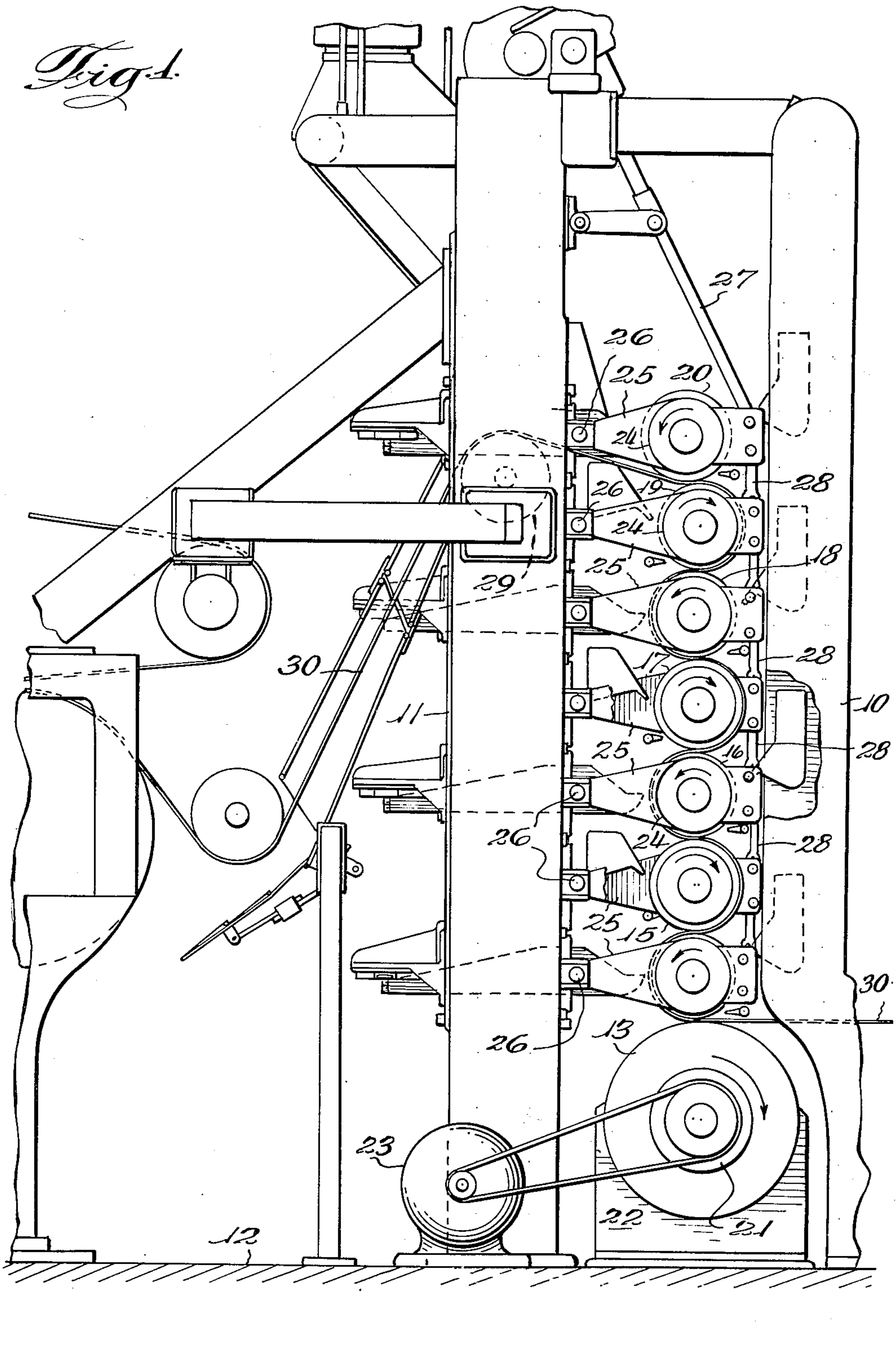
July 17, 1962 R. G. MINARIK 3,044,392

PAPERMAKING MACHINE

Filed July 10, 1959 4 Sheets-Sheet 1



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PAPERMAKING MACHINE

Filed July 10, 1959 4 Sheets-Sheet 2

Fig. 2.

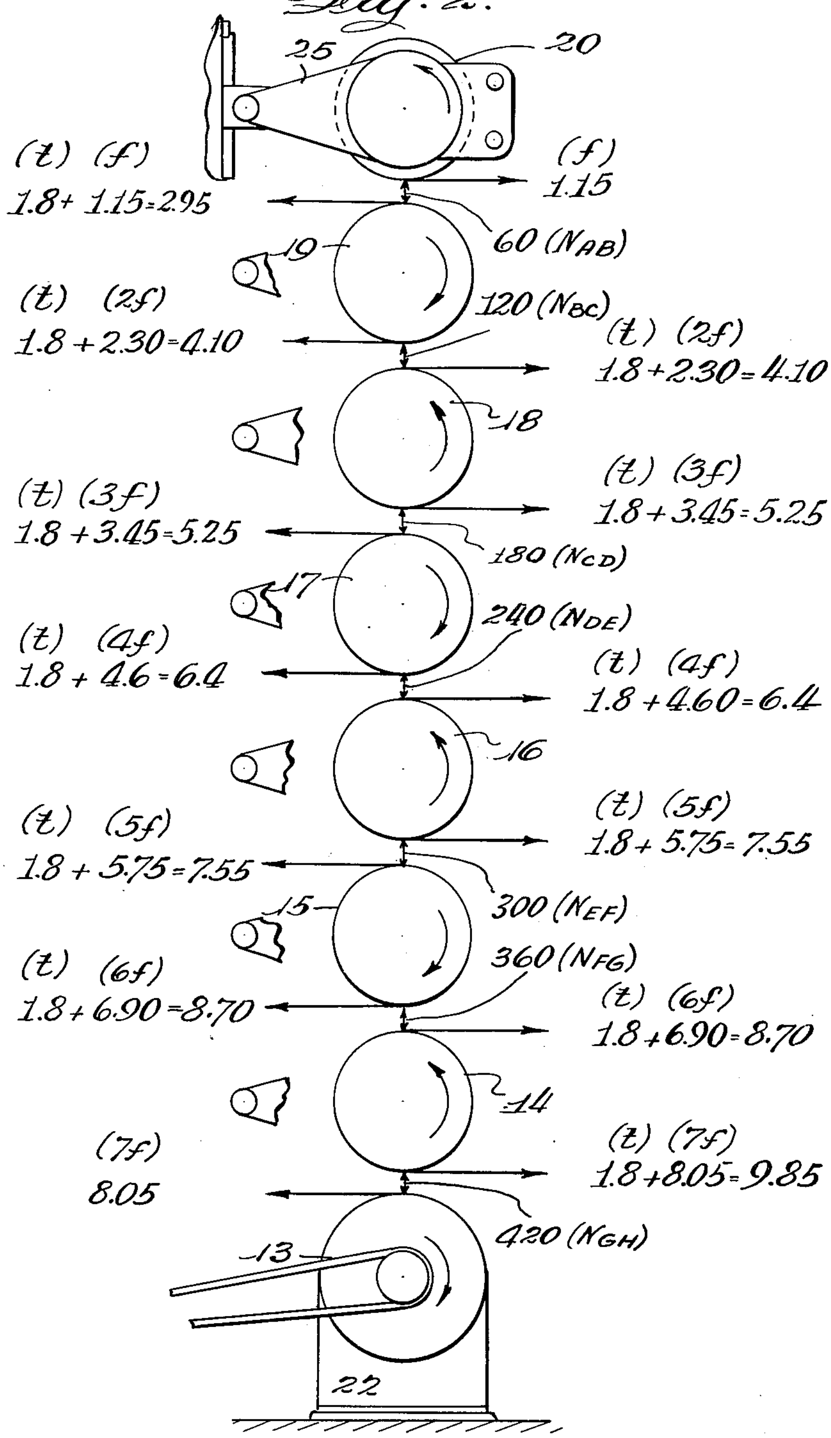


Fig. 4.

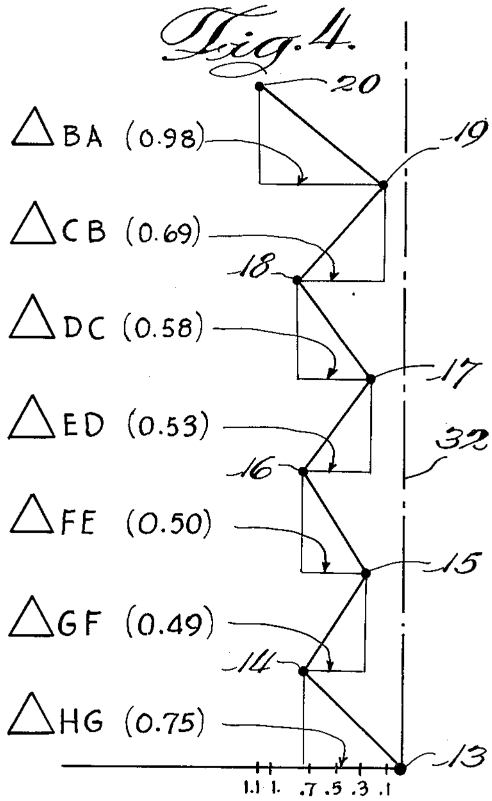
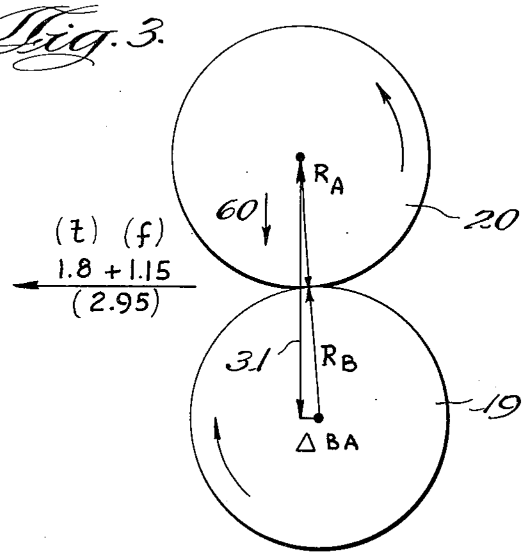

20
△BA (0.98)
19
△CB (0.69)
18
△DC (0.58)
17
△ED (0.53)
32
16
△FE (0.50)
15
△GF (0.49)
14
△HG (0.75)
13
1.1 1. .7 .5 .3 .1

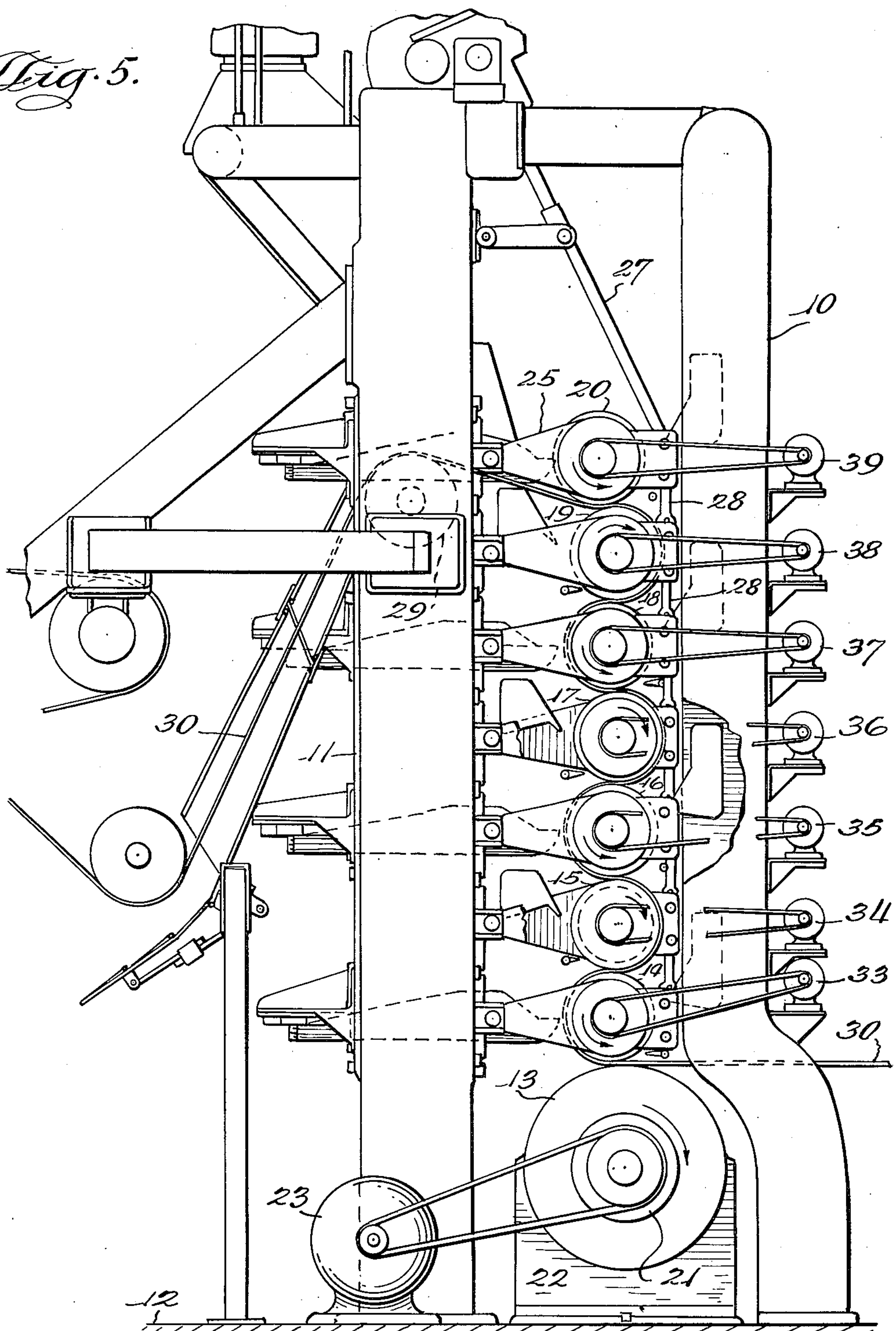
Fig. 3.


R_A
60
20
(t) (f)
1.8 + 1.15
(2.95)
31
R_B
19
△BA

PAPERMAKING MACHINE

Filed July 10, 1959 4 Sheets-Sheet 4

Fig. 5.



3,044,392

PAPERMAKING MACHINE

Rudolf G. Minarik, Menasha, Wis., assignor to Kimberly-Clark Corporation, Neenah, Wis., a corporation of Delaware

Filed July 10, 1959, Ser. No. 826,301
6 Claims. (Cl. 100—162)

This invention relates to papermaking machines and more particularly to calenders or calender stacks.

A calender for paper or like material comprises in general, a plurality of uprightly aligned calender rolls in a stack. The bottom roll or king roll of the stack is driven by a suitable mechanical or electrical mechanism, and each of the rolls above the lowest roll is driven by the roll immediately below it by friction. Paper sheet is passed through the nips of these rolls downwardly through the stack, and the paper is acted on so as to be smoothed, ironed, compacted and given a fine smooth finish.

Such a calender is employed as a part of the drier section of a papermaking machine, and the rolls are made of a fine grained cast iron that takes a high polish in order to give a fine finish to the paper. A calender stack may also be employed beyond the drier end of the machine for imparting higher degrees of finish to paper than is possible with machine calenders. These are so-called supercalenders and have alternate intermediate filled rolls of materials possessing resilient properties in lieu of inert metal rolls.

It has been found in the operation of such calender stacks, particularly those in the drier end of a papermaking machine, that the stacks produce a barring or alternate depressions and high areas in the paper across its width. I have determined that apparently these crosswise depressions and ridges in the paper are due to vibrations of the calender rolls horizontally, and thus this barring is in reality chatter marks caused by roll vibration.

Each of the intermediate rolls in such a stack at each of its nips is subjected to at least two horizontal forces. One of these forces is from the tension on the paper sheet as it passes around the roll, and the other force is due to the transmission of the power that is utilized for driving the stack from the lowermost or king roll.

These forces are horizontal and additive and tend to deflect each roll horizontally, similarly to a uniformly loaded beam, to pull the centers of the rolls out from the roll nips. The roll centers on leaving the nips, which contain the forces causing the horizontal deflecting movements, tend to return into the nips, since the weight of the upper rolls is thus relieved from the particular roll being considered. These horizontal movements of the rolls occur quite rapidly, and the actions of the rolls in leaving and then returning to the nips apparently result in the horizontal bars or changes in thickness of the paper.

As might be expected, among the factors that may increase barring are increased calender roll width, more slender rolls, higher speeds, higher sheet moisture, and varying friction characteristics of the sheet being calendered. The speed of operation and width of calenders has been increased from time to time, and under these conditions the barring effect of the calender stack becomes intolerable.

It is an object of the present invention to provide an improved calender construction so improved that barring of the paper or other sheet material passing through the calender is substantially prevented.

I have found that if the horizontal forces on the calender rolls at the nips are neutralized, the rolls will not be drawn out of the nips as previously described, and the horizontal vibration of the rolls causing barring of the paper stock does not occur. It is therefore an object of the invention to provide an improved calender construction in which the lateral forces on the rolls at the nips are essentially neutralized.

Concisely, the invention contemplates the offsetting of each of the rolls of a calender stack with respect to the rolls above and beneath it in order to balance out the lateral forces and prevent lateral deflections and vibrations of the rolls. Since the paper sheet passes around opposite sides of alternate rolls of the calender stack, the rolls are each offset in an opposite direction with respect to rolls above and beneath it in order to so balance the lateral forces on the roll.

The invention consists of the novel constructions, arrangements, and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will be apparent from the following description of the preferred embodiments of the invention, illustrated with reference to the accompanying drawings, wherein:

FIGURE 1 is a side elevational view of a paper calender stack of the type embodying the principles of the invention;

FIGURE 2 is a schematic side view of the calender stack illustrating the forces acting on the rolls when the rolls are positioned on a single vertical axis, with the rolls shown separated for better illustration of these forces;

FIGURE 3 is a schematic side view of the two top rolls of the calender stack showing the offsetting of the lower roll (the offsetting being shown exaggerated for purposes of illustration) with respect to the top roll according to the present invention;

FIGURE 4 is a diagram showing the directions in which the centers of the rolls in the calender stack are offset with respect to vertical center lines of higher rolls, according ot the invention; and

FIGURE 5 is a schematic side view of a paper calender stack constituting a modification of the invention.

Like characters of reference designate like parts in the several views.

Referring now to the drawings, the calender illustrated in FIGURE 1 comprises a pair of upright frame members **10** and **11** fixed on a floor **12** and calender rolls **13**, **14**, **15**, **16**, **17**, **18**, **19**, and **20** disposed in an upright stack. Each of the rolls **4** to **20** is illustrated as being of the same size, and the lowermost roll **13**, which may be termed a king roll, is larger in size than the others. The king roll **13** is provided with opposite journals fitting in bearings **21** that are disposed in a frame **22** by means of which the king roll is rotatably mounted. The king roll **13** is driven from a suitable prime mover such as a motor **23**, and any suitable power transmitting connections may be provided between the motor **23** and one of the journals of the king roll **13** for this purpose.

Each of the rolls **14** to **20** is provided with opposite journals fitting within bearings **24**. The bearings are carried by arms **25** which are mounted by means of pivots **26** on the frame member **11**. Each of the rolls **14** to **20** bears with its weight and the weight of the rolls above it on the roll below it. The rolls may be separated from each other by use of a link **27** acting on the uppermost arm **25** and the links **28** connecting the consecutive arms **25** together for the purpose of cleaning the rolls or for other maintenance work.

A guide roll **29** is supported by the frame member **11**, and the paper sheet **30** acted on by the calender stack extends over the guide roll **29**, into the nip between the rolls **19** and **20**, around the right side of the roll **19**, through the nip between the rolls **18** and **19** and around the left side of the rolls **18**. The paper **30** extends through the nip between the rolls **17** and **18** and from thence extends in the same manner around opposite sides of the rolls **17**, **16**, **15**, and **14** and through the nips between these rolls. The paper extends around the left side of the roll **14** as seen in FIGURE 1 and through the nip between the king roll **13** and the roll **14** as shown. The sheet **30** may be drawn from the drier end of a paper machine (not shown) to the guide roll **29** and may be drawn from the calender stack to a winder (not shown).

Each of the rolls **13** to **20** has at each of its nips horizontal forces acting on the roll, which would tend to bow the roll. Referring to FIGURE 2, which diagrammatically shows the forces on the rolls when the rolls have their centers disposed on a single vertical axis, it will be observed that the sheet **30**, which has a certain tension on it and which travels over the right side of the roll **19**, produces a force (t) on the roll **19** to the left at both the upper and lower nips of the roll. The sheet **30** in travelling over the left half of the roll **18** produces a corresponding force (t) on the roll **18** but in the opposite direction. The forces due to the sheet on the rolls **19**, **17**, and **15** are toward the left as seen in the figures, and the forces on the other intermediate rolls **18**, **16**, and **14** are to the right as seen in the figures. As far as is known, the forces due to the tension on the sheet **30** are substantially the same throughout the calender stack.

A formula for determining the force (t) at each nip due to tension in the paper web is as follows:

$$t\text{ (lbs. per lineal inch)} = \frac{\text{horsepower stack to drier} \times 33{,}000}{\text{sheet width in inches} \times \text{speed of sheet in feet per minute}}$$

In a particular example, the power transmitted through the sheet **30** from the calender roll stack back into the drier section of the associated paper machine was 32 horsepower. The power transmitted through the paper sheet **30** between the stack and a winder in back of the stack was about the same, namely, 32 horsepower. The speed of the paper was 1850 feet per minute and the sheet width was 320 inches. The formula given above with these values substituted is as follows:

$$t = \frac{32 \times 33{,}000}{320 \times 1850} = 1.8 \text{ p.l.i. (pounds per lineal inch)}$$

Thus, for the example just given, the horizontal forces tangential to the rolls due to the tension in the sheet is 1.8 pounds per lineal inch, and this is apparently approximately the same at each nip as is illustrated in FIGURE 2.

Although the forces due to the paper sheet at each nip are appreciable, nevertheless, the major parts of the total horizontal forces at the nips between the rolls are rather due to the driving forces on the rolls. As has been mentioned, the calender roll stack is driven from the motor **23**, and the power from the motor provides additional forces at the nips between the rolls. At the nip between the upper two rolls **19** and **20**, for example, the force (f) on the upper roll, which is the force driving the upper roll, may be determined by the following formula (assuming that the upper rolls **14** to **20** are identical and therefore that the horsepower is equally distributed between the nips of the stack):

$$f = \frac{\text{H.P. into the stack} \times 33{,}000}{\text{No. of nips} \times \text{f.p.m.} \times \text{sheet width}}$$

For the particular example given above, the power driving the calender stack amounts to 145 horsepower; there are 7 nips; the sheet is driven at 1850 feet per minute; and the sheet width is 320 inches. The tangential force (f) on the upper roll **20** due to the motor **23**, therefore, amounts to the following:

$$f = \frac{145 \times 33{,}000}{7 \times 1850 \times 320} = 1.15 \text{ p.l.i.}$$

Thus, the tangential driving force on the upper roll **20** at its nip equals 1.15 pounds per lineal inch.

As is indicated in FIGURE 2, the tangential force on the roll **19** at its upper nip is the sum of the forces (t) and (f) which, for the particular example given, is 1.8+1.15 or 2.95 pounds per lineal inch.

The horizontal forces at the other nips are likewise the sums of the forces due to the sheet tension and the roll driving forces. For successively lower nips below the highest, the tangential driving forces increase in arithmetic progression. In the particular example given, the tangential driving forces at the second nip from the top is 2.30 p.l.i. or 2×1.15 p.l.i., which is the tangential driving force (f) at the highest nip. Likewise, for the 3rd, 4th, 5th, 6th, and 7th nips from the top, the tangential driving forces are respectively 3, 4, 5, 6, and 7 times the "unit" tangential driving force (f) or 1.15 p.l.i. for the particular example mentioned. For each of the rolls at its nips, the forces due to the sheet tension and the driving forces are additive, and for the particular example previously mentioned, the magnitudes of these combined forces are indicated in FIGURE 2.

The invention contemplates that all of these lateral forces, which are the sums of the forces due to driving the rolls and due to the tension on the sheet, shall be reduced substantially, preferably to substantially zero, thus materially decreasing or eliminating the roll bowing forces and roll vibration and sheet barring due to the roll bowing forces. This is done according to the invention by offsetting each of the rolls with respect to the rolls above and below by varying amounts. The amount of offsetting is determined by the tangential forces at the nips on each of the rolls and the nip pressures, that is, the pressures of successive rolls at each nip on each other.

The pressure at the nip between the upper two rolls **19** and **20** is determined by the weight of the roll **20**. The rolls **14** to **20** in the illustrated calender stack have equal diameters and weights, and in the particular example mentioned, the upper roll **20** provides a nip pressure of 60 pounds per lineal inch. In the next lowest nip, namely between rolls **18** and **19**, the nip pressure in pounds per lineal inch is doubled since both of the rolls **19** and **20** are supported by the roll **18**. Likewise the nip pressures in the successively lower nips are respectively, 3, 4, 5, 6, and 7 times the unit nip pressure in pounds per lineal inch between the rolls **19** and **20**.

In order that the aggregate horizontal force (t)+(f) on the roll **19** existing at its upper nip shall be reduced substantially to zero, the roll **19**, according to the invention, is offset slightly to the right as seen in the figures with respect to the roll **20**. This is in the direction of the paper carrying side of the roll **19**, which is the right side of the roll **19**. Referring to the diagram shown in FIGURE 3, the distance that the center of the roll **19** is offset with respect to a vertical center line **31** passing through the center of the upper roll **20** is indicated by the quantity (Δ_{BA}). Referring to FIGURE 3, the tangent of an angle (a) is determined by the forces acting on the upper nip of the roll **19**, ($t+f$), and (N_{AB}), which is the nip pressure in pounds per lineal inch that exists between the rolls **19** and **20**. The tangent is

$$\left(\frac{t+f}{N_{AB}}\right)$$

The tangent must also be

$$\left(\frac{\Delta_{BA}}{R_A+R_B}\right)$$

where (R_A) and (R_B) are the radii of the rolls **20** and **19** respectively. Therefore, the amount (Δ_{BA}) that the roll **19** must be displaced with respect to the vertical center line **31** through the upper roll **20** in order to balance the force ($t+f$) may be determined from the following formula:

$$\frac{\Delta_{BA}}{R_A+R_B} = \frac{t+f}{N_{AB}}$$

This relationship assumes that the nip forces act vertically and horizontally and disregards the small angularity errors. Transposing, the relationship becomes:

$$\Delta_{BA}=(R_A+R_B)\left(\frac{t+f}{N_{AB}}\right)$$

In the particular example mentioned above in which the roll radii are 10 inches, this equation becomes:

$$\Delta_{BA}=(10+10)\left(\frac{1.8+1.15}{60}\right)=0.98''$$

Thus, the roll **19** is displaced to the right as seen in the figures about 1 inch in order to balance, and reduce substantially to zero, the lateral force on the roll **19** at its upper nip, which is the sum of the force (t) due to sheet tension and the force (f) due to the driving of the roll **20** from the roll **19**.

The offsetting of the roll **18** with respect to the roll **19**, which is to the left as seen in the figures (see FIGURE 4 in particular), is determined in the same manner. The corresponding formula is:

$$\Delta_{CB}=(R_B+R_C)\left(\frac{t+f}{N_{BC}}\right)$$

where (R_B) and (R_C) are the diameters of the rolls **19** and **18** respectively, and (N_{BC}) is the nip pressure between these rolls.

Referring to the particular example mentioned, substituting numerical values, this formula becomes:

$$\Delta_{CB}+(10+10)\left(\frac{1.8+2.30}{120}\right)=0.69''$$

Thus the roll **18** is offset 0.69 inch with respect to the vertical center lines through the center of the roll **19**.

Likewise, the formulae for the amount of displacement of the other lower rolls, with respect to center lines passing through the rolls immediately above, and also the substituted values for the specific example mentioned, are as follows:

$$\Delta_{DC}=(R_C+R_D)\left(\frac{t+3f}{N_{CD}}\right)=(10+10)\left(\frac{1.8+3.45}{180}\right)=0.58''$$

$$\Delta_{ED}=(R_D+R_E)\left(\frac{t+4f}{N_{DE}}\right)=(10+10)\left(\frac{1.8+4.6}{240}\right)=0.53''$$

$$\Delta_{FE}=(R_E+R_F)\left(\frac{t+5f}{N_{EF}}\right)=(10+10)\left(\frac{1.8+5.75}{300}\right)=0.50''$$

$$\Delta_{GF}=(R_F+R_G)\left(\frac{t+6f}{N_{FG}}\right)=(10+10)\left(\frac{1.8+6.90}{360}\right)=0.49''$$

$$\Delta_{HG}=(R_G+R_H)\left(\frac{t+7f}{N_{GH}}\right)=(10+22)\left(\frac{1.8+8.05}{420}\right)=0.75''$$

where (Δ_{DC}), (Δ_{ED}), (Δ_{FE}), (Δ_{GF}), (Δ_{HG}), are respectively the displacements of the rolls **17**, **16**, **15**, **14**, and **13**; (R_C), (R_D), (R_E), (R_F), (R_G), (R_H) are respectively the radii of the rolls **18**, **17**, **16**, **15**, **14**, **13**; and (N_{CD}), (N_{DE}), (N_{EF}), (N_{FG}), (N_{GH}) are respectively the nip pressures that exist in the lower 5 nips of the calender stack starting with the nip between the rolls **17** and **18**.

For the particular example given, the radius of the king roll is 22 inches, and for this particular example, and as indicated in FIGURE 4, the displacements for the rolls **18**, **17**, **16**, **15**, **14**, and **13** with respect to vertical center lines through the rolls immediately above these rolls, are 0.58 inch, 0.53 inch, 0.50 inch, 0.49 inch, and 0.75 inch.

It will be observed particularly from FIGURE 4 that the displacements of each lower roll is in a direction opposite to the sheet tension at the two nips of the roll. The rolls **19**, **18**, **17**, **16**, **15**, **14**, and **13** are alternately displaced in a zig-zag fashion, to the right and to the left with respect to the roll immediately above each roll. As will be seen from FIGURE 4, in which a vertical center line **32** for the king roll **13** has been drawn, the rolls above the king roll **13** are all displaced to the left, that is, in the direction from which the sheet **30** passes between the rolls **19** and **20**, with respect to the center line **32**. The uppermost roll **20** has the largest displacement from the center line **32**, and the rolls **18**, **16**, and **14** progressively approach the center line **32**. The roll **19** is closest to the center line **32**, and the rolls **17** and **15** progressively are at greater displacements from the center line **32**.

Preferably, in such a roll stack with offset rolls, none of the rolls, with the exception of the king roll **13**, is crowned. In view of the fact that the offsetting of the rolls with respect to each other is for relatively small distances, the offsetting has no discernible effect on existing roll crowns used with vertical stacks.

In order that the rolls may be offset as above described with respect to each other, the arms **25** may be made of different lengths, or else the arms **25** may be mounted on the frame member **11** using shims of different thicknesses, if desired.

The lateral forces on the rolls are substantially reduced to zero by offsetting the rolls by varying amounts as described. Both the tension of the paper sheet and also the driving forces for the rolls are taken into account; and even though the sheet tension forces may or may not change throughout the roll stack, nevertheless, these forces are minor compared to the roll driving forces, and inaccuracies in respect to the sheet tension forces do not change the results materially. Since the roll bowing forces are substantially eliminated, any tendency for the rolls to vibrate horizontally with movement of the roll center portions into and out of the nips between the rolls and the barring effect on the paper passing between the rolls are substantially eliminated. The paper processed in the calender stack of the invention is thus of much higher quality and has a much more uniform thickness and finish than paper processed with conventional roll stacks in which the rolls are vertically aligned.

As will be observed from FIGURE 2, each of the intermediate rolls **14** to **19** may be considered to have unresolved couples on them, that is, there is a greater lateral force at the lower nip on each roll than at the upper nip. For example, referring to FIGURE 2, the lateral force at the upper nip on the roll **19** is ($t+f$) while the lateral force at the lower nip on this roll is ($t+2f$). In the particular case mentioned, the force on the upper nip amounts to 2.95 p.l.i. and the force on the lower nip amounts to 4.10 p.l.i. In order to balance these unresolved couples, for the purpose of providing a calender stack that is even more stable than one in which the rolls are simply offset as previously described, each of the upper rolls **14** to **20** may be driven in addition to the normally driven king roll. Referring to FIGURE 5, motors **33** to **39** are respectively provided for driving the rolls **14** to **20**, and the motors are so controlled as to provide a torque on the rolls driven by the motors just sufficient to balance the unresolved couples. As will be apparent, the unresolved couple for any particular roll amounts to the difference between the lateral forces at the nips multiplied by the radius of the roll. If desired, only half of the upper rolls may be driven with the same results; for example, the motors **34**, **36**, and **38** may be used.

I wish it to be understood that the invention is not to be limited to the specific constructions and arrangements shown and described, except only insofar as the claims may be so limited, as it will be understood to those skilled in the art that changes may be made without departing from the principles of the invention.

I claim:

1. In a calender for a paper web, a first calender roll, means for mounting said roll to hold it axially fixed and permit it to rotate, means for driving said roll in rotation, a plurality of other calender rolls, a fixed frame, and mounting means connected to said frame for each of said other rolls permitting vertical movement and roll rota-

tion of each of said other rolls and holding said other rolls disposed in a generally vertical stack with said first roll so that the paper web may pass through the nips between said rolls and over and in contact with opposite sides of alternate ones of the intermediate rolls in the stack with said first roll supporting the weight of said other rolls and said first roll driving said other rolls due to the friction between the adjacent ones of the rolls and the web, said mounting means disposing said rolls so that alternate ones have their centers on one side of a vertical axis and the others have their centers on the other side of said axis with the sides of the rolls over which the web passes being remote from said axis and with the center of each said lower other roll being closer to said axis than the center of said other roll immediately thereabove in said stack.

2. In a calender for a paper web, a relatively large diameter calender king roll, means for mounting said roll to hold it axially fixed and permit it to rotate, means for driving said roll in rotation, a plurality of other smaller diameter calender rolls, a fixed frame, an arm swingably mounting each of said smaller rolls with respect to said frame to permit vertical movement and roll rotation of each of said smaller rolls and holding said smaller rolls disposed in a generally vertical stack with said king roll so that the paper web may pass through the nips between said rolls and over and in contact with opposite sides of alternate ones of the intermediate rolls in the stack with said king roll supporting the weight of said smaller rolls and said king roll driving said smaller rolls due to the friction between the adjacent ones of the rolls and the web, said arms disposing said smaller rolls so that alternate ones have their centers on one side of a vertical axis and the others have their centers on the other side of said axis with the sides of the smaller rolls over which the web passes being remote from said axis and with each of said smaller rolls below the uppermost in said stack having its center closer to said vertical axis than the smaller roll immediately thereabove and with said king roll having its center farther from said axis than the center of said smaller roll immediately thereabove in the stack.

3. In a calender for a paper web, a first calender roll, means for mounting said roll to hold it axially fixed and permit it to rotate, means for driving said roll in rotation, a plurality of other calender rolls, and mounting means for each of said other rolls permitting roll rotation and vertical movement of each of said other rolls and holding said other rolls disposed in a generally vertical stack with said first roll so that the paper web may pass through the nips between said rolls and over and in contact with opposite sides of alternate ones of the intermediate rolls in the stack with said first roll supporting the weight of said other rolls and said first roll driving said other rolls due to the friction between adjacent ones of the rolls and the web, said mounting means disposing said rolls so that alternate ones have their centers on one side of a vertical axis and the others have their centers on the other side of said axis with the sides of the rolls over which the web passes being remote from said axis, the distance that each of said rolls below the top roll is set off with respect to the roll immediately thereabove being determined by the relation

$$C\left(\frac{T+F}{N}\right)$$

where C is a constant, T is the tension of the paper web throughout the roll stack, F is the force driving the upper roll of the pair of rolls being considered and N is the nip pressure between the particular pair of rolls being considered.

4. In a calender for a paper web, a first calender roll, means for mounting said roll to hold it axially fixed and permit it to rotate, means for driving said roll in rotation, a plurality of other calender rolls, and mounting means for each of said other rolls permitting roll rotation and vertical movement of each of said other rolls and holding said other rolls disposed in a generally vertical stack with said first roll so that the paper web may pass through the nips between said rolls and over and in contact with opposite sides of alternate ones of the intermediate rolls in the stack with said first roll supporting the weight of said other rolls and said first roll driving said other rolls due to the friction between adjacent ones of the rolls and the web, said mounting means disposing said rolls so that alternate ones have their centers on one side of a vertical axis and the others have their centers on the other side of said axis with the sides of the rolls over which the web passes being remote from said axis, the distance in inches each of said rolls below the top roll is offset with respect to the roll immediately thereabove being determined by the relation

$$(R_K+R_L)\left(\frac{T_1+F_1}{N_{KL}}\right)$$

where R_K and R_L are the diameters in inches of the particular pair of rolls being considered, T_1 is the tension in pounds per lineal inch of the paper web throughout the roll stack, F_1 is the force in pounds per lineal inch driving the upper roll of the pair of rolls being considered and N_{KL} is the nip pressure in pounds per lineal inch between the particular pair of rolls being considered.

5. In a calender for a paper web, a first lower calender roll, journals for mounting said roll to hold it axially fixed and permit it to rotate, means acting on one of said journals for driving said roll in rotation, a plurality of other calender rolls each of which is smaller than said first roll, and mounting means for each of said smaller rolls permitting roll rotation and vertical movement of each of said smaller rolls and holding said smaller rolls disposed in a generally vertical stack with said first roll and above the first roll so that the paper web may pass through the nips between said rolls and over and in contact with opposite sides of alternate ones of the intermediate rolls in the stack with said first roll supporting the weight of said smaller rolls and said first roll driving said smaller rolls due to the friction between adjacent ones of the rolls and the web, said mounting means disposing said rolls so that each smaller roll has its center horizontally displaced with respect to a vertical axis passing through the roll just below it toward the side of the roll over which the web passes, the lowermost one of said smaller rolls being displaced farther from the vertical axis through said first roll than from the vertical axis through the said smaller roll immediately above this lowermost smaller roll in the stack.

6. In a calender for a paper web, the combination as set forth in claim 5, and means for driving a plurality of said rolls in the stack above said first calender roll.

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