United States Patent [19]

Busker

[11] **3,908,808**

[45] **Sept. 30, 1975**

[54] **ULTRASONIC CALENDERING OF PAPER WEBS**

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[73] Assignee: **Nakajima All Co., Ltd.,** Tokyo, Japan

[22] Filed: **Sept. 17, 1973**

[21] Appl. No.: **397,887**

[52] **U.S. Cl.** ..... **100/35;** 29/110; 68/3 SS; 72/199; 100/176; 162/205; 162/305; 162/361; 156/580

[51] **Int. Cl.²** **B30B 13/00;** B30B 3/04

[58] **Field of Search** ..... 72/199, 35; 100/155, 172, 100/176; 156/73, 580, 582; 29/115, 110; 162/205, 206, 192; 68/3 SS

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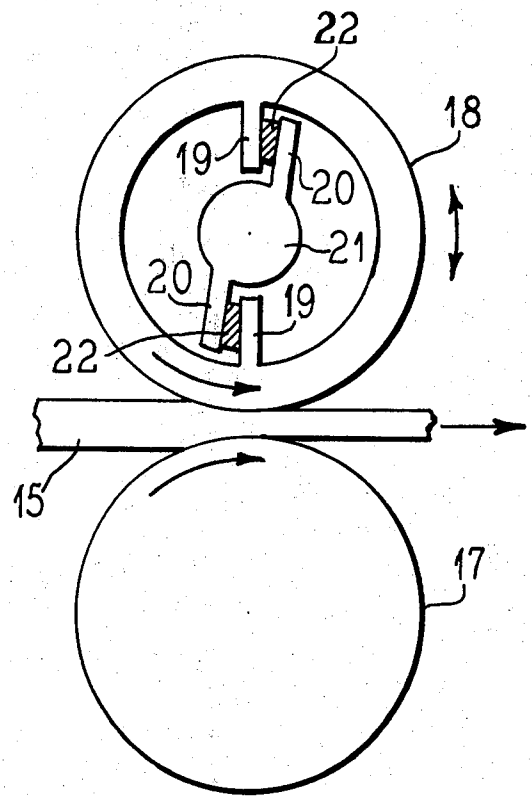
Primary Examiner—Peter Feldman
Attorney, Agent, or Firm—Gifford, Chandler & Sheridan

[57] **ABSTRACT**

More rapid and improved calendering of a paper web is achieved by vibrating at ultrasonic frequency at least one of the calendering rolls at a nip through which the web runs. Accelerated attainment of gloss of the finished sheet through friction or shear stress, and smoothness of the finish sheet by pressure or compressive stress are provided for.

8 Claims, 5 Drawing Figures



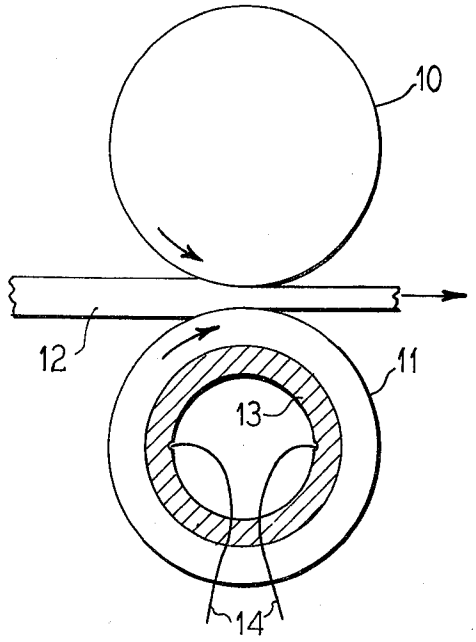


Fig. 1

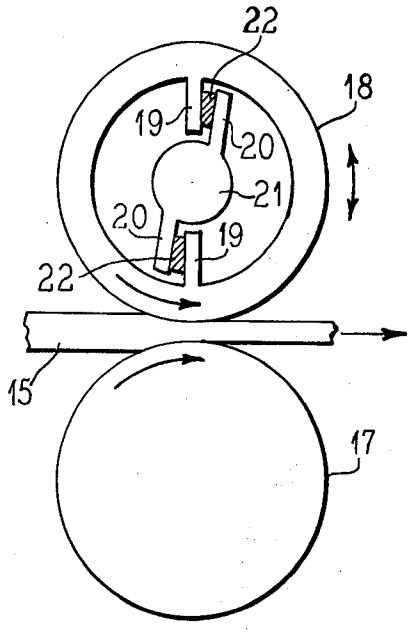


Fig. 2

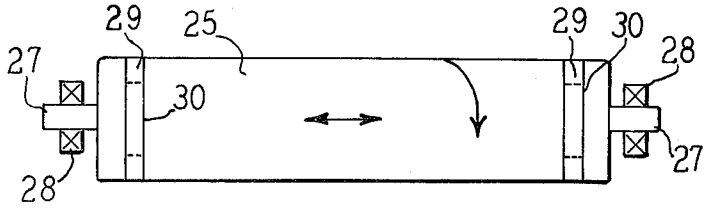


Fig. 3

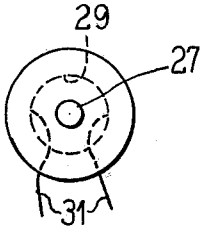


Fig. 4

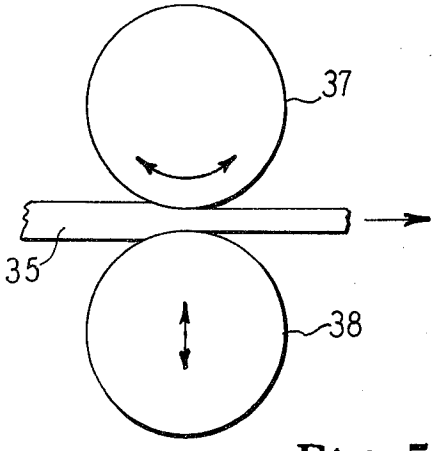


Fig. 5

ULTRASONIC CALENDERING OF PAPER WEBS

This invention relates to calendering of paper webs and is more particularly concerned with accelerating the calendering process with improved calendering results.

Fundamental considerations of calendering of paper webs lead to the view that both compressive and shear stress must be applied simultaneously to accomplish the desired changes in surface and structure. Evaluations are based on measurements of printability, smoothness, caliper, opacity, and other measurements. Various prior studies have shown that pure hydrostatic pressure has little or no transforming effect on paper. However, when a high compression stress is applied simultaneously with a shear stress, the paper is tranformed into a translucent horn-like mass. Supercalendering is employed to produce glassine with desirable translucency. In calendering, simultaneous application of hyrostatic pressure and shear stress occurs in running of the web through the nips of the calender rolls which apply rolling friction or deformation. Surface smoothness is attained in nearly direct proportion to the number of nips through which the web passes. Caliper and wire mark drops very rapidly in the first two nips and levels off after the third nip. Change in porosity through each nip is almost equal. Printing quality is said to improve in equal increments in each nip.

While it has heretofore been proposed to apply controlled ultrasonic vibration to rolling of metal (Product Engineering, Apr. **22, 1968,** page **106**) that technique, has not, so far as I am informed, been employed in calendering of paper webs and the special conditions and requirements for handling and treating the relatively soft felted fiber structure of such webs.

It is, accordingly, an important object of the present invention to improve the calendering of paper webs.

Another object of the invention is to provide a new and improved method of and means for reducing the number of calendering nips through which the paper webs must pass to attain the desired properties in the paper.

A further object of the invention is to provide a new and improved method of and means for applying both friction or shear stress and pressure or compressive stress in the calendering of paper webs.

Still another object of the invention is to provide for ultrasonic calendering of paper webs.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings although variations and modifications may be effected without departing from the spirit and scope of the novel concepts embodied in the disclosure, and in which:

FIG. **1** is a schematic illustration of one means for ultrasonic calendering.

FIG. **2** is a schematic illustration of a modified means for ultrasonic calendering.

FIG. **3** is a schematic illustration of a calendering roll for attaining another mode of ultrasonic calendering.

FIG. **4** is an end elevational view of the roll in FIG. **3**; and

FIG. **5** is a schematic illustration of means for attaining multiple modes of ultrasonic calendering effects.

As illustrated in FIG. **1,** a pair of calendering rolls **10** and **11** mounted in any preferred paper calendering machine stack are adjusted relative to one another to receive a paper web **12** therebetween and apply calendering pressure thereto as the paper runs through the nip of the rolls, effecting compression of the web. Ordinarily, the paper web is run through a plurality of individual nips, the number depending upon the ultimate condition of smoothness and density desired in the paper.

According to the present invention, the number of nips through which the paper web **12** must run to attain the desired results is greatly reduced. This is achieved according to one preferred mode by vibrating at ultrasonic frequency at least one of the rolls **10** and **11** as the web runs through the nip of the cooperatively rotating rolls. By way of example, the calender roll **11** comprises a hollow cylinder within which vibration effecting means are mounted in the form of tightly fitted cylinders of an electrostrictive material **13** such as barium titanate. High frequency, i.e. **12** KHz, electrical energy is applied to the crystal cylinders **13** by any suitable means such as through electrical conductors **14** from a suitable source. The high frequency energy applied to the crystal cylinders **13** causes the roll **11** to expand and contract at the high frequency and with a preferred amplitude, for example **0.7** mils. Inasmuch as smoothness and other properties desired in the paper web **12** are obtained in direct proportion to the number of nips through which the web runs in a conventional calender, the number of cycles to which the web is subjected to compressive stress in running through the single nip of the rolls **10** and **11** should obtain substantially the same results in this single pass as would be effected in running through the same number of individual nips in a conventional calender. For example, by subjecting the web **12** to seven or eight cycles in the nip between the rolls **10** and **11** should achieve the same results as running the web through seven or eight individual nips at the same speed and under the same conditions of paper web quality, moisture content, etc.

Not only compressive stress, but shear stress can be applied and controlled in calendering the paper web. Friction or shear stress affects the surface or gloss characteristics of the finished sheet, whereas smoothness is produced more by pressure or compressive stress exerted on the paper web during calendering. For example, in FIG. **2** an arrangement is shown for implementing application of shear stress to a paper web **15** running through the nip of cooperatively rotating calender rolls **17** and **18,** at least one of which is equipped to vibrate with ultrasonic frequency in a peripheral direction. In other words, the rotation of one of the rolls, in this instance the roll **18** is modulated ultrasonically to control the shear stress effect on the web **15.** Means for attaining this end, comprise construction of the roll **18** as a hollow cylindrical shell having diametrically opposite longitudinally extending radial internal fins **19** respectively in face-to-face opposition to corresponding radial outwardly extending fins **20** on an axial support core **21,** with electrostrictive material **22** secured to and between the pairs of fins **19, 20.** High frequency electrical energy applied to the material **22** causes cooperative vibration of the fins **19** and **20** and thereby ultrasonic frequency modulation of normal rotation of the roll **18** as indicated by the double prong arrow, whereby to subject the web **15** to shear stress multiplied by the ultrasonic oscillatory vibrations of the pe-

riphery of the roll **18** in contact with the web **15** running through the nip of the rolls **17** and **18.**

Cross-machine shear stress may be applied to the paper web by having at least one of a pair of calender rolls vibrate at ultrahigh frequency longitudinally. For this purpose, at least one of the rolls of a pair of calender rolls may be constructed as exemplified in FIGS. **3** and **4,** wherein a roll **25** having at its opposite ends journals **27** rotatably supporting the roll in bearings **28** has means for effecting longitudinal high frequency vibrations of the roll as indicated by the double pronged arrow in FIG. **3.** For this purpose, the roll may be equipped with a respective doughnut or ring **29** of electrostrictive material adjacent to each opposite end, as for example mounted in a groove **30** in each instance. These rings **29** are excited in alternating phase by high frequency electrical energy supplied by a suitable source through leads **31.** Thereby the roll is vibrated longitudinally at ultrasonic frequency while rotating in contact with a paper web running through the nip of a pair of calender rolls of which the roll **25** comprises one of the pair.

FIG. **5** represents the application of combined modes of shear and compressive stress application to a paper web **35** as it runs through the nip of a pair of calender rolls **37** and **38.** In this instance shear stress is applied by the roll **37** vibrated at ultrasonic frequency oscilatably while rotating cooperatively with the roll **38** which is vibrated radially at ultrasonic frequency. For this purpose, the roll **37** may be vibrated in the manner of the roll **18** in FIG. **2,** and the roll **38** vibrated in the manner of the roll **11** in FIG. **1.** If preferred, longitudinal or reciprocal vibration may be applied to either of the rolls **37** or **38** alternatively to or in addition to the particular ultrasonic vibration mode indicated thereon in FIG. **5.**

From the foregoing it will be apparent that the present invention accomplishes with a substantially lower number of calender stack rolls new and improved results as compared to prior requirements for substantially larger number of calender stack rolls.

It should also be understood that the ultrasonic frequency vibration of the rolls may be produced by other means for generating the vibrations than the electromechanical means described. For example advantage may be taken of natural frequencies of mass elastic systems.

It will be understood that variations and modifications may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim as my invention:

1. A method of calendering paper web, comprising:
running the paper web through the nip of a pair of cooperatively rotating calender rolls;
and vibrating peripherally at ultrasonic frequency at least one of said rolls as the web runs through said nip.

2. A method according to claim **1,** comprising ultrasonically vibrating both of said rolls in different modes of vibration.

3. A method according to claim **1,** comprising vibrating said one roll radially and peripherally vibrating the other roll at ultrasonic frequency.

4. A method according to claim **1,** comprising vibrating said one roll radially and vibrating the other of said rolls at ultrasonic frequency longitudinally.

5. Apparatus for calendering paper web, comprising:
a pair of cooperatively rotatable calendering rolls providing a nip through which the paper web runs;
and means for vibrating peripherally at ultrasonic frequency at least one of said rolls as the web runs through said nip.

6. Apparatus according to claim **5,** comprising means for ultrasonically vibrating both of said rolls in different modes of vibration.

7. Apparatus according to claim **5,** comprising means for vibrating said one roll radially and means for peripherally vibrating the other roll at ultrasonic frequency.

8. Apparatus according to claim **5,** comprising means for vibrating said one roll radially and means for longitudinally vibrating the other of said rolls at ultrasonic frequency.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,908,808
DATED : September 30, 1975
INVENTOR(S) : Leroy H. Busker

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

First Sheet of Patent change "Assignee: Nakajima All Co., Ltd., Tokyo, Japan" to --

--Assignee: Beloit Corporation,
Beloit, Wisconsin--

Signed and Sealed this

thirteenth Day of *April 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks