# United States Patent [19]

**Bevington, Jr.**

[11] **3,831,501**

[45] **Aug. 27, 1974**


[54] **SHEET PLICATING DEVICE**


[75] Inventor: **Richard E. Bevington, Jr.,** Kingsport, Tenn.

[73] Assignee: **Eastman Kodak Company,** Rochester, N.Y.



[22] Filed: **July 16, 1973**

[21] Appl. No.: **379,533**

[52] **U.S. Cl.** ..... **93/1 C,** 93/1 WZ, 93/84 R, 93/84 FF

[51] **Int. Cl.** ..... **B31f 1/08**

[58] **Field of Search** ..... 93/1 C, 77 FT, 60, 1 WZ, 93/84 R, 84 FF; 156/161, 166



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,164,702 | 7/1939 | Davidson | 93/1 C |
| 3,150,576 | 9/1964 | Gewiss | 93/84 FF |
| 3,205,791 | 9/1965 | Goodfellow et al. | 93/1 C |
| 3,348,458 | 10/1967 | Tipper | 93/84 R |
| 3,383,449 | 5/1968 | Muller | 93/1 C |
| 3,621,764 | 11/1971 | Muller et al. | 93/1 C |



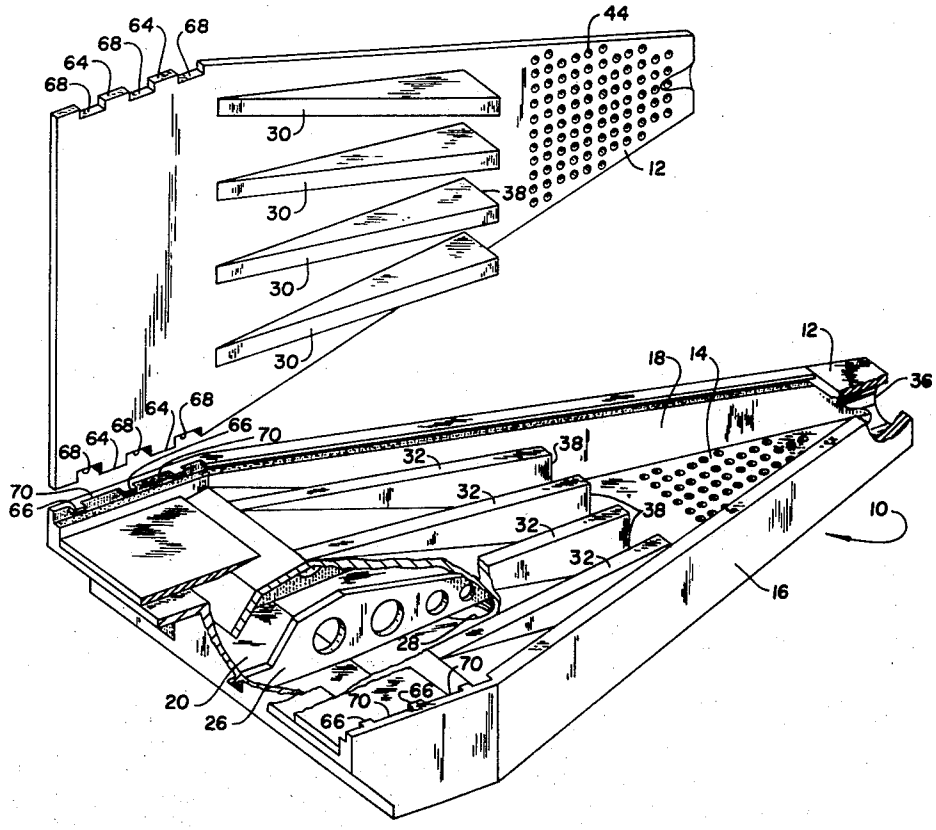
*Primary Examiner*—Roy Lake
*Assistant Examiner*—James F. Coan
*Attorney, Agent, or Firm*—Donald W. Spurrell



[57] **ABSTRACT**

Plicating device or jet for receiving a material in continuous, band, ribbon or sheet-like form, uniformly plicating and compacting the material into a shape of relatively low cross-sectional area, and presenting the plicated and compacted material through an exit for further processing. The jet folds and condenses the material so that the axis of the fold is generally parallel to the direction of travel of the material. The position and amplitude of each fold as well as the degree of compacting is highly controlled. The device is formed to provide a slot-like band inlet communicating with a venturi connected to a gas inlet to transport the band to a folding cavity having nested vanes around which the band is plicated along its direction of travel.


**22 Claims, 7 Drawing Figures**



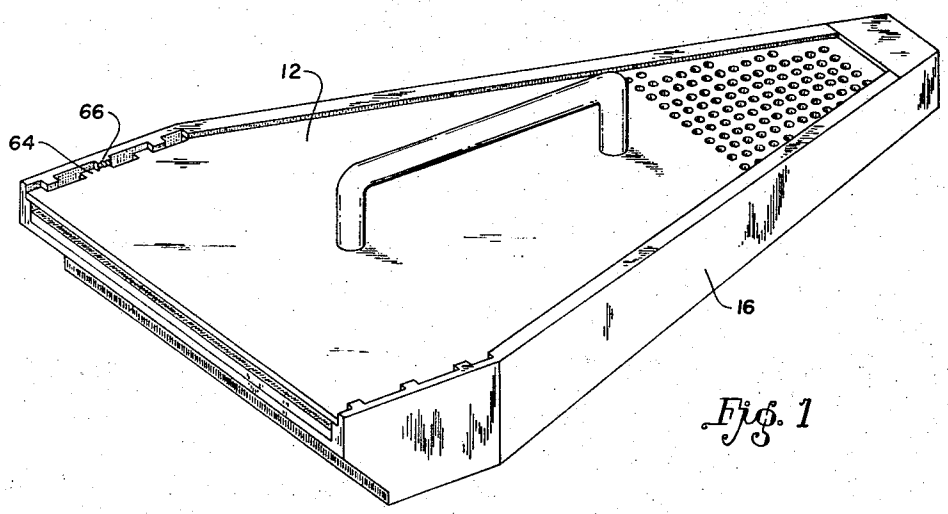



Fig. 1

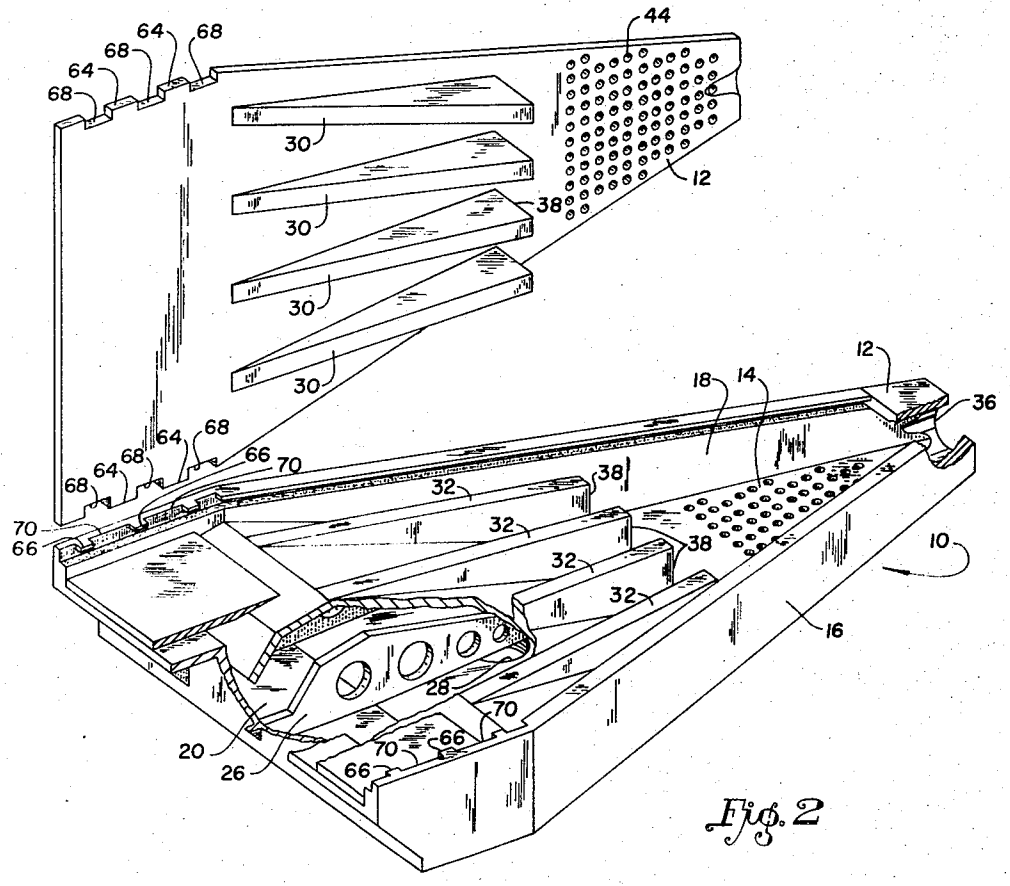



Fig. 2

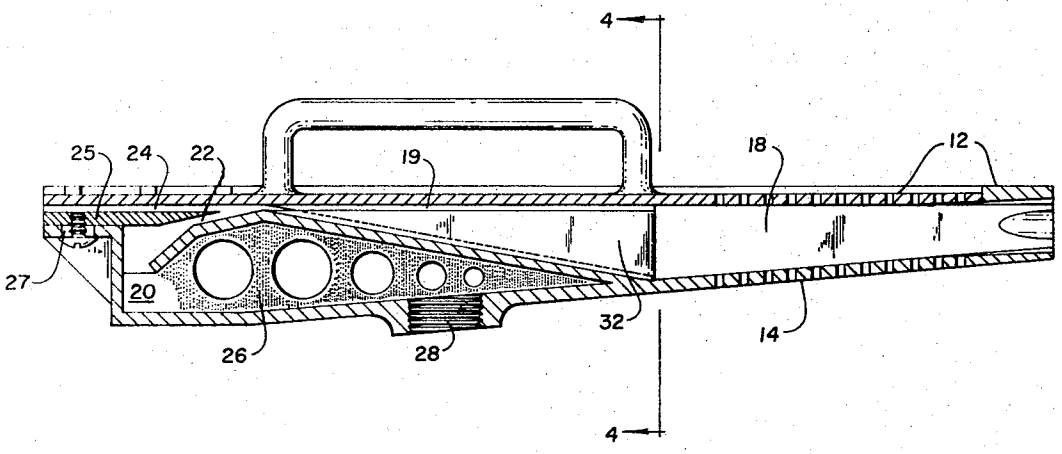



Fig. 3

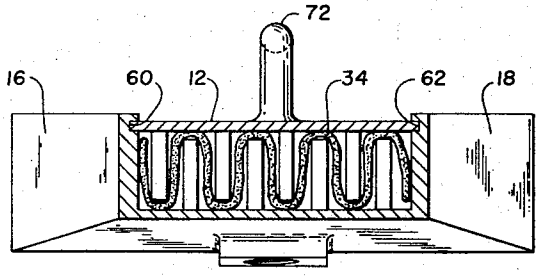



Fig. 4

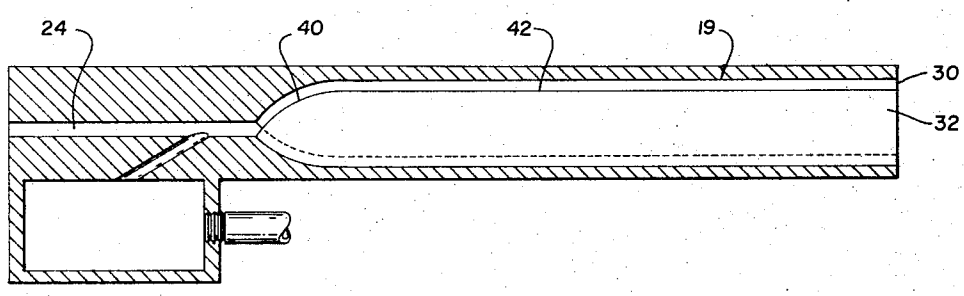



Fig. 5

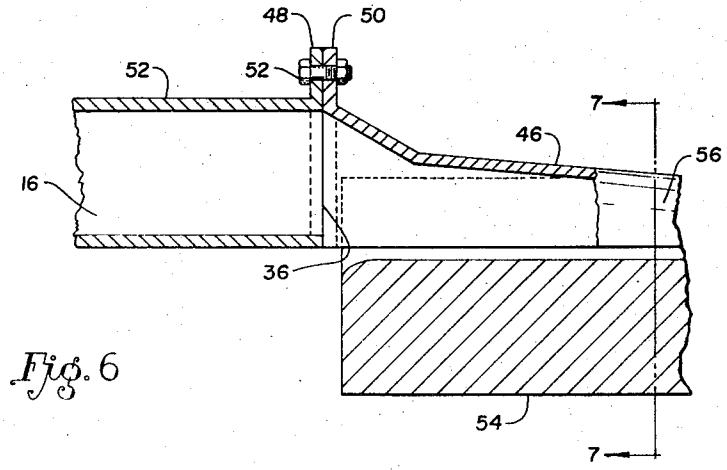



Fig. 6

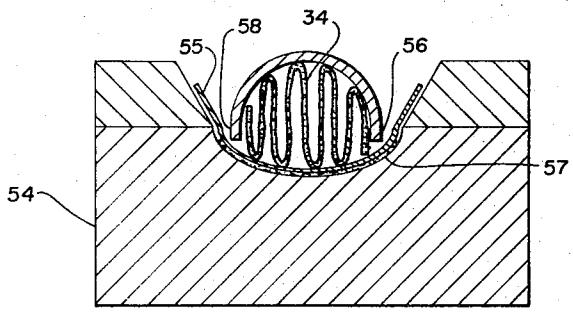



Fig. 7

# SHEET PLICATING DEVICE

This invention concerns a plicating device or jet for receiving a material in continuous ribbon or sheet-like form, uniformly plicating and compacting the material into a shape of relatively low cross-sectional area, and presenting the plicated and compacted material through an exit for further processing. The jet folds and condenses the material so that the axis of the fold is generally parallel to the direction of travel of the material. The position and amplitude of each fold as well as the degree of compacting is highly controlled.

The invention, in more specific embodiments, concerns the adaptation of the plicating jet to cigarette filter rod or plug making machines and to filters made in accordance with the present invention wherein the filtering medium is accurately and uniformly plicated in the filter rod to impart highly desirable characteristics thereto.

Various forms of sheet folding devices are, of course, known for folding such materials as paper, cardboard and the like. These devices are satisfactory up to the point where the fragile nature or pliability of the sheet overcomes the capability of the feeding or take-off mechanism to function at high speed without rupturing the sheet or pulling or stretching it out of shape. This is particularly true in the case of fabric sheets, especially nonwoven materials, which must be folded or compressed but thereafter used in a way which demands a high degree of dimensional accuracy and density or weight consistency.

A particularly demanding application for folding devices is for nonwoven bands or sheets as in the manufacture of cigarette filters wherein pressure drop or draw is important and related to such factors as weight, crimp, and density of the tow throughout the rod. In such manufacture, the folding or plicating of the tow which then feeds into the garniture of the plug maker such as that shown in U.S. Pat. Nos. 3,205,107; 3,107,309; 3,345,917; and 3,297,512, the disclosures of these patents being incorporated herein by reference, must not significantly alter the tow in regard to its bulk, crimp, density and the like by means of undue tension, drag, friction or other unregulated operating characteristics of the device.

Objects therefore of the invention are: to provide a plicating device for sheet material, including paper, plastics, nonwoven natural and synthetics, which minimizes changes in the physical characteristics of the material during the plicating operation; to provide such a device which operates with no moving parts and which can be assembled and disassembled with ease; to provide such a device which can be readily installed on commercial filter plug machines; to provide such machines with the plicating device attached; and to provide cigarette filter rods, filters, and cigarettes having the filters produced in accordance with the present invention.

These and other objects hereinafter appearing have been attained in accordance with the present plicating device hereinafter described in detail and which may be defined in its broad sense as a band plicating device comprising a housing having upper, lower and side wall means defining a folding cavity, said wall means further providing a band feeding slot opening into one end of said cavity, a plicated band outlet exiting from the other end, and a gas inlet communicating with said slot,



the ratio of height to width of said outlet being greater than that of said slot, a plurality of upper vanes spaced across said cavity and supported by said upper wall means, said vanes extending generally toward said band outlet from a point adjacent the junction of said feeding slot and said cavity and extending downwardly into said cavity to a point spaced from said lower wall means, a plurality of lower vanes spaced across said cavity and supported by said lower wall means, said lower vanes extending generally toward said band outlet from a point adjacent the junction of said feeding slot and said cavity and extending upwardly into said cavity to a point spaced from said upper wall means, said upper and lower vanes being spaced from and projecting between each other to give an undulated configuration to said cavity along its transverse axis.

Further objects and advantages of the present invention will become apparent from the following description and drawings wherein:

FIG. **1** is an isometric view of the plicating jet;

FIG. **2** is a partially sectional, isometric view of the plicating jet with the top lifted and rotated back 90°;

FIG. **3** is a longitudinal sectional view of the jet;

FIG. **4** is a cross-sectional view of FIG. **2** taken along line **4—4** in the direction of the arrows;

FIG. **5** is a longitudinal sectional view of a variation of the jet;

FIG. **6** is a partial sectional view of the jet attached to the garniture tongue of a plug maker; and

FIG. **7** is a cross-sectional view of the garniture of FIG. **6** with plicated tow therein, taken along line **7—7** thereof in the direction of the arrows.

Referring to the drawings, the plicating jet or device comprises a housing generally designated **10** having upper wall means **12,** lower wall means **14,** and side wall means **16** and **18,** providing folding or plicating cavity generally designated **19** (FIG. **3**). As shown in FIGS. **2** and **3,** wall means **14, 16** and **18** may be formed and arranged to provide a plenum chamber **20** which may be of any suitable configuration and size, a transporting or working gas inlet or venturi **22** and a band feeding slot **24.** Chamber **20** is preferably baffled by one or more apertured plates **26** to distribute gas flowing in through line **28** uniformly across inlet **22** and its junction with slot **24.** A jet plate **25** adjustable longitudinally of the device by means of adjustment slots **27,** and extending throughout the width of slot **24** may be provided to achieve the best air flow through **22** for feeding the material in **24.**

A plurality of upper vanes **30** are supported by wall means **12** and are adapted to project or nest between a plurality of lower vanes **32** supported by lower wall means **14.** The spacing of the upper and lower vanes from each other and from the opposite walls is such that the material being folded **34** can easily pass therebetween.

As shown in FIGS. **2–4,** vanes **30** and **32** extend generally toward the plicated band outlet **36,** and in this embodiment are actually angled theretoward, such that their longitudinal axes would converge at some point downstream of their ends **38.** Also, in this embodiment, both the upper and lower vanes increase in depth in substantially the same direction, that is, toward lower wall **14** from the plane of wall **12.** As shown in FIG. **5,** the depth of the vanes **30** and **32** could increase in both directions from a common plane, and the outer edges of the vanes could have a variety of configurations such

as the arcuate shape of the leading end **40**, and the straight configuration of section **42**. Also, the vanes could extend the full length of the folding cavity **19** as shown in FIG. **5**. A plurality of gas outlets **44** may be provided conveniently in upper wall means **12** or lower wall means **14**, or both so that excessive gas pressure will not be felt in the garniture of the plug maker and disrupt further operations such as tow compression, filter tip paper wrapping, and sticking of the filter tip paper adhesive.

Referring to FIG. **6**, the plicating jet is shown attached to the plug maker such that the outlet **36** is adjacent the garniture tongue **46**. This attachment may be made conveniently by providing a flange **48** on the end of the plicating jet for securement to a mating flange **50** on the garniture tongue by bolts **52**. The plicating jet may be further stabilized or secured in position relative to the garniture solely, for example, by suitable brackets secured thereto and to the base or other rigid portions of the plug maker. The particular garniture configuration is not critical to the invention, the garniture serving as shown in FIG. **7** to wrap the filter tip paper **55** transported by an endless belt or tape **57**, by means of tapered grooved bottom plate **54** and the outsides **56** and **58** of the garniture tongue walls, around the plasticized, plicating tow **34** in preparation for application of the adhesive to the filter tip paper. In this FIG. **7** the folded tow is shown in an expanded, enlarged condition for purposes of clarity.

In FIG. **4**, upper wall **12** is shown as nesting in grooves **60** and **62** in side walls **16** and **18**, respectively. As shown in FIG. **2**, the mating tabs **64** and **66**, respectively, on upper wall **12** and the side walls, forming their adjacent associated slots **68** and **70**, allow wall **12** to be positioned adjacent the grooves, and, upon forward sliding motion inserted into the grooves with tabs **64** positioned under tabs **66**, in a frictional manner. This construction provides an extremely convenient means for allowing rapid assembly and disassembly of the device as may become necessary for cleaning thereof or for manual manipulation of the tow band. Handle **72** is of further convenience in removing wall **12**.

## EXAMPLE

A plicating jet embodying the present invention was installed between a cellulose acetate filter tow blooming process which included a banding air jet, a set of deregistering rolls, and a triacetin plasticizer applicator, and the garniture of a Molins PM-5 cigarette filter rod or plug making machine. The actual connection of the plicating jet to the plugmaker was made by abutting the outlet of the jet against the garniture tongue and clamping the working gas pipe which was connected into the plenum chamber **20** to the base of the plasticizer and delivery roll portion of the blooming process unit which in turn was secured to the plug maker. The cellulose acetate filter tow in the form of a flat band as shown, for example, as **11** in U.S. Pat. No. 3,017,309 previously incorporated herein by reference, was directed from the blooming process delivery rolls into the band feeding slot **24**. The plate **25** had been adjusted so that approximately 50 scfm of air moved through venturi **22**, plenum pressure was maintained at 10 psig, and air was sucked into band feeding slot **24** with the tow. The tow band was carried through slot **24** into contact with the air from **22** and the air and tow passed into the folding cavity **19** where the air stream and the tow were transformed from a flat ribbon shape into a plicated shape by the vanes therein. The vertical side walls **16** and **18** converged along the length of the folding cavity and therebeyond while the upper and lower walls diverged from the junction of **22** and **24** toward the band outlet. The cross-sectional area of cavity **19** adjacent the ends **38** of the vanes was slightly greater than at the front of said cavity, that is, the portion adjacent the junction of feed slot **24** and venturi **22**.

The sheet of tow, following the path of the air stream in which it was carried, bent to conform to the space between the vanes so that, at the end of the vanes, the tow had been transformed from a ribbon or flat band shape to a plicated shape. The tow was further compressed in the section between the end of the vanes and the tow outlet. This section of the apparatus converged in the direction of tow travel. This convergence further compressed the tow and reduced the cross-sectional area of the tow bundle to approximately the size of the entrance of the garniture on the plug maker. The condensing funnel, horn or trumpet such as shown in U.S. Pat. No. 3,017,309 was eliminated. The upper and lower walls of this converging section were ventilated by small holes so that the air used to convey the tow was vented to the atmosphere, leaving the tow in a low tension, well compacted form that had regained crimp by being relaxed from the tension state developed during prior deregistration of the fiber crimp. The tow at this point in the apparatus was a precisely folded, uniform bundle which was then fed into the garniture of the aforesaid Molins plug maker which produced the finished rods. These rods were characterized by highly uniform pressure drops as shown in the following Table I with particular reference to the markedly reduced coefficients of variation obtained by the present invention. The apparatus employed in obtaining the data of Table I is that shown in Defensive Publication T874,005 dated May 19, 1970, wherein the plicating device replaces the condensing trumpet **10** and photocell **40**.

TABLE I

Tow 3.3 d/f, 39,000 total denier

| Process | Tow Feed Rate | Average Pressure Drop, Inches of water | Standard Deviation | Coefficient of Variation |
|---|---|---|---|---|
| Standard miniature blooming process | Maximum | 14.7 | 0.442 | 2.99 |
| | Medium | 12.1 | 0.326 | 2.70 |
| | Minimum | 10.6 | 0.248 | 2.34 |
| Standard miniature with plicating jet | Maximum | 12.25 | 0.307 | 2.50 |
| | Medium | 14.27 | 0.207 | 1.45 |
| | Minimum | 16.24 | 0.294 | 1.81 |

The invention is applicable to any flexible material capable of air jet handling, such as continuous filament tow, a tow formed from staple fiber, woven or nonwoven material, or a mixture of several materials. The material could be fed to the plicating device in any form capable of jet handling, such as continuous sheets, ribbons, tubular form, U-shaped, or the like. The feeding inlet **24** could be any desired configuration including rectangular, circular, square, crescent, elliptical, or other such forms.

The venturi **22** could be a plurality of slots, or a slot formed or supplemented with a combination of types or shapes of passageways designed to achieve a desired effect with the particular material being handled. For example, it could be formed from a series of holes of circular or other cross-sectional shapes, some or all of which would be biased to provide for material forwarding characteristics. This passageway could also be connected to a common plenum or to several plenums, or to a combination of plenums which provide different gases at different pressures for achieving a desired effect.

The transporting gas or fluid could be compressed gases, pressurized liquids, steam, special treating mediums such as plasticizer vapors, or a combination of several types of fluids. In addition, this working or transporting fluid could be supplied to **22** in a continuous manner, pulsed, modulated, or as a combination thereof in the case of multi-fluid treatment of the material.

The vanes in the folding cavity could also be used for further treatment of the material, such as to heat or cool the transporting gas and the material, or as a supply point for adding a secondary treating or working fluid such as ink, dye, plasticizer, or steam. In addition, the vanes themselves could be vented to a vacuum chamber or to the atmosphere to remove part or all of the working fluid from the folding cavity. The vanes could also be aided or replaced in some applications of this invention by properly biased and controlled jets which would divert the mixture of working fluid and material in a manner similar to the vanes.

The tow outlet could be any shape compatible with the flow of the material in its exit form. It could be the termination of a converging section, or a diverging section, and could be formed to interface with belts, rolls, jets, or other material forwarding means.

Although the invention has been described in considerable detail with particular reference to certain preferred embodiments thereof, variations and modifications can be effected within the spirit and scope of the invention.

I claim:

**1.** A band plicating device comprising a housing having upper, lower and side wall means defining a folding cavity, said wall means further providing a band feeding slot opening into one end of said cavity, a plicated band outlet exiting from the other end, and a gas inlet communicating with said slot, the ratio of height to width of said outlet being greater than that of said slot, a plurality of upper vanes spaced across said cavity and supported by said upper wall means, said vanes extending generally toward said band outlet from a point adjacent the junction of said feeding slot and said cavity and extending downwardly into said cavity to a point spaced from said lower wall means, a plurality of lower vanes spaced across said cavity and supported by said lower wall means, said lower vanes extending generally toward said band outlet from a point adjacent the junction of said feeding slot and said cavity and extending upwardly into said cavity to a point spaced from said upper wall means, said upper and lower vanes being spaced from and projecting between each other to give an undulated configuration to said cavity along its transverse axis.

**2.** The device of claim **1** wherein said feeding slot extends substantially across the full width of said cavity.

**3.** The device of claim **1** wherein said upper and lower vanes project into said cavity substantially normally to the transverse axis of said feeding slot.

**4.** The device of claim **1** wherein the depth of said upper and lower vanes increases over at least a substantial portion of their length from said point adjacent said juction.

**5.** The device of claim **1** wherein the forward portion of at least one of said upper and lower wall means is formed to provide said gas inlet which communicates directly with said slot substantially along the entire width of said slot, and is oriented relative to said slot and said folding cavity to direct gas into said slot in the general direction of said cavity.

**6.** The device of claim **1** wherein the longitudinal axes of said ridges converge downstream thereof.

**7.** The device of claim **1** wherein said side wall means converge from points approximately adjacent the transverse ends of said band feeding slot to the sides of said band outlet.

**8.** The device of claim **2** wherein said upper and lower vanes project into said cavity substantially normally to the transverse axis of said feeding slot.

**9.** The device of claim **8** wherein the depth of said upper and lower vanes increases over at least a substantial portion of their length from said point adjacent said junction.

**10.** The device of claim **9** wherein the forward portion of at least one of said upper and lower wall means is formed to provide said gas inlet which communicates directly with said slot substantially along the entire width of said slot, and is oriented relative to said slot and said folding cavity to direct gas into said slot in the general direction of said cavity.

**11.** The device of claim **10** wherein the longitudinal axes of said vanes converge downstream thereof.

**12.** The device of claim **11** wherein said side wall means converge from points approximately adjacent the transverse ends of said band feeding slot to the sides of said band outlet.

**13.** The device of claim **4** wherein the forward ends of said upper and lower vanes are tangential to their supporting wall means.

**14.** The device of claim **1** wherein said band outlet is substantially round.

**15.** The device of claim **1** wherein said wall means are formed to provide a baffled plenum chamber for distributing gas substantially uniformly to said slot across substantially its full width.

**16.** The device of claim **1** assembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

**17.** The device of claim **8** assembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

**18.** The device of claim **9** assembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

**19.** The device of claim **10** assembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

**20.** The device of claim **11** asembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

**21.** The device of claim **12** assembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

**22.** The device of claim **15** assembled on a filter rod making machine with the outlet of the device adjacent the tongue of the garniture.

* * * * *