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(54) **Process and apparatus for reordering expanded tobacco**

(57) A process reorders tobacco that has been expanded by impregnating the tobacco under pressure with liquid carbon dioxide, forming a solid mass of the tobacco and solid carbon dioxide, and heating the solid mass in an expansion zone to sublime the carbon dioxide and thereby expand the tobacco. The expanded

tobacco is discharged from the expansion zone and before the temperature of the expanded tobacco is below about 27°C, the tobacco is contacted with humidifying air having a temperature of about 27°C to about 33°C and a relative humidity of about 58% to about 88%.

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DescriptionBackground of the Invention

5 **[0001]** The present invention relates to a process for reordering tobacco, and in particular to a process for reordering cut tobacco filler after carbon dioxide expansion.

[0002] The filling power of cut tobacco filler is frequently increased prior to incorporation into cigarettes. Often, this increase in filling power is achieved by impregnating the filler with an impregnant followed by subjecting the filler to conditions under which the impregnant is rapidly transformed into a gaseous state, thereby expanding or "puffing" the cellular structure of the filler.

10 **[0003]** In one of these processes, known as the dry ice expanded tobacco process, or DIET process, tobacco cut filler is sealed in a pressure vessel, which is pressurized to from about 300 to about 500 psi. Liquid carbon dioxide is introduced into the vessel to impregnate the cut filler. The vessel is then depressurized to convert the liquid CO₂ to solid CO₂ resulting in a frozen mass of tobacco cut filler and solid CO₂, or dry ice. This mass, which may be first subdivided into pieces, is introduced into a sublimator or expansion zone in which the mass is subjected to a high temperature of about 400°F to about 700°F, resulting in rapid conversion of the solid CO₂ to gaseous CO₂ and the expansion of the tobacco filler.

15 **[0004]** Tobacco discharged from the sublimator normally has a temperature of from about 180 °F to 250 °F and normally about 200 °F. The moisture content of the expanded filler is about 2-6% wt., or less, making the tobacco filler very fragile and susceptible to shattering.

20 **[0005]** In order to render the filler suitable for subsequent processing into cigarettes, the moisture content of the filler is increased, normally to about 12-14%. In this process, known as "reordering" in the industry, the dry filler is subjected to a high moisture content environment. For example, the tobacco can be tumbled in a rotating cylinder while being treated with steam or a fine spray of water.

25 **[0006]** Conventional expanded tobacco reordering processes have had two major disadvantages. First, in some processes, considerable time is required to increase the moisture content from the 2% or so level to the desired 12-14% level. In addition, reordering causes some collapse of the cellular structure of the expanded tobacco, resulting in a significant loss in the filling power that was initially achieved during the expansion stage. Conventionally reordered expanded tobacco typically has a filling value of from about 630 to about 680 cc/100gm.

30 **[0007]** Various alternative processes have been proposed to address one or both of these deficiencies. For example, U. S. Patent 5,383,479 to Winterson et al. describes a process for reordering dry ice expanded tobacco in which the expanded tobacco, after first being cooled to ambient temperature, is carried on a belt dryer through zones of increasing humidity ranging from an initial humidity of about 30% RH, increasing to about 60% RH. During reordering, the tobacco is conveyed along the belt dryer through the different humidity zones in which humidified air at a temperature of 75°F to 95°F is blown downwardly onto, or upwardly through, the tobacco. Total time required to ramp the humidity is from 30 to 90 minutes. Tobacco reordered in this manner is said to have no statistically significant loss of filling power as determined by standard analysis of variance procedure.

35 **[0008]** Even if the process described in the preceding patent is effective in reordering tobacco filler without loss in filling power, there is still a need for a process in which reordering without significant filling power loss can be achieved in a significantly shorter time than the minimum 30 minutes required for the above process.

Summary of the Invention

45 **[0009]** Using the present process, it is possible to reorder expanded tobacco to a moisture level of 12-14% in less than 15 minutes with reduced loss of filling power. This unexpected result is achieved by immediately subjecting the expanded tobacco to defined humidity conditions immediately after the expanded tobacco is removed from the sublimator and before the temperature of the expanded tobacco has cooled below about 80 °F.

[0010] More specifically, cut tobacco filler that has been expanded by the dry ice expansion process, or DIET process, under known conditions is humidified before significant cooling following the expansion process by blowing air having a temperature of 80-91°F and about 58 to about 83% RH through a tobacco bed for from about 2 up to about 15 minutes. Preferably, the tobacco bed has a thickness of from about 0.25 to about 4 inches.

50 **[0011]** For example, the hot, expanded filler may be discharged directly from the sublimator onto a moving belt conveyor, which may be air permeable, or onto a vibrating conveyor, to carry the filler through a humidity zone in which air is blown down onto, or up through, the tobacco on the conveyor. The operation of the conveyor are adjusted so that any given part of the tobacco remains within the humidity zone for from about 2 to about 15 minutes. Preferably, the tobacco stays in the humidity zone from about 6 to about 12 minutes. Typically, uniform humidity of the air is maintained across the zone. Air velocity is normally in the range of from about 15 CFM to about 30 CFM per sq. ft. of bed. As the invention is practiced with different volumes of tobacco, other air velocities may be desirable.

[0012] A preferred embodiment of the invention also provides an apparatus for expanding and reordering tobacco. A tobacco expander has an expansion zone to expose tobacco impregnated with an impregnant to heat to sublime the impregnant from the tobacco to cause tobacco expansion, resulting in expanded, elevated tobacco. A reordering zone downstream of the expansion zone is close enough to the discharge outlet of the expansion zone so that the expanded, elevated temperature tobacco remains at an elevated temperature when it reaches the reordering zone. The reordering zone includes a blower to blow humidified air through the expanded, elevated temperature tobacco in the reordering zone.

[0013] A preferred embodiment of the invention provides reordered expanded tobacco with a filling value of about 750 cc/100gm, a 10-19% improvement over conventional processes.

Brief Description of the Drawing

[0014]

Fig. 1 is a schematic view of the apparatus used to practice the present process.

Fig. 2 is a graphical representation of corrected filling values obtained at various combinations of relative humidity and temperature.

Detailed Description of the Preferred Embodiment

[0015] As an example, filler tobacco having a cut-width of 32 cuts per inch is impregnated with liquid CO₂ in a pressurized vessel 10. The CO₂ impregnated tobacco, containing approximately 23% moisture and 11% carbon dioxide, is heated in a sublimator 12 using air and steam heated to a temperature of 343°C (640°F) to convert the CO₂ from its solid state to a gaseous state, thereby expanding the tobacco. Although carbon dioxide is currently preferred by the tobacco industry as the change of state medium, other materials have been used and it is expected that the reordering process described herein is useful for them, as well.

[0016] The expanded tobacco, having a temperature upon exiting sublimator 12 of from 180°F to 220°F, is then discharged through rotary lock 14 of sublimator 12 directly onto the feed end 18 of a 1X12 foot fluidized bed 16. Other sizes can be used. In the preferred embodiment, air having a relative humidity of 78% and a temperature ranging from 70 to 90°F is then blown upwardly through the screened bottom of vibratory conveyor 16 at a rate of 243 cubic feet per minute. The tobacco is levitated and reordered by the warm moist air, with the mechanical action of fluidized bed 16 carrying the tobacco from the entrance end to the discharge end 20 of conveyor 16 over a period of from 2 to 15 minutes preferably about 6 to about 12 minutes. The tobacco is caused to move to the discharge end at the bed by the fluidization of the bed, coupled with vibration. As the depth of tobacco builds at the feed end 18, gravity evens out the bed depth by moving the tobacco towards the discharge end 20.

This may be aided by sloping the bed. Retention time and bed depth can be varied and controlled using dams, wiers, and other devices on the bed surface.

[0017] Multiple samples collected from tests at various temperatures and relative humidities were measured for Corrected Fill Value (CFV) at different filling values at a 0.5 lb./minute flow rate. The results depicted in Fig. 2 were obtained. Three additional tests were conducted at 78% RH and a flow rate of 0.25 lb./min., with the following results:

°F	CFV
87	748.5
87	758.2
89	730.3

Filling Value and Moisture Measurement Procedures

[0018] Ten tobacco samples were collected for each Fluidized Bed test. One corrected filling value (CFV) measurement was performed on each of the tobacco samples collected. Two moisture analyses were performed on the tobacco used to conduct each CFV measurement. A Sartorius Basic balance was used to determine each moisture tin's tare weight. The moisture tin identifications and weights were recorded.

[0019] A Model 5000 Specific Volume Electronic Readout Unit is used for the filling value measurements. The procedure used is documented in SOP: QAS-MC-44 "Filling Value of Cut Tobacco-QA." This machine requires 30-minutes to warm-up, and its accuracy is verified against a set of standards before each use. The expanded tobacco samples were mixed to achieve a homogeneous mixture. A Mettler P1200 balance was used to determine each sample's weight before its filling value was measured. The weight of each sample, and the filling value measurement were recorded.

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The tobacco used for each filling value measurement was placed into two moisture-tins, and the tins were weighed. The moisture-tin weights and tobacco identifications were recorded.

The moisture tins were placed in a Lab-Line Ultra-Clean oven, Model # 3499M-3 for drying. The oven temperature was set for 105° C, and the timer was set to maintain this temperature for eight hours (11:00 PM- 7:00 AM). The moisture-tins were removed from the oven, the lids were replaced, and the tins were allowed to cool. The moistures and the corrected filling values were calculated for each tobacco sample. The Specific Volume Readout Unit used for this analysis was designed to measure the corrected filling value of tobacco when used in conjunction with the following Corrected Filling Value Formula:

Corrected Filling Value Formula:

$$\underbrace{((\text{TTW} / \text{ATW}) * \text{UFV})}_{\text{Weight \& Volume Corrected}} * \underbrace{E^{((S) * (\text{TM} - \text{AM}))}}_{\text{Moisture Corrected to 13.5\%}} = \text{CFV}$$

Abbreviation Key:

[0020]

TTW = Theoretical Tobacco Weight

ATW = Actual Tobacco Weight

UFV = Uncorrected Filling Value

CFV = Corrected Filling Value

S = Slope of Moisture Correction Curve

AM = Actual Moisture

TM = 13.5% = Theoretical Moisture

[0021] The theoretical tobacco weight (75g) is divided by the actual tobacco weight (70.6g), resulting in the percentage of theoretical to actual weight.

Percentage of Theoretical Tobacco Weight: $75 / 70.6 = 1.0623229$

[0022] The 70.6g tobacco sample had an actual filling value of 653.646cc. The Specific Volume Electronic Readout Unit divides (via instrument calibration) this sample (volume and weight) by a factor of 0.75 changing the volume to 820.40cc (Uncorrected Filling Value). The result of multiplying the percentage of theoretical tobacco weight (1.0623229) by the uncorrected filling value is the filling value corrected to 100-grams (Weight Corrected Filling Value).

Weight Corrected Filling Value:

$$((1.0623229) * 820.40) = 871.529 \text{ cc/100g}$$

[0023] The weight corrected filling value was further adjusted based on the tobacco's moisture content. A Moisture Correction Curve was generated from filling value analyses of the same tobaccos having various moisture contents. For example, filling value analyses of six to eight tobacco samples distributed across a moisture range of 10 to 16% would be sufficient to generate a Moisture Correction Curve. The two axes of this curve would consist of Moisture (%) plotted against the Corrected Filling Value (cc/100g). The slope of the Moisture Correction Curve would then be used in conjunction with the actual moisture content to calculate the Corrected Filling Value (weight and moisture corrected).

Example:

[0024]

Line 1:

Moisture Corrected to 13.5%

$$((75\text{g} / 70.6) * 820.40) * E^{((-0.07499) * (13.50\% - 12.86\%))}$$

Weight & Volume Corrected

Line 2: 871.529 * E-00479936

Line 3: 830.68 cc/100g

[0025] Actual tests with a pilot plant apparatus showed that tobacco reordered with air at 110°F and 58% relative humidity had a CFV of 687.1 and a moisture content of 10.5%. With air at 63% relative humidity and 110°F, the CFV was 613.4 and moisture content of 12.2%. Additional experimental results were as follows:

68% RH				73% RH				78% RH				83% RH				88% RH				93% RH				
CFV	°F	Loss	Mois	CFV	°F	Loss	Mois	CFV	°F	Loss	Mois	CFV	°F	Loss	Mois	CFV	°F	Loss	Mois	CFV	°F	Loss	Mois	
	70				70				70				70			766.3	68	110.4	12.1		699.4	68	116.5	13.6
	75				75				75				75			724.5	69	125.1	12.9			69	116.5	13.6
	80				80				80	0	13.6		80									80	229.6	15.9
	85				85				85	33.8	12.6		85									85		
										43.2	12.2													
729.1	90		10.5	685.6	90		12.9	709.6	90	76.1	12.8		90				89				90			
	95				95			754.9	91	41.9	12.9						90							
								640.3	95	83.1	14.8		95				95					95		
666.9	100	111.6	13.6	695.5	100	84.0	13.5	645.6	100	77.8	15.2													
110	110			110	110			110	110															

[0026] The data indicates the preferred temperature for the reordering process is between about 80°F and 90°F, with tobacco showing signs of collapsing and resultant loss of filling value as the temperature ranges higher or lower than this range. Also, the relative humidity should be within the range of from about 73% to about 88% more preferably up to about 78%. However, a lower relative humidity, e.g., as low as about 58%, can be used, but with a corresponding increase in residence time being required, because the pickup of moisture into the tobacco is slower at lower relative humidity.

[0027] The samples tested were found to have average moisture content of 14.06% and a corrected fill value (CFV) of 758.2 cc/100g. In comparison, expanded tobacco reordered in a rotating cylinder with spray nozzles to a moisture content of 14% exhibited a CFV of 670 cc/100g. Thus, a significant increase of 13.6% in fill value was achieved. In addition, no significant changes in leaf content or smoking perception for conventionally-made cigarettes were noted. This is also true for cigarettes made with a low ignition propensity paper described in U.S. Patent application serial number 09/795,054 filed February 26, 2001, the entire disclosure of which is incorporated herein by reference. These cigarettes exhibited the same reduced ignition propensity noted in that patent application.

[0028] Thus, the present invention provides a process and related apparatus that is effective in rapidly reordering tobacco with a reduction in the loss of filling power normally associated with expanded tobacco reordering processes. Among the advantages of the invention is the ability to have faster throughput, thereby reducing inventory costs and providing better control over the inventory, so that it can better suit just in time manufacturing schedules.

[0029] The apparatus is shown in Figure 1 with the feed end 18 the fluidized bed 16 situated to receive the expanded tobacco as it drops by gravity from the rotary lock 14, and this is preferred for its simplicity. However, other configurations that keep the tobacco above about 80°F during transport from the lock to the source of humidifying air without causing its collapse may also be used. A moving belt conveyor may also be used.

[0030] This disclosure refers to humidified air, but will be appreciated that other humidified gases such as humidified CO₂ or nitrogen may also work well in the practice of the invention, and should be considered as falling within the definition of "humidifying air" as used herein.

[0031] To sum up, the invention provides a process for reordering expanded tobacco that has been heated to at least 82°C in an expansion zone, by discharging the expanded tobacco from the expansion zone and contacting it with humidifying air having a temperature of 26-33°C and a relative humidity of 68% to 88%.

Claims

1. A process for reordering carbon dioxide expanded tobacco having a moisture content of less than 8% that has been heated to 82-121°C (180-250°F) during expansion in an expansion zone comprising:

discharging the expanded tobacco from the expansion zone (12) into a reordering zone (16); and blowing humidifying air through the tobacco in the reordering zone before the temperature of the tobacco decreases to a temperature below 27°C (80°F) to increase the moisture content of the tobacco to at least about 14%, the humidifying air having a temperature of 26-33°C (80-91°F) and a relative humidity of from 58% to 88%.

2. The process of claim 1 wherein the moisture content is increased from less than 8% to at least 12% in less than 15 minutes.

3. The process of claim 1 or claim 2 wherein the moisture content is increased from less than 8% to at least 12% in 6-12 minutes.

4. The process of any preceding claim wherein the reordering zone is a vibrating conveyor (16) with an air permeable floor, the tobacco being deposited on the floor and the air being blown upwardly through the floor and the tobacco.

5. The process of claim 4 wherein the air is blown at a velocity of from 4.572-9.144 M³/Min/M² (15 CFM to 30 CFM per square foot) of the floor.

6. A process for expanding and reordering tobacco comprising:

impregnating the tobacco under pressure with a liquid impregnant;
converting the liquid impregnant to solid to form a solid mass of the tobacco and solid;
heating the solid mass in an expansion zone to a temperature of 82-121°C (180-250°F) to convert the impregnant to a gas, and thereby expand the tobacco;

discharging the expanded tobacco from the expansion zone; and
initially contacting the expanded tobacco with humidifying air having a temperature of 26-33°C (80-91°F) and
a relative humidity of 58 to 88% before the temperature of expanded tobacco falls below 26°C (80°F).

7. The process of claim 6 wherein the expanded tobacco is contacted with humidifying air for from 2 to 15 minutes,
preferably from 8 to 12 minutes.

8. The process of claim 6 or claim 7 wherein the moisture content of the expanded tobacco is raised to about 12 to 14%.

9. The process of any one of claims 6 to 8 including forming a bed of the tobacco when the tobacco is discharged
from the expansion zone, and blowing humidifying air through the tobacco bed.

10. The process of any preceding claim wherein the tobacco has a temperature of from 82-121°C (180-250°F) when
contacted by the humidifying air.

11. A process for expanding and reordering tobacco comprising:

providing a sublimator having a discharge opening and an air permeable conveyor having a feed end adjacent
the sublimator discharge opening and a discharge end;
placing solid impregnated tobacco into the sublimator;
heating the tobacco in the sublimator to a temperature of at least 82°C (180°F) to convert the impregnant to
a gas to thereby expand the tobacco;
discharging the expanded tobacco having a temperature of at least 82°C (180°F) from the sublimator discharge
opening onto the feed end of the conveyor; and
blowing humidifying air through the tobacco while the tobacco is conveyed from the feed end of the conveyor
to the discharge end of the conveyor to increase the moisture content of the tobacco to at least 12%, the
humidifying air having a temperature of from 26-32°C (80-90°F) and a relative humidity of 58% to 88%.

12. The process of claim 11 wherein the conveyor is a vibrating conveyor having an air permeable floor, the air being
blown upwardly through the floor and the tobacco.

13. The process of any one of claims 4 to 12 wherein the tobacco is deposited on the floor at a rate to provide a
thickness of tobacco on the floor of 6.35 to 102 mm (0.25 to 4 inches).

14. The process of any one of claims 11 to 13 wherein the tobacco is conveyed from the conveyor feed end to the
discharge end is from 6 to 12 minutes.

15. The process of any one of claims 11 to 14 wherein the air is blown through the tobacco at the rate of from 4.57 to
9.14 M³/Sec/M² (15 to 30 CFM/sq.ft.) of conveyor.

16. The process of any one of claims 11 to 15 wherein the tobacco is discharged from the sublimator at a temperature
of from 82-121°C (180-250°F).

17. The process of any one of claims 11 to 16 wherein the tobacco when discharged from the sublimator has a moisture
content of less than 8%.

18. The process of any preceding claim wherein the tobacco is cut tobacco filler.

19. The process of any preceding claim wherein the relative humidity of the humidifying air is from 68% to 78%, pref-
erably about 78%.

20. An apparatus for expanding and reordering tobacco comprising:

a tobacco expander having an expansion zone (12) to expose tobacco impregnated with an impregnant to
heat to sublime the impregnant from the tobacco to cause tobacco expansion, resulting in expanded, ele-
vated temperature tobacco, the expansion zone having a discharge outlet to discharge expanded, elevated
temperature tobacco, and
a reordering zone (116) downstream of the expansion zone and close enough to the discharge outlet of the

expansion zone so that the expanded, elevated temperature tobacco remains at an elevated temperature when it reaches the expansion zone, the reordering zone including a blower to blow humidified air through the expanded, elevated temperature tobacco in the reordering zone.

5 **21.** An apparatus as claimed in claim 20 further comprising a conditioner for the humidified air to adjust the relative humidity and temperature of the humidified air to desired levels.

22. An apparatus as claimed in claim 21 wherein the conditioner is adapted to adjust the level of temperature to between 26 and 33°C (80 and 91°F).

10 **23.** An apparatus as claimed in claim 21 or claim 22 wherein the conditioner is adapted to adjust the level of relative humidity to between 58% and 88%, preferably between 68% and 78%.

15 **24.** A process for reordering carbon dioxide expanded tobacco having a moisture content of less than 8% that has been heated to 82-121°C (180-250°F) during expansion in an expansion zone comprising:

discharging the expanded tobacco cut filler from the expansion zone onto a vibrating conveyor with an air permeable floor at a rate to provide a thickness of tobacco on the floor of 6.35 to 102 mm (0.25 to 4 inches); and blowing humidifying air having a relative humidity of about 78% upwardly through the floor of the conveyor and through the tobacco at a velocity of from 4.57 to 9.14 M³/Min/M² (15 CFM to 30 CFM per square foot) of the floor to increase the moisture content of the tobacco, the humidifying air having a temperature of 26-33°C (80-91°F), wherein the tobacco has a temperature of from 82-121°C (180-250°F) when first contacted by the humidifying air and the moisture content is increased from less than 8% to at least 12% in from 6 to 12 minutes.

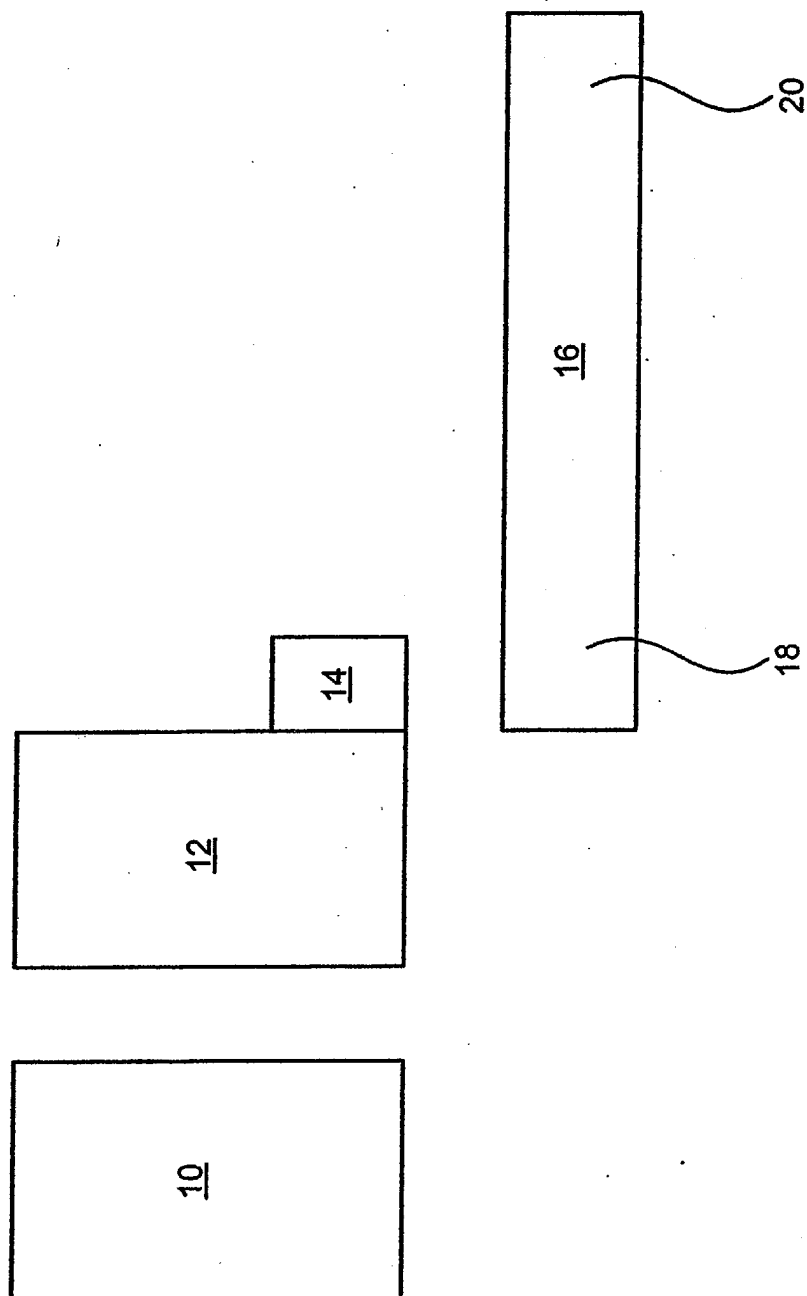


FIG. 1

