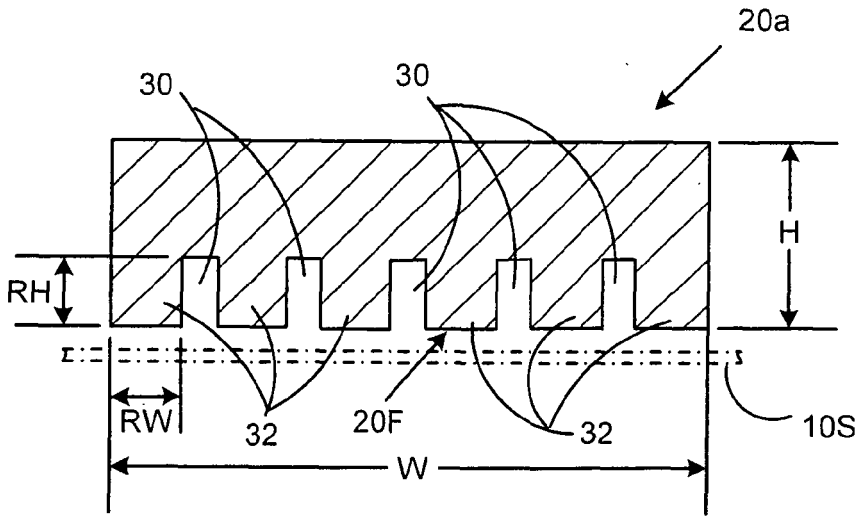
20a
30
30
H
RH
RW
32
20F
32
10S
W

FIG. 3