A still further object of the invention is to provide an improved web splitting mechanism wherein the relative thicknesses of layers separated from the web can be uniformly controlled.

A further object of the invention is to provide an improved sheet splitting mechanism receiving individual sheets of paper and splitting the sheets accurately.

Techniques have heretofore been developed to obtain the parallel sectioning of paper but have not been wholly satisfactory. These have included, for example, the use of a razor blade, grinding off layers with fine Carborundum paper, peeling off successive layers with adhesive tape and by parallel sectioning with a microtome. The present arrangement is capable of high speed and continuous parallel sectioning of paper webs and sheets and is capable of accurately controlling the thickness of these sections.

The present invention involves a mechanism and a process in which a wetted paper web is divided in the plane of the sheet by progressively freezing the outer surface of the sheet to smooth surfaces in a dynamic process and splitting the sheet in an interior plane in a zone which has not been frozen by the advancing ice fronts created due to the temperature of the sheet being reduced starting at its outer surfaces.

Other objects, advantages and features will become more apparent with the teaching of the principles of the present invention in connection with the disclosure of the preferred embodiments thereof in the specification, claims and drawings, in which:

FIGURE 1 is a side elevational view of a web splitting mechanism embodying the principles of the present invention;

FIGURE 2 is a top plan view of the mechanism of FIGURE 1;

FIGURE 3 is a side elevational view of a sheet splitting mechanism embodying the principles of the present invention;

FIGURE 4 is a top plan view of the mechanism of FIGURE 3; and

FIGURE 5 is a fragmentary sectional view taken substantially along line V—V of FIGURE 4.

On the drawings:

The method and apparatus shown in FIGURES 1 through 5 embodies freezing the sides of a wetted or water-soaked sheet to the surfaces of two metal rolls, cooled below the freezing temperature of water and rotating with a pressure or spring-loaded nip. The wet sheet, introduced into the roll nip, is split internally into two frozen sections on the outgoing side of the nip with the rolls being rotated at a rate which is related to the temperatures of the roll surfaces so that the splitting occurs as a dynamic process in which the interior plane of the splitting takes place in a zone which has not been frozen by the advancing ice fronts produced by the splitting rolls. The split sections are doctored from the rolls and the split sections in turn can be re-split until the sections become too thin for a uniform split. The rolls are cooled to a point below 32°F.

In the arrangement of FIGURES 1 and 2, a pair of hollow smooth surfaced cylindrical metal rolls 10 and 11 form a web receiving nip N therebetween. A web W is received by the nip, with the rolls rotating in the direction indicated by the arrowed lines. The web W may be of any type which is to be split into layers, such as a paper web which is in plies or laminated of different types of stock which must be separated so that the different layers are used in separate pulping batches. The web also may be of a layer of pulp and a layer of plastic or other sheeting. In each instance the moisture content of the web will be known and it can be predetermined as to the nip pressure and roll temperature required to cause the
surfaces of the web to freeze and adhere to the surfaces of the rolls 10 and 11. The temperature of the rolls 10 and 11 and the speed of rotation thereof are interdependent factors which are related so that a roll surface speed is chosen which gives the web adequate time in the nip to freeze to the roll surface. As higher speeds of operation are sought, lower temperatures are provided for more rapid freezing. The moisture content of the web is also a factor and the nip pressure must be such that adequate contact pressure is afforded between the roll surface and web so that the moisture within the web will be in surface contact with the roll to form frozen crystals which adhere to the roll surface.

The roll 10 is supported on end bearings 12 and 13, FIGURE 2, and the roll 11 is supported on end bearings 14 and 15. As shown in FIGURES 1 and 2 the rolls are supported on a stand 16 which has upright supports 17 for the bearings 12 and 13. Also on the stand are end supports 18 for the bearings 14 and 15. The support 17 is shown rigidly secured at its base to the stand 16, and the supports 18 are rigidly supported by their lower ends so as to permit a slight difference in spacing between the axes of the rolls as the nip pressure is changed.

For driving the rolls a drive gear 19 is driven by suitable power means, not shown, which may be provided with a variable speed control so as to obtain the nip speed desired. The drive gear 19 drives gears 20 and 21 respectively connected to shafts 22 and 23 for the rolls 10 and 11. Flexible drives 24 and 25 are provided to accommodate slight changes in the relative positions of the axes of the rolls 10 and 11.

Suitable means are provided for biasing the rolls together to control the nip pressure, as shown by turnbuckles 26 and 27 which have the usual central adjuster with travelling nuts at the ends connected to the uprights 17 and 18.

The web W passes down into the nip N and its split forming layers W-1 and W-2 which are separated from the rolls 10 and 11 at a location following the off-running side of the nip N. As illustrated adjustable doctor blade mechanisms 26 and 27 are provided having a doctor blade edge which engages the surface of the rolls 10 and 11 and separates the web layers W-1 and W-2. The layers are received by suitable means such as wind-up rolls.

For cooling the rolls 10 and 11 to a temperature below the freezing temperature of the moisture in the web W, refrigerating liquid such as brine is directed into the rolls through refrigerating liquid supply pipes 28 and 29, the liquid flows into the hollow rolls 10 and 11 through distribution pipes 30 and 31 which extend coaxially into the rotating rolls 10 and 11. The pipes 30 and 31 may emit the refrigerant liquid at their open ends or may be provided with perforations along their length.

For removing the refrigerating liquid return lines 34 and 35 are provided. The supply and return lines connect to the rolls 10 and 11 through rotary fittings 32 and 33 which permit the continual recirculation of liquid during rotation of the rolls 10 and 11.

The refrigerating liquid is led through suitable piping to refrigerating coolers 36 and 37. The liquid is circulated such as by pumps 40 and 41. The lines are provided with temperature controls 38 and 39 which maintain the temperature in the rolls 10 and 11 at the desired degree. Automatic temperature controls may be provided by providing surface contacting temperature measuring devices, not shown, connected to the temperature controls 38 and 39.

Control of the relative thicknesses of the layers which adhere to the rolls 10 and 11 can be regulated by the relative speeds of the rolls. If the porosity of the layers of the web is different it may be necessary to have a temperature differential between the rolls 10 and 11 for obtaining the proper splitting of the web at the correct location. Also, if a non-uniform split is to be accommodated, and a heavier layer is to be removed by one roll than the other, its temperature may be lowered so that the depth of freezing is deeper than for the other roll. Temperature control may also be used where the layers removed are different such as where a plastic layer is to be removed from the layer of paper web.

It is also contemplated that the moisture of the web W may be controlled as by providing sprays for the web in advance of the nip N. For example where a plastic sheet is to be removed from the paper web, it may be desirable to moisten the surface of the plastic such as by positioning a light vapor spray adjacent the plastic surface in advance of the nip N.

In operation a continuously travelling web W is fed from a supply into the nip N between the rolls 10 and 11 which are cooled to a temperature below the freezing point of the moisture in the web. The layers of the web will adhere to the surface of the rolls and will split, and the layers W-1 and W-2 are separated from the rolls such as by doctor blades 26 and 27. Various separating means may be used and the drawings illustrate pivotally supported doctor blades mounted on pivots 26a and 27a and weights pivoted at their lower ends so as to maintain contact with the roll surfaces due to counterweights 26b and 27b of the blade assemblies.

In the arrangement of FIGURES 3 through 5 splitting rolls 50 and 51 are mounted parallel to provide a nip N therebetween. The roll 50 is supported on journals 52 and 52a at the ends mounted in suitable bearings 54 and 55. The roll 51 is supported on journals 53 and 53a carried in bearings 54a and 55a.

Since the rolls are of substantially identical construction, only the roll 50 need be described in detail and is shown in FIGURE 5 as being hollow. In some instances the chamber 56 therein may be filled with a heat transfer liquid such as methyl alcohol. Within the chamber is a heat transfer cooling liquid coil 57 and liquid is circulated therein by supply and return lines 61 and 62 which extend through the hollow extension 65 of the journal 52b. Methyl alcohol may be used as the heat transfer liquid within the coil 57.

The rolls are driven by a sprocket 58, driven by a chain 63, FIGURES 3 and 4, which is driven by a drive sprocket 64. The rolls rotate at the same speed being interconnected by gears 59 and 59a.

The interior chamber 56 of the roll is closed by a seal 60 permitting rotation and preventing leakage of the liquid therein. Temperature determination and temperature control of the roll can be determined by heat sensitive member 64 projecting into the chamber 56 engaging the coil 57 and measuring the temperature of the coolant leaving the coil 57, and the temperature indicator 65. The member 64 may also be arranged to measure the temperature of the space within the roll, or the roll surface. Temperature indicators may be provided for each of the rolls and maintain the same by controlling the flow of coolant through the roll 58 and the roll 51 through suitable valving arrangements, not shown, and if desired automatic control mechanism may be provided.

As above described, the temperature of the rolls is related to their speed of rotation so that freezing of the water within the rolls progresses to the center by the time the sheet leaves the nip so that the sheet is split internally along a plane at a zone which has not been frozen between the advancing ice fronts from the two roll surfaces. By maintaining one roll colder than the other it is possible to obtain different temperatures with a temperature or, in other words, to divide the sheet into layers of different thicknesses.

The rolls have a polished surface preferably with a finish of about 10 microns. The rolls are of stainless steel, and the nip pressure of about 3.0 pounds per linear inch is achieved although this may be varied. The web is scraped off with a doctor blade which may be of ordinary steel creping doctor stock, and the doctor is loaded against the rolls with about 4
5 pounds per linear inch nip pressure. It is important to keep the doctor blades sharp, and so long as they remain sharp the frozen sections are doctored off the rolls cleanly and with a clean roll cylinder edge. The doctor blades, with the doctors being shown at 84 and 85.

Exit temperatures of the coolant from the coils 57 are preferably held between 25° and 30° F. The temperature of the roll surface is substantially the same as the liquid exit temperature in most installations. For all installations the temperature should be controlled so that the surface of the roll is between 25° and 30° F., although lower temperatures can be used in special circumstances. For example in splitting a full thickness of a sheet of newsprint, a linear roll surface speed of 1.8 inches per second may be used with a coolant exit temperature of 23° F. and to split a one-half section of newsprint into one-fourth sections, the speed must be increased to 3.6 inches per second. To split a one-fourth section into one-eighth sections, a speed of 7.2 inches per second is used. Thus with a fixed temperature the proper splitting effect may be obtained by controlling the roll speed.

The mechanism for receiving the portion of the sheet split by the roll 51 is also carried on the bell crank 67. The mechanism for splitting the sheet so that the sheets are interleaved is shown in FIGURES 5 through 11.

As shown in FIGURES 3 through 5, the bearings 54a and 55a for the roll 51 are movably mounted in a bell crank support 67 supported on a pivot support shaft 66 on the frame 65. Nip pressure is obtained by applying a force to a lower arm of the bell crank 67 by a coil compression spring 68 compressed by an adjustable nut 69 on a pivotally mounted bolt 70 on the frame 65.

The mechanism for receiving the portion of the sheet split by the roll 51 is also carried on the bell crank 67.

The sheets are received by trays 79 and 80 located immediately following the sharp doctor blades 84 and 85. The trays are pivoted on bosses 81 and 82 with the tray 80 being pivoted by a pivot handle 83. The trays are held in place and the doctor blades are held against the rolls 50 and 51 by tension springs 88 and 89.

Cleaning doctors 86 and 87 engage the rolls following the sheet separating doctors, and these cleaning doctors remove particles of pulp which may adhere to the surface of the rolls and remove ice crystals which may tend to form. The cleaning doctors are held against the rolls by coil tension springs 92 and 93, and the doctors are pivoted on their shafts 90 and 91.

For delivering individual sheets up into the nip 50 so that they enter uniformly and to avoid the need for hand feeding tray 72 is supported on a pivotal arm 71 mounted on a shaft 73. The sheet 54 is swung with its leading edge up into the nip 50 when the arm 71 is pivoted by moving a handle 74 downwardly. The tray 72 is of a length such that the leading edge of the sheet 54 projects to be received by the nip 50. The tray is releasably held in its lowered position by a latch including a latch member 76 on the tray and a pivotal latch member 75 held in latching position by a torsion spring 77. The latch is pivotally supported on a bracket 78.

Thus it will be seen that we have provided an improved web splitting mechanism which meets the objections, advantages and features above set forth. The device may be in the form of separate platens or other members having web or sheet engaging surface areas and the illustrated arrangement utilizing rolls is desired because of being able to obtain continuous operation at relatively high surface speeds.

The drawings and specification present a detailed disclosure of the preferred embodiments of the invention, and it is to be understood that the invention is not limited to the specific forms disclosed, but covers all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by the invention.

We claim as our invention:
1. A mechanism for separating layers of laminated web comprising,
a pair of chilled cylindrical rolls forming a web receiving nip therebetween,
means for cooling the surfaces of said rolls to a temperature below the freezing point of moisture in the web,
means for rotating the rolls so that the web will be drawn into said nip and opposed surfaces will be frozen to the surfaces of the rolls, and
means for removing the separated layers of the web from the rolls after the web has passed through the nip.

2. A mechanism for separating layers of laminated web comprising,
a pair of chilled cylindrical rolls forming a web receiving nip therebetween,
means for cooling the surfaces of said rolls to a temperature below the freezing point of moisture in the web,
means for rotating the rolls so that the web will be drawn into said nip and opposed surfaces will be frozen to the surfaces of the rolls, and
means for removing the separated layers of the web from the rolls after the web has passed through the nip.

3. A mechanism for separating layers of laminated web comprising,
a pair of chilled cylindrical rolls forming a web receiving nip therebetween,
means for cooling the surfaces of said rolls to a temperature below the freezing point of moisture in the web, and
means for removing the separated layers of the web from the rolls after the web has passed through the nip.

4. A mechanism for separating layers of laminated web comprising,
a pair of chilled cylindrical rolls forming a web receiving nip therebetween,
means for cooling the surfaces of said rolls to a temperature below the freezing point of moisture in the web, and
means for removing the separated layers of the web from the rolls after the web has passed through the nip.

5. A mechanism for separating layers of laminated web comprising,
means for cooling the surfaces of said rolls to a temperature below the freezing point of moisture in the web, and
means for removing the separated layers of the web from the rolls after the web has passed through the nip.

6. The method of splitting moist paper sheets which comprises,

sandwiching a moist sheet between a pair of metal members which are cooled below the freezing point of moisture in the sheet,
allowing each side of the moist sheet to be frozen to its respective metal member, and parting the metal member thereby splitting the sheet.

7. The method of separating layers of a laminated moist web comprising the steps, passing the web through a nip formed between a pair of smooth rolls rotated at the same surface speed and urged together to form a pressure nip, cooling the rolls to below the freezing point of the moisture in the web and freezing the surfaces of the web to the surfaces of the rolls, and separating the separated layers of the web adhered to the surface of the rolls from the surface of the rolls following the nip.

8. A mechanism for separating layers of laminated moist paper web comprising, first and second smooth surfaced hollow rolls forming a pressure nip therebetween, a stand for said rolls having a fixed first support for the first roll having roll support bearings and a second support for the second roll having roll support bearings and being movable for adjusting nip pressure, a turverbuckle adjuster at the ends of the rolls connected between the supports for drawing the supports together and increasing nip pressure, a drive for said rolls for driving the rolls at the same surface speed, flexible drive shaft means extending between the drive and each of said rolls for accommodating adjustment of the roll axes with adjustment of nip pressure, first and second doctor blades respectively for the rolls positioned after the off running side of the nip for separating layers of the web from the rolls, a refrigerant inlet leading into each of said rolls for cooling the rolls below the freezing temperature of moisture in the web, and a refrigerant outlet for each of the rolls so that the refrigerant can be recirculated and the rolls maintained at the temperature below the freezing point of the moisture in the web.

9. A mechanism for separating layers of laminated web comprising, first and second chilled cylindrical rolls forming a web receovving nip therebetween, means for rotating the rolls so that the web will pass through said nip, means for cooling the rolls to a temperature below the freezing point of the moisture in the web so that the web will freeze and adhere to the surfaces of the rolls, means for removing the separated layers of the web from the rolls after the nip, and means for controlling the relative temperatures of said first and second rolls so that the thickness of the layers of the web adhering to each of said rolls can be controlled as a function of the temperature of the rolls.

10. The method of splitting a web into layers of controlled thickness which comprises, engaging opposing surfaces of the web with members having surface areas, cooling each of said surface areas to a predetermined temperature and decreasing the temperature of one of said areas relative to the other area for increasing the thickness of layer which will adhere to said area, and separating said areas for splitting the web.

11. A mechanism for separating layers of sheets comprising, a pair of chilled cylindrical rolls forming a sheet receiving nip therebetween, means for cooling the surface of said rolls to a temperature below the freezing point of moisture in the sheet, means for rotating the rolls so that the sheet will be drawn into said nip and opposed surfaces will be frozen to the surfaces of the rolls, means for removing the separated layers of the sheet from the rolls after the sheet has passed through the nip, and means for carrying a sheet up into the nip.

12. The method of separating layers of a sheet comprising, cooling the exposed surfaces of the sheet to a temperature below the freezing point of moisture in the sheet so that the temperature drops beginning at the outer surfaces thereof so that ice fronts progress inwardly from the outer surfaces of the sheet, and immediately separating the sheet drawing the layers outwardly when the ice fronts reach a zone intermediate the outer surfaces of the sheet but before the ice fronts meet.

13. The method of continually separating layers of a sheet progressively along the sheet which comprises, chilling the sheet from the outer surfaces thereof in a cooling zone which is moved progressively along the sheet so that an ice front advances inwardly into the sheet and longitudinally along the sheet, and progressively splitting the sheet along an inner zone progressing longitudinally with said zone located between the advancing ice fronts.

14. The method of separating layers of a sheet comprising, the steps of wetting the sheet and obtaining substantially uniform moisture content throughout, passing the sheet through a nip formed between a pair of smooth rolls rotated at the same surface speed and urged together to form a pressure nip with the rolls being cooled below the freezing point of the moisture, and separating the separated layers of the sheet on the outgoing side of the nip between the rolls.

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ANDREW R. JUHASZ, Primary Examiner.