APPARATUS FOR PLEATING PAPER

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This invention relates to a rotary pleater for pleating sheet material such as paper, and is capable of pleating such material accurately and at high speed.

Sheet material such as cloth and paper has been pleated heretofore by means of a reciprocating bar that pushes the material forward against a movable stop to form successively pleats, but the reciprocator pleater will not operate at high speed. It has also been proposed heretofore to use cooperating gears provided with inter-acting teeth to bend and pleat paper and other materials; but this toothed construction tends to stretch and tear paper.

The present invention contemplates a simple apparatus comprising cooperating feed rolls each having a plurality of longitudinally extending blades. The rolls serve to feed the material forward and the blades score the advancing material along the desired fold lines. The rolls also cause the material such as paper to bend at the fold lines, as it is pushed away from the rolls, to form the desired pleats. This apparatus is capable of forming the pleats accurately and at high speed without straining or damaging the paper.

More specifically, the primary feature of the present invention resides in a pair of cooperating feed rolls each having several blades extending lengthwise of the roll and projecting slightly from the roll surface. The blades of one roll are staggered in relation to the blades of the other roll so that the advancing sheet is scored first at one face and then at the other face by squeezing the sheet between a blade and a roll surface. Means are provided for retracting the movement of the scored sheet away from the feed rolls so that it will bend first in one direction and then the other, as it leaves the rolls, to form the pleats. The scored sheet such as paper always bends in a direction to compress the paper at the scored line, while the opposite face of the paper that is stretched during the bending action is not weakened by the scoring operation.

The feed rolls above mentioned as provided with the longitudinally extending scoring blades may be variously constructed. For example, these rolls may each have a smooth outer surface that backs up the paper sheet while it is being scored by a blade, or the backing rolls may be provided with slight depressions in which the paper is pressed by the scoring blades. Furthermore, these rolls may, if desired, be provided with annular ribs and grooves for forming narrow ribs lengthwise of the paper passing between the rolls.

The rotary pleater of the present invention was designed primarily to pleat porous paper used to filter gases such as air, and liquids such as engine lubricating oils. Such filter paper, in order to perform well, needs to be an uncalendered paper, as calendered rolls tend to gloss the surface of a sheet and close its pores. Furthermore, such filter paper should be sufficiently stiff when used in an air or oil filter to withstand the up-stream fluid pressure without collapsing in use. Also, such filter paper should have good filtering properties so that it will remove all dirt particles larger than a predetermined size and will function for a long time before it becomes so clogged with dirt that it needs to be replaced. As a result of these requirements, such filter paper is very different from relatively firm, strong, tough calendered paper, and the present rotary pleater was carefully designed to pleat uniformly, comparatively tender felt paper without cracking the paper or injuring its surface.

The present pleater is a precision machine in that it will operate to form pleats that are highly uniform as to height and fold, and will run at very high speed. For example, the reciprocating pleater above mentioned, when used to form paper pleats about one inch high, will not produce more than about 100 pleats per minute, whereas the present rotary pleater will produce the same size paper pleats at a speed of over 6000 per minute.

The above and other features of the present invention will be further understood from the following description when read in connection with the accompanying drawings; wherein,

Fig. 1 is a side elevation of a rotary pleating machine constructed in accordance with the present invention.

Fig. 2 is a top plan view of Fig. 1.

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 1.

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 1.

Fig. 5 is a sectional view taken on the line 5—5 of Fig. 2.

Fig. 6 is a side view of a portion of the machine illustrated in Fig. 1 showing the opposite side from that of Fig. 1.

Fig. 7 is a vertical sectional view through part of the cooperating feeding and scoring rolls and shows how the paper is scored.

Fig. 8 is a perspective view showing the paper after it has been pleated.

Fig. 9 is a modification showing the feed rolls as having shallow depressions that cooperate with the scoring blades.

Fig. 10 is a modification showing the feeding and scoring rolls as having annular grooves and ribs.

Fig. 11 is a longitudinal sectional view through part of the rolls of Fig. 10.

Fig. 12 shows the paper having the longitudinal ribs formed by the rolls of Fig. 10; and

Fig. 13 is a modification showing in end view the feeding and scoring rolls with one yieldingly mounted with respect to the other.

Referring to the embodiment of the invention shown in Figs. 1 to 8, the entire device may be mounted on a table or other supporting means which will support the machine at a desired distance from the floor. The machine is shown as having a base portion formed of an angle beam 10 which has the downwardly extending side walls 11. To this beam 10 is secured near one end thereof the uprights 12 and 13 adapted to support the feed rolls to be described. The upright 12 is shown as considerably wider than the upright 13, and these uprights are welded or otherwise secured to a base plate 14 that is rigidly fastened to the beam 10. Each upright 12 and 13 is provided with a bearing 15 in which the shaft 16 for a lower roll 17 rotates. The shaft 16 is power driven and is rigidly secured to the roll 17 mounted thereon.

The uprights 12 and 13 are each provided with an opening 18 in which a bearing block 19 is slidably mounted, and each block 19 is provided with a bearing member 20 in which the upper shaft 21 is journaled. An upper roll 22 is mounted upon and rigidly secured to the shaft 21. Each feed roll 17 and 22 is provided with several scoring blades 23 which are mounted in the roll to extend longitudinally thereof and they project a slight dis-
tance from the curved outer surface of the roll, so that when a sheet of paper P is advanced between these rolls, it will be periodically scored, as best shown in Fig. 7. It should be pointed out that the blades 23 of the upper roll are staggered with respect to the blades 23 of the lower roll so that the paper passing between the rolls 17 and 22 will be cut first at one face of the paper, and at the other, as will be apparent from Figs. 5 and 7. The blades 23 do not cut the paper but compress the same at the fold lines as shown and bend the paper initially in the direction in which it is to be further bent to form the desired pleat. It is desired to emphasize the fact that for best results the parallel edge of each blade on the point of separation is at a distance from the curved outer surface of the roll, so that when a sheet of paper P is advanced between these rolls, it will be periodically scored as shown in Fig. 7. In order to cause the scored paper to fold back and forth at the scored lines to produce the desired pleats, it is necessary to retard the travel of these pleats away from the rolls 17 and 22. When the machine is first started up and is rotating slowly, the operator may use his hand to retard the travel of these pleats away from the rolls along the lower guide bars 24; but as soon as a predetermined number of pleats have been formed, the desired resistance to the travel of these pleats along the guide lines 24 away from the feed rolls is secured, in the construction shown, by providing two or more weighted retarding plates, such as indicated by 32, and each of which may comprise a flat metal plate which is curved upwardly at its forward end as indicated in Figs. 33. This forward end is welded or otherwise secured to a pivot pin 33', the opposite ends of which are journaled in the supports 34 that are rigidly secured to the upper face of the bridge member 36. The arrangement is such that these retarding plates 32 may swing up and down to rest yieldingly upon the upper edge of the scored pleat F. The downward movement of these plates is preferably arrested by the stop rods 32'. In order to vary the pressure each of these pivoted plates 32 will exert upon the tops of the pleats, each plate 32 preferably has extending upwardly therefrom a post 35 on which any desired amount of disc-shaped weight 36 may be placed to rest upon such plate. Each weight 36 has a central hole adapted to receive the guide post 35. In this way the load upon each plate 32 may be varied as desired by varying the number of weights 36 placed thereon.

Each lower guide bar 24 is provided at its forward end with a blade 37 which projects into an annular recess 38 formed about the roll 17, and each upper bar 25 is provided with a similar blade 39 that projects into an annular recess 40 that encircles the upper roll 22. The purpose of these protruding blades 37, 39 is to prevent the advancing paper from clamping to the surface of a roll and following around a roll. The upper bar 25 as shown do not touch the pleats F, and their main function is to support the pivoted plates 32. The receiving end of the machine shown is preferably provided with a guiding apron 41 having the upstanding sides 42 and transverse bars 43. This construction is such as to guide the paper strip P to be pleated from a suitable source of supply.

It is desirable to make provision for adjusting one feed rod towards and from the other, to vary the feeding pressure exerted upon the sheet of paper P passing between the rolls and to accommodate paper of different thickness. This is accomplished, as shown in Fig. 1, by providing the shaft 26 of the upper roll in the sliding blocks 19 above described. These blocks at each side of the machine are continuously urged upwardly by a coiled spring 44, and upward movement of these blocks 19 under the pressure of the springs 44 is limited by the adjustable screws 45, having a knurled head, and the lower end of these are against the desired sliding blocks 19. Each screw is provided with a lock nut 46.

It is important to positively drive both rolls. In the construction shown the shaft 16 of the lower roll is provided with a V-shaped driving pulley 47 that has the driving belt 48. The shaft 16 has rigidly secured thereto a driving gear 49 which, through a train of gears, positively drives the upper feed roll 22 and also permits vertical adjustment of this roll. To this end, the gear 49 drives a laterally disposed gear 50 which is rotatably mounted on the upright 12 by a stub shaft 51. This gear 50 meshes with an upper gear 52 which is rotatably mounted on an adjustable shaft 53 supported by the upright 12. The gear 52 in turn meshes with and drives a gear 54 which is mounted upon the upper roll shaft 21. Since, as above stated, the present machine is a precision machine that operates to form pleats that are highly uniform as to height, it is found desirable to provide means whereby the gear 54 may be angularly adjusted through a small angle with respect to the shaft.
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21 it drives. This is important because as the space between the upper and lower feed rolls is varied, the angular position of the blade 23 with respect to a pair of lower blades 23 will be shifted slightly, with the result that successive pleats will not be of identical height. This can be corrected by adjusting the gear 54 very slightly in an angular direction with respect to its shaft 21, and the locking bolts 55 are provided to permit this angular adjustment of the gear. In the construction shown, the lower drive gear 54 is enclosed in the protecting housing 56.

As the accumulated pleats F travel lengthwise of the guide bars 24, they finally reach the discharge apron 57. It may be desirable to employ herringbone gears as the gears 49, 59, 52 and 54 to reduce back-lash between the rolls 17 and 22.

The pleating machine of the present invention may be employed to pleat paper or other sheet material, but was designed primarily to pleat at high speed porous filter paper used to form filter elements adapted to filter liquids, such as oil, or gases such as air. The paper P is, therefore, a selected paper having the desired porosity and is preferably treated with a resin such as phenol formaldehyde that serves to toughen the paper and increase thereto without seriously reducing its porosity. In order that the fluid to be filtered may enter between the filter pleats when they are pressed close together, it has been found heretofore desirable to provide such paper with pleat ribs and grooves extending longitudinally of the paper strip, as shown in Fig. 10, and in which the filter fluid may travel towards the fold of the pleated paper.

It has, therefore, been the practice heretofore to pass the long strip of filter paper between grooving rolls which will provide the same with shallow longitudinal grooves as the paper approaches the pleating machine. It is found, however, that the rolls used to provide these longitudinal grooves cause the paper to spread laterally somewhat, thus changing its width. To overcome this difficulty, it is desirable to provide cutters which will trim the side edges of the sheet so that it will have just the desired width as it approaches the pleating mechanism of the present invention. The longitudinal grooving rolls just mentioned should be driven in accurate timed relation with the feed rolls 17 and 22 so that both sets of rolls will advance the paper at the same speed. The cutters for trimming the sides of the sheet may be rotating cutters driven at high speed; they may be driven from the shaft 16 by pulleys 58 and 59.

The paper being pleated preferably contains, as above stated, a resinous material such as phenol formaldehyde and preferably is in a slightly moist condition when pleated, which facilitates the bending of the paper to form the pleats. The pleated paper upon leaving the discharge apron 57 preferably goes into a curing oven, not shown, that serves to heat-cure and set the resin of the paper. Such curing oven may have chains or aprons for advancing the pleats through the oven at a predetermined speed with respect to the speed at which the pleats are formed by the apparatus of the present invention. The shaft 16 is, therefore, shown as provided with a third pulley 60 which may be employed to drive the chains just mentioned of the curing oven at a desired speed with respect to the speed of the pleating machine of the present invention.

While in the apparatus shown and described the pleater serves to produce at high speed pleats that are highly uniform as to height, the apparatus contemplated by the present invention may be used to produce pleated paper having alternately high and low pleats, since all that is necessary to accomplish this is to change the position and number of scoring blades 23 provided in one roll with respect to the scoring blades 23 of the other roll. To change from pleats of one height to pleats of a different height, the rolls 17 and 22 should be replaced by other rolls having the blades 23 spaced apart a distance equal to twice the height of a pleat.

It will be seen from the foregoing that the advancing sheet of paper P is secured firmly by the pressure exerted by the blades 23 while the paper rests against the backing roll 17 or 22, and that the paper is scored in the direction in which the paper is to be bent, so that the score is always at the inside of the bend rather than at the outer radius of the bend. This is desirable because as a result of this construction the paper is not weakened at the curved outer surface of the bend where the strain is most severe.

While the pleating rolls above described do an excellent job in pleating comparatively soft paper which has not been calendered, its scoring pressure on relatively firm paper may injure such paper. Therefore, in working with a firm compact paper, it may be desirable to use the modified construction shown in Fig. 9 and wherein the scoring blades press the paper into shallow recesses.

Now referring to Fig. 9, the paper P' is shown as having the slight ribs R extending longitudinally thereof. This paper is shown as being acted upon by the cooperating feeding and impeding rolls 61 and 62. Each of these rolls has the longitudinally extending scoring blades 63, and these rolls operate the same as rolls 17 and 22 to score the paper, except that the rolls 61 and 62 are provided with the shallow longitudinally extending recesses 64 positioned to cooperate with the blade 63 as shown. The scoring blades 63 act to deflect the paper P' into the recesses 64 as shown in Fig. 9 to form the fold lines of the pleats, without the necessity of forcing the blades deep into the paper structure. By using the construction of Fig. 9 a firm paper can be pleated in accordance with the present invention without injuring the paper sheet. If desired, instead of providing each roll with the recess 64, the rolls 61 and 62 may be provided with inserted rubber blocks, not shown, positioned to yieldingly receive the pressure of a blade 63 against a roll.

The modified construction shown in Fig. 10 comprises cooperating feed rolls 65 and 66 having extending longitudinally thereof the scoring blades 67. These rolls 65 and 66 operate the same as rolls 17 and 22 except that the rolls of Fig. 10 are provided with the annular ribs 68 and grooves 69, as shown in Fig. 11, and which act to impart to the sheet of paper P' the longitudinally extending ribs 70 (see Fig. 12). It will be seen that the rolls of Fig. 10 perform the double function of providing the paper with longitudinal ribs and with transverse pleats as shown.

The apparatus of the present invention was, as above stated, designed primarily to pleat a porous uncalendered paper. Such paper is likely, in a single sheet, to vary considerably in thickness throughout its length, so that if a thick section of a running sheet should pass between rolls 17 and 22, the blades 23 would score this portion of the paper deeper than desired. To avoid this difficulty it may be desirable to employ the modified construction of Fig. 13 and wherein spring means are provided to permit one roll to move away from the other when the pressure between them becomes excessive. The construction shown in Fig. 13 has the feed rolls 71 and 72 that may be identical in construction and operation to rolls 17 and 22, except that roll 72 can move upwardly slightly when the pressure on the paper becomes excessive. In this view are shown the uprights 73 which are provided at each end of the rolls. These uprights at each end of the rolls have a fixed bearing block 74 and a sliding upper bearing block 75. The distance between these blocks can be varied by moving the sliding wedge 76 between them in the direction of its length. Each sliding upper block 75 is continuously urged downward by a coiled spring 77 and the pressure exerted by each spring may be varied by adjusting the bolt 78 that presses downward on such spring. The springs 77 will serve not only to
relieve excessive pressure upon the paper passing therebetween, but may be employed also to maintain sufficient pressure between the rolls to insure a positive feed of the paper at all times. To accomplish this, the wedges should be backed off from between the blocks enough to permit the rolls to grip firmly between them the thinnest paper passing therebetween.

The apparatus of the present invention, while very simple in construction, produces highly uniform paper pleats at high speed. Furthermore, the mechanism of the present invention will pleat uncalendered filter paper having felt-like properties, without stretching the paper or scuffing its surface, or otherwise changing the porosity of its filter web.

Having thus described our invention, what we claim and desire to protect by Letters Patent is the following:

1. Apparatus for pleating an advancing sheet of filter paper, comprising a pair of feed rolls each having a sheet engaging outer surface, scoring blades extending longitudinally of the rolls and protruding slightly from the roll surface in staggered relation to one another so that when the rolls are rotated they continuously engage and advance the sheet and score it at first one face and then the other, a guide way for the pleated sheet delivered by the rolls, and means for retracting the advancing movement of the pleats along the guide way to thereby cause the paper to bend back and forth near the rolls at the score lines.

2. Apparatus as in claim 1 wherein the sheet material is compressed by the blade to reduce its thickness along the score lines.

3. Apparatus as in claim 1 wherein the sheet material is scored by pressing it between a scoring blade of one roll and a smooth backing surface of the other roll.

4. Apparatus as in claim 1 wherein the nip of the two rolls serves to pull the sheet forward to the rolls.

5. Apparatus as in claim 1 wherein loaded weights constitute the means for retracting the advancing movement of the pleats along the guide way.

6. Apparatus as in claim 1 wherein the sheet is folded in a direction to compress the sheet material along the scored line.

7. Apparatus for pleating an advancing sheet of uncalendered filter paper, comprising a pair of feed rolls each having a paper gripping surface and each having several scoring blades extending lengthwise of the roll and protruding slightly from the roll surface, the blades of one roll being staggered relatively to the blades of the other roll so that when the rolls are rotated they will continuously grip and advance the paper and score it at first one face and then the other, and means for retracting the movement of the scored paper away from the rolls so as to cause it to bend back and forth along the scored lines and form pleats.

8. Apparatus for pleating an advancing sheet of uncalendered paper, comprising a pair of feed rolls geared together and each having scoring blades extending lengthwise thereof and protruding slightly from the roll surface in staggered relation to one another so that the rotating rolls will continuously grip and advance the sheet and score it at first one face and then the other, means for retracting the movement of the scored sheet away from the rolls so as to cause it to bend back and forth along the scored lines to form pleats, and one of said rolls having a gear that can be adjusted angularly relatively to such roll so as to vary the angular position of the blades of one roll to the blades of the other roll.

9. Apparatus for pleating an advancing sheet of uncalendered paper, comprising a pair of feed rolls having cooperating paper advancing surfaces, each roll having several scoring blades extending lengthwise thereof and protruding slightly from said surface, the blades of one roll being staggered relatively to the blades of the other roll so that when the rolls are rotated they will score the paper at first one face and then the other, said rolls having annular grooves and recesses to form ribs lengthwise of the paper, and means for retracting the travel of the scored paper away from the rolls so as to cause it to bend back and forth along the scored lines to form pleats.

10. Apparatus for pleating an advancing sheet of uncalendered paper, comprising a pair of feed rolls having cooperating paper advancing surfaces, each roll having several scoring blades extending lengthwise thereof and protruding slightly from said surface, the blades of one roll being staggered relatively to the blades of the other roll so that when the rolls are rotated they will score the paper at first one face and then the other, and means for retracting the travel of the scored paper away from the rolls so as to cause it to bend back and forth along the scored lines to form pleats.

11. Apparatus for pleating an advancing sheet of uncalendered paper, comprising a pair of feed rolls having cooperating paper advancing surfaces, each roll having several scoring blades extending lengthwise thereof and protruding slightly from said surface, the blades of one roll being staggered relatively to the blades of the other roll so that when the rolls are rotated they will score the paper at first one face and then the other, means for yieldingly pressing one roll towards the other so that the distance between the rolls can increase, and means for retracting the travel of the scored paper away from the rolls so as to cause it to bend back and forth along the scored lines to form pleats.

12. Apparatus for pleating an advancing sheet of filter paper so as to produce pleats that are highly uniform as to height and fold formation; comprising a pair of smooth surfaced cylindrical feed rolls each having scoring blades extending lengthwise of the roll and arranged to protrude from the roll a distance substantially less than the thickness of the paper to be pleated, said rolls being positioned so that the blades of one are staggered relatively to the blades of the other and each blade serves to press the paper against the other roll to compress the roll along the line of fold, means for rotating the rolls so that the paper is continuously gripped and advanced by the nip of the rolls along a guide way, and means for retracting the movement of the pleats along the guide way to thereby cause the paper to bend back and forth at the scored lines and form successive pleats.

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