Abstract: The invention relates to a system in a dryer section of a web forming machine for guiding a fabric (12) and further the web (14) with guide rolls (16). Of the guide rolls (16), at least one is covered by the web (14) supported by the fabric (12) for less than 90°. In addition, at least one guide roll (16) covered by the web (14) for less than 90° is a grooved roll (22). In the cross direction of the web forming machine, the grooved roll (22) has adjacent grooves (24), which grooves (24) are separate vacuum zones over the area covered by the web (14). The grooved roll (22) is adapted as such to create a vacuum.
The invention relates to a system in a dryer section of a web forming machine for guiding a fabric and further the web with guide rolls, of which guide rolls the web supported by the fabric covers at least one of the roll less than 90°.

Patent publication FI 102623 is known in prior art. This patent publication proposes a system in which paper is dried with an impingement unit included in a web forming machine. The impingement unit controls the fabric and the web with guide rolls as desired. The fabric and indirectly the web touch the guide rolls located at the impingement unit for less than 30°. The last guide roll in the impingement unit is a suction roll from which the web is transferred to the following drying unit. The fabric and indirectly the web touch the suction roll placed as the last guide roll of the impingement unit for less than 90°.

Also known in prior art is patent publication FI 20002429. This patent publication proposes a vertical impingement unit in which the fabric and indirectly the web touch the guide rolls located at the vertical impingement unit for less than 30°. The drying units proposed in publications FI 971714 and US 4361466 also include guide rolls which are touched by the web for less than 30°.

In impingement units known in prior art, the fabric and the web travel between dryer cylinders as a common straight run. Thus a closing gap is formed between the fabric and the guide roll onto which the fabric arrives. The web, fabric and dryer cylinder surface moving towards this gap generate an overpressure in the closing gap via the boundary layer flows conveyed by them. The overpressure in the closing gap causes a pressure difference over the fabric and the web, which creates runnability
problems. Increasing web speeds increase the overpressure problems of the closing gap even more.

For keeping the fabric and the web in connection with the guide rolls, i.e. for removing the overpressure generating in the closing gap, suction rolls are used as guide rolls. Suction roll surfaces are perforated or grooved in order that the aspiration brought inside the suction roll is evenly distributed on the surface of the suction roll shell. The suction roll is typically a sector suction roll in which case the aspiration is conveyed through it only to the desired sector. The use of a sector suction roll requires a smaller airflow than a suction roll aspirating over its entire shell surface. The overpressure peak is removed also with suction boxes and by combining suction boxes and suction rolls. These devices, however, need an intensive vacuum or an airflow for which remarkable amount of energy is required in producing them. Costs produced by energy are very significant. In addition, suction rolls soil and they are difficult to clean. Suction rolls also include wearing parts, such as seals.

Patent publication FI 105573 proposes a roll in which an open surface structure is connected in an open manner to the roll journal with support components. In this publication, the roll is proposed to be used as a turning roll in connection with the single-fabric run of a paper machine dryer section, in which case the roll creates an airflow between it. The fabric and indirectly the web touch the turning roll typically for about 220°. More generally, the fabric and indirectly the web touch the turning roll for more than 180°.

Patent application FI 20031461 proposes a roll which is a grooved roll with deep grooves. The roll's open surface structure is connected to the roll journal in a closed manner. In the publication, the roll is proposed to be used as a turning
roll in connection with the single-fabric run of a paper machine dryer section, in which case the roll creates a "vacuum in the wrap area of the fabric and web. The fabric and indirectly the web touch the turning roll typically for about 220°. More generally, the fabric and indirectly the web touch the turning roll for more than 180°.

The object of the invention is to provide a system which can reduce the energy consumption of a web forming machine. The characteristic features of this invention are that at least one guide roll which is covered by the web for less than 90° is a grooved roll, and in the cross direction of the web forming machine, the grooved roll has adjacent grooves, which are separate pressure zones, i.e. vacuum zones, over the area covered by the web. The grooved roll is adapted as such to create a vacuum. The pressure zones in the grooved roll are vacuum zones, since the grooved roll creates a vacuum efficiently in the fabric and web wrap area.

In the dryer section of a web forming machine, i.e. a fiber web forming machine, which expression comprises here the drying applications of a paper machine line, the fabric and further the web are guided with guide rolls. The web forming machine, i.e. a fiber web forming machine, refers to paper, board, tissue and pulp machines. The web covers at least one of the guide rolls for less than 90°. In addition, at least one guide roll that is covered by the web for less than 90° is a grooved roll. The grooved roll has adjacent grooves in the cross direction of the web forming machine. Such a grooved roll is adapted to create a vacuum. Vacuum is generated when the grooves are side by side in the cross direction of the web forming machine and no walls exist perpendicularly to the rotation direction. The grooves are separate vacuum zones over the area covered by the web. When the grooves are separate vacuum zones in the area covered by the web, the grooves are not connected to each other
through the inner constructions of the grooved roll. When the grooves in the grooved roll are not open to the inner constructions of the grooved roll, the grooved roll can efficiently create a vacuum in the wrap area. That is, the grooved roll is adapted as such to create a vacuum. Surprisingly it has been detected that in a grooved roll with deep grooves, even a very small wrap by a fabric-supported web helps the roll generate a vacuum in the wrap area. Vacuum is created in connection with the grooved roll both in the opening and the closing gap. In this case Vac rolls, in which the vacuum to be created in connection therewith uses a remarkable amount of energy, can be replaced with grooved rolls. In addition to energy consumption, cleaning of grooved rolls is notably easier than Vac roll cleaning. Grooved rolls can also be implemented with a lighter design than before. Consequently, in connection with a grooved roll, it is also possible to exclude the drive of a guide roll, when the web-supported fabric covers the guide roll for over 2°. In other words, at least one guide roll, which is a grooved roll, is non-driven. Non-driven guide rolls, in turn, enable simpler and more reliable implementation of guide rolls than before.

The operation of the grooved roll and the Vac roll has been compared in grooved roll trials. Trial runs have shown that when using a grooved roll according to the invention, the web keeps more tightly attached to the fabric surface in connection with a guide roll than in connection with a Vac roll with a corresponding fabric wrap, although the Vac roll has a vacuum. Measured at the vacuum connection, the vacuum of the Vac roll is multiple compared to the vacuum generated by the grooved roll under the fabric.

When the grooves are separate pressure zones, more specifically vacuum zones, in the area covered by the web, the grooves are not connected to each other through the inner constructions of
the grooved roll. For example, in Vac rolls that are used in publications FI 971714 and US 4361466 according to the mentioned prior art, the grooves are not separate vacuum zones since the grooves are connected to each other through the roll's inner construction. The shell of Vac rolls includes low grooves with holes at the bottom for directing the vacuum present inside the Vac roll to the web. The grooves included in the Vac rolls do not, however, generate a pressure, but the pressure is directed from inside the roll uniformly to the fabric and further to the web. Nor are the grooves in the roll proposed in publication FI 105573 separate pressure zones, since the roll's surface structure is connected to the roll journal in an open manner using support components. Thus the grooves are connected to each other through the inner structures of the roll, and the grooves belong to the same vacuum zone. The vacuum generation capability of the roll proposed in publication FI 105573 is remarkably low compared to a grooved roll with deep grooves used in the system according to the invention.

In one embodiment, the system includes a runnability component between two guide rolls, of which at least one is a grooved roll. The guide rolls, between which the runnability component is included, are on the same side of the fabric-supported web. The runnability component enables an extensive area of influence for the vacuum. Advantageously, the runnability component located in connection with the grooved roll is passive. With a passive runnability component, the vacuum created by the grooved roll in the area of the fabric-supported web wrap can be extended to between the two grooved rolls.

The invention is described below in detail by making reference to the enclosed drawings, which illustrate some of the embodiments of the invention, in which
Figure 1 shows the system according to the invention,
Figure 2 shows a grooved roll used in the system according to the invention including three groove zones,
Figure 3 shows a grooved roll used in the system according to the invention, in which the adjacent grooves are separate vacuum zones,
Figure 4 shows the system according to the invention provided with a runnability component located between a grooved roll and a conventional guide roll,
Figure 5a shows the system according to the invention provided with a runnability component,
Figure 5b shows the system according to the invention provided with a runnability component,
Figure 5c shows the system according to the invention provided with a runnability component,
Figure 6 shows the system according to the invention in a vertical impingement unit,
Figure 7 shows the system according to the invention provided with an active runnability component,
Figure 8 shows the system according to the invention provided with a semi-passive runnability component,
Figure 9 shows the system according to the invention provided with a passive runnability component,
Figure 10 shows one embodiment of the system according to the invention provided with several grooved rolls and, between these, passive runnability components,
Figure 11 shows the system according to the invention provided with a passive runnability component which includes a flow channel,
Figure 12 shows a grooved roll used in the system according to the invention, which includes several separate zones in the cross direction of the web forming machine, and
Figure 13 shows the system according to the invention in which a grooved roll with several separate zones is used.
Figure 1 illustrates the system 10 according to the invention for guiding a fabric 12 and further a web 14 supported by the fabric 12 in the dryer section of a web forming machine. The fabric 12 and further the web 14 are guided with guide rolls 16 of which guide rolls 16 at least one guide roll 16 is covered by the web 14 for less than 90°. In other words, the web covers at least one guide roll for 1° - 90°. The guide roll 16 is a roll which is used to guide the web 14. Support rolls 20 are used in turn to support the fabric 12 to form a fabric loop 18.

The fabric 12 is located between the web 14 and the guide roll 16. That is, the web 14 does not cover the guide roll with a direct contact. In addition, at least one guide roll 16 that is covered by the web 14 for less than 90° is a grooved roll 22. The grooved roll has adjacent grooves in the cross direction of the web forming machine, the width of which is at least 10 mm, advantageously at least 20 mm, and the grooved roll is adapted to create a vacuum. The depth of the grooves in the grooved roll that is adapted to create a vacuum can be remarkably great. However, the depth of the grooves in the grooved roll according to the invention is generally 100 mm at the maximum, advantageously 50 mm at the maximum. Thus the groove depth is 10 - 100 mm, advantageously 20 - 50 mm. The grooves are separate vacuum zones over the area covered by the web, whereby the grooved roll can direct a remarkable vacuum to the web.

The system 10 shown in Figure 1 is applied, for example, in an impingement unit of a web forming machine. The web 14 and the fabric 12 cover the first three guide rolls 16 at a wrap angle of α, which is less than 30°. When the guide roll is a grooved roll, the overpressure in the closing gap reduces substantially when the web/fabric covers the grooved roll for less than 30°. The web/fabric covers the grooved roll advantageously for more than 4° in order that the vacuum becomes notable and the grooved roll receives the energy required for the rotation from the fabric movement. The web/fabric thus covers the grooved
roll advantageously for 4 - 30°. Very advantageously, the web/fabric covers the grooved roll for 5 - 9°. When the wrap angle is more than 5°, the grooved roll can reliably receive the energy required for the rotation from the fabric supporting the web. On the other hand, when the wrap angle is less than 9°, the grooved rolls can form long, gradually curving drying entities. A gradually curving drying entity enables impingement sections that are sufficiently long as regards web drying. Figure 10 shows a drying entity including five grooved rolls 22. The web covers each grooved roll functioning as a guide roll at a wrap angle α, which is about 7°. As mentioned above, very advantageously between 5 - 9°. Within the range of five grooved rolls the web curves for a total of angle β, which is only about 35°.

In the system according to the invention shown in Figure 1, the two successive guide rolls 16 are grooved rolls 22. The two successive guide rolls 16, which are grooved rolls 22, are additionally located on the same side of the web 14 supported by the fabric 12. Regardless of flows caused by the grooved rolls, the two successive grooved rolls operate independently and the flows caused by them do not disturb each other remarkably.

In the system 10 according to the invention shown in Figure 1, a grooved roll 22 is also present in connection with the following fabric loop 18', which is illustrated for a range of two rolls. This grooved roll generates a vacuum for stabilizing the fabric and the web supported by the fabric. A runnability component is typically present in connection with this grooved roll for extending the vacuum to the desired area. This runnability component is advantageously passive.
The system 10 according to the invention shown in Figure 1 can be used in an impingement unit. An impingement unit is typically covered by a hood, more specifically by a blow hood. Of the hood, only short pieces of the hood edge 19 are shown in the figure.

Figure 2 shows a grooved roll 22 used in the system according to the invention, in which the adjacent grooves 24 are separate vacuum zones. This grooved roll 22 includes a center construction 28 and a groove-like surface construction 30, i.e. a steel shell, in which the grooves 24 are open only to the outside of the grooved roll 22. The surface structure 30, i.e. the steel shell, is attached to an end ring 31.

Figure 2 shows a grooved roll 22 including at least two groove zones 21. The grooves 24 have the same depth within the groove zone 21, but the grooves have a different depth between the groove zones 21. It is also possible to contemplate a situation in which all grooves would have a different depth. In this case the number of the groove zones would be the same as the number of grooves. When the grooved roll includes several groove zones, the manufacturing costs of the grooved roll can be reduced improving at the same time the pressure profile of the grooved roll. With a good pressure profile, the vacuum generated by the grooved roll in connection with the web, i.e. the vacuum directed to the fabric from the grooved roll, can be adjusted with greater freedom than before. The pressure directed to the fabric from the grooved roll refers to the pressure generated by the grooved roll in connection with the fabric. In addition, the mass of the grooved roll compared to the rigidity of the grooved roll can be made smaller. In other words, while the weight of the grooved roll remains the same, the rigidity of the grooved roll increases.

Manufacturing grooved rolls in which the grooves are separate vacuum zones is very challenging. At present, grooved rolls are
manufactured mainly by machining. In this case the grooved roll is manufactured by lathing or milling grooves as desired in a thick shell blank of the grooved roll.

The grooved roll and the runnability components in connection with it generate a vacuum in the roll area that is covered by the fabric. A vacuum is needed in a fiber web forming machine particularly in the web edge areas for the sake of runnability of the fiber web forming machine. In the center part of the grooved roll, in the cross direction of the fiber web forming machine, the vacuum level can be lower. In this case the grooves can be lower in the center part of the grooved roll. The manufacturing costs of the grooved roll reduce when the amount of work required for grooving decreases. The effect provided by the grooving in lowering the bending rigidity reduces allowing to use grooved rolls in machines that are wider than before.

The grooved roll 22 shown in Figure 2 includes three groove zones 21 for a half grooved roll 22. Three groove zones in a half grooved roll is an extremely advantageous embodiment due to the combination of the grooved roll properties and manufacturing costs. More generally, the number of groove zones 21 is 2 - 6, advantageously 3 - 4, in a half grooved roll 22. Two groove zones enable different vacuums at the edge and in the center part of the grooved roll. This pressure profiling into two parts in a roll half already provides the greatest benefits from profiling. When the amount of groove zones is increased from two to three, the manufacturing costs reduce further and, at the same time, the rigidity of the roll improves compared to the mass. When the number of groove zones in a half roll exceeds six, the manufacturing costs also start rising. When optimizing the ratio between the mass and the rigidity, grooved rolls having more than six groove zones can also be contemplated. However, such grooved rolls are special cases due to the manufacturing costs.
The grooved roll 22 shown in Figure 2 includes a total of five groove zones 21, of which three groove zones 21 are visible in the grooved roll 22 half shown. The three groove zones 21 are 5 a first groove zone 23, a second groove zone 25, and a third groove zone 27. The third groove zone also continues past the roll center point. As a dimensioning example, grooving for a 11000 mm wide grooved roll is given. The depth \( f_{23} \) of the grooves 24 in the first groove zone 23 is 30 mm and the width \( h \) of the first groove zone 23 is 760 mm. The depth \( f_{25} \) of the grooves 24 in the second groove zone 25 is 25 mm and the width \( i \) of the second groove zone 25 is 1540 mm. The depth \( f_{27} \) of the grooves 24 in the third groove zone 27 is 20 mm and the width \( i \) of the third groove zone 27 is 3050 mm. Altogether, a 10700 mm wide area of the grooved roll is then grooved. The width \( g \) of the end neck 17 is 150 mm. The grooved roll in question can be used until to a machine speed of about 2100 m/min. If all grooves had been made 30 mm deep, the machine speed could have been only about 1900 m/min. By using several groove zones it is thus possible to reduce the manufacturing costs and increase the machine speed. Increasing the machine speed is possible when the rigidity of the grooved roll is higher than before. In this case the lowest specific frequency of the grooved roll, like also the highest possible operating speed, is higher than before.

The width of the tail transported in connection with tail threading is typically 600 mm. When the width of the first groove zone is 760 mm, the tail coincides with this band. The aspiration of the band in question is sufficient as regards tail threading.

As shown in Figure 2, the grooves 24 in the grooved roll 22 have a depth \( f \) and a width \( e \). In addition, the depth \( f \) of the grooves 24 is greater than the width \( e \), which is very essential as regards the vacuum production. In a grooved roll with deep
grooves, when the groove depth is greater than the width, a grooved roll with deep grooves generates a vacuum in the wrap area even with a very small web wrap.

In the grooved roll 22 shown in Figure 2, the depth $f$ of the grooves 24 is $2 - 15$ times, advantageously $3 - 8$ times the width $e$ of the grooves 24. The groove dimensions can be, for example, a groove depth of more than 10 mm, advantageously of more than 20 mm. Very advantageously, however, the groove is 30 - 60 mm deep. The depth of the grooves in grooved rolls is thus notably more than the 4 mm deep and 5 mm wide groove that is generally used in Vac rolls. The groove width, on the other hand, is 4 - 10 mm, advantageously 6 - 7 mm. The width of the necks is 1 - 8 mm, advantageously 3 - 6 mm.

Figure 3 shows, in the system according to the invention, a grooved roll 22 used for guiding a fabric 12 and further the web 14 supported by the fabric. The fabric is on top of the grooved roll 22 with the web 14 above it. The grooved roll 22 has adjacent grooves 24 in the longitudinal direction of the grooved roll 22, i.e. in the cross direction of the web forming machine. The grooved roll 22 does not have walls perpendicularly to the rotation direction of the grooved roll. When the web covers the grooved roll, the grooved roll generates a vacuum in the area within which the web covers the grooved roll.

In the grooved roll 22 shown in Figure 3, the intervals between the grooves 24 are advantageously substantially straight and machine-directional. The walls are not, however, necessarily completely machine-directional, but the grooves in the grooved roll surface can also have a coil pitch. A pitched groove can be implemented as extending continuously over the entire dimension of the grooved roll. On the other hand, there may be even several pitched grooves; for example, pitched grooves extending from the center of the grooved roll to the edges. The pitch
angle is less than 15°, advantageously less than 5°. In this case the vacuum generation capability of the grooved roll is at a good level because the walls are not remarkably against the rotating movement.

In the grooved roll 22 shown in Figure 3 used in the system according to the invention, adjacent grooves 24 are separate vacuum zones over the area covered by the web 14. This grooved roll 22 includes a center construction 28 and a groove-like surface construction 30 with a contact between them forming a substantially closed construction in which the grooves are open only to the outside of the grooved roll. The center construction includes a center journal 29 in the case of Figure 3. It is known as such that the grooved roll can be provided with a journal using journal pins, a center journal, or a stationary journal, the grooved shell of which is adapted to rotate. Thus, by utilizing the boundary layer flow conveyed by the roll and the web/fabric, a vacuum is generated which keeps the web attached in connection with the grooved roll. A groove-like surface structure creates a vacuum directed to the web as the result of controlling the radial forces. The grooves 24 are in the surface structure 30 of the grooved roll 22. When the grooves are in the surface structure of the grooved roll, the grooves 24 do not go through the surface structure 30. Thus the grooves are not in contact with each other through the inner constructions of the grooved roll. Such grooves are separate vacuum zones, i.e. pressure units. When the grooves are separate vacuum zones, a more efficient vacuum generation is achieved with the grooved roll than with a grooved roll in which the grooves belong to the same vacuum zone.

In the grooved roll 22 shown in Figure 3, the adjacent grooves 24 are constructionally separate from each other. Each groove goes around the grooved roll only for one round. In addition, the grooves are not in contact with each other through the
inner constructions of the grooved roll. Thus each groove is an individual vacuum zone.

Nevertheless, the adjacent grooves, which are separate vacuum zones, are not necessarily constructionally separate. In the cross direction of a web forming machine, the adjacent grooves, which are separate vacuum zones, can constructionally belong to, for example, the same coil, i.e. a pitched groove. In this case they are, however, separate vacuum zones because one vacuum zone starts when the web covers the grooved roll and ends when the web releases from the grooved roll surface. In this case the adjacent grooves are separate vacuum zones over the area covered by the web. In the same groove, during the same round, there is also a second vacuum zone over that portion of the groove in which the web does not cover the grooved roll. Grooves that are separate vacuum zones are thus constructionally separate during the vacuum zone.

The depth of the grooves 24 in the grooved rolls 22 used in the system shown in Figure 3, is 10 - 100 mm, advantageously 20 - 50 mm. When the grooves of the grooved roll are so deep, a vacuum is generated during the groove rotation over that portion of the grooved roll which is covered by the web. The groove width is in turn 6 - 10 mm. The narrow necks between the grooves have a width of 1 - 8 mm. Advantageously, the groove volume is considerably high compared to traditionally grooved rolls and Vac rolls, in connection with which an active runnability component is used.

Figure 4 shows the system 10 according to the invention in connection with an impingement unit with the system 10 including a runnability component 32 located between two guide rolls 16. The impingement unit itself is not shown completely. A hood 39 is located above the impingement unit having its edges 19 close to the surface of the web 14. Of the successive guide rolls 16, between which the runnability component 32 is lo-
cated, at least one is a grooved roll 22. The runnability component improves the operation of the grooved roll. In addition, the successive guide roll s 16, between which the runnability component 32 is located, are located on the same side of the web 14. When the successive guide roll s 16 are located on the same side of the web 14, the runnability component can generate a vacuum between them.

In the system according to the invention shown in Figure 4, the runnability component 32' in connection with the grooved roll 22 is passive, whereas the runnability component 32'' in connection with a grooved roll 16, which is a smooth roll, is active. This active runnability component 32'' includes a blow channel 40 for generating aspiration. An airflow blow is used to create aspiration according to the ejector principle. A passive runnability component in connection with a grooved roll enables saving energy as a separate suction flow is not needed. In addition, a passive runnability component is simpler as an entity.

Figures 5a - 5c show embodiments of the systems according to the invention, which include a runnability component 32 between two grooved rolls 22 functioning as guide rolls. In addition, the grooved rolls 22, between which the runnability component 32 is located, are on the same side of the web 14 supported by a fabric 12. Thus the grooved roll 22 following the runnability component generates the vacuum existing in connection with the runnability component 32. When the grooved rolls 22 located on the same side of the web 14 supported by the fabric 12 are connected with the runnability component 32, the grooved rolls co-operate with the runnability components. The co-operation of the grooved rolls 22 in connection with the runnability components 32 allows to generate a remarkable vacuum over the entire range between the grooved rolls 22.
A hood as shown in Figure 5a, more specifically a blow hood 39, covers an impingement group located in the dryer section, in which the fabric 12 belonging thereto and further the web 14 are adapted to be guided by the grooved rolls 22. Of the 5 grooved rolls 22, the web 14 supported by the fabric 12 covers at least one for less than 90°. The grooved roll 22 is adapted as such to generate a vacuum. In addition, the hood includes blow zones 92 on both sides of the grooved roll 22 and an exhaust zone 94 at the grooved roll 22. In the blow zones, dry air is blown towards the web. The exhaust zone, in turn, aspirates air removing moisture along with it. Thus the hot impingement air coming from the blow zone presses the web against the fabric at the closing and opening gaps of the grooved roll. Then the air coming from the blow zone prevents the web from releasing in the closing and opening nips, although the vacuum may be weaker at these. The exhaust zone, in contrast, is located at the vacuum sector of the grooved roll. The vacuum is the highest at the vacuum sector of the grooved roll so that the web does not detach from the fabric despite the exhaust zone. Exhaust and blow openings are naturally placed also within the ranges between the grooved rolls. Blow/exhaust zones exist over the entire range of the hood in the machine direction, which makes drying efficient as ventilation is efficient.

In the machine direction the exhaust zone is, for example, 30 - 70 mm, advantageously 50 mm. Advantageously, the exhaust zone includes one large exhaust opening having a width equal to the fiber web forming machine. The exhaust opening is protected all over with a net which prevents access of paper shred, for example, to the exhaust opening along with aspirated air. The blow zones arranged in the closing and opening gaps, i.e. on both sides of the grooved roll, are, for example, 150 - 350 mm, advantageously 250 mm, in the machine direction. The blow zones include blow openings, which are holes/openings/slots with dimensions of 3 - 10 mm, advantageously 5 mm. The exhaust
opening could also include several smaller exhaust openings. Advantageously, the blow openings included in the blow zone 92 are smaller than the exhaust openings included in the exhaust zone 94.

As shown in Figure 5a, the blow zones 92 on both sides of one grooved roll 22 cover a longer range of the web 14 than the exhaust zone 94 at the same grooved roll. Thus the pressure of the in-flowing blow medium, typically a combustion gas, pressing the web against the fabric, is uniform.

In Figures 5a – 5c, the runnability components 32 in connection with the grooved rolls 22 are advantageously passive. The edges of passive runnability components can be mechanically sealed, for example, with a flat wear-resistant edge or a doctor-like labyrinth seal. Sealing can also be accomplished with a combination of these such that the doctor-like seal extends best to the gap and there is more freedom for the sealing of the other edges. When the runnability component is passive, the volume of the space defined by the runnability component and the fabric, i.e. the box, is advantageously small. The design is opening towards the following grooved roll, as in Figures 5a and 5c. When the design is opening towards the following grooved roll, the extension of the roll's suction effect area improves, and the above travelling fabric can depressurize the runnability component and partly the opening gap, formed by the runnability component and the fabric, on the side of the roll preceding its gap seal.

In Figures 5a – 5c, sealing on the side of the runnability component 32, which is passive, and the closing gap 36 of the following grooved roll 22 also influences the vacuum generating in the runnability component 32, i.e. the box. At its simplest, the seal is directly against the grooved roll, when the contact angle does not form a closing gap between the seal and the grooved roll, and even in other cases, when it is desired to
reduce the vacuum present in the runnability component. When more efficient sealing is desired, or a closing gap forms between the runnability component and the grooved roll, the vacuum of the runnability component and the grooved roll can be intensified by extending the sealing against the roll's rotation direction. Thus, the longer the seal, the more it is possible to restrict access of air along with the grooved roll.

In the systems according to the invention shown in Figures 5a-5c, the runnability components 32 between the grooved rolls 22 are different. When sealing the opening gap 34 to the runnability component 32, the most important is to prevent air from flowing out from the grooved roll and, along with the fabric, to between the runnability component and the fabric. For this reason, sealing is extended in the opening gap as deep as possible to the gap. Indeed, at a higher speed and vacuum, the deflection of the fabric towards the runnability component can be avoided, preventing thus also seal and fabric wear, by moving the seal slightly further away from the opening gap.

In systems according to the invention shown in Figures 5a-5c, control parameters related to the runnability components 32 include the length of the gap seal following the surface of the passive runnability component and the grooved roll, and the opening of the opening gap between the following runnability component and the related grooved roll. The length of the gap seal on the roll surface in its rotating direction influences the extension of produced vacuum. The gap opening, in turn, influences the vacuum production.

In the systems according to the invention shown in Figures 5a-5c, at least one grooved roll 22 is non-driven. The grooved roll can be non-driven, since the grooved roll design can be implemented as rotating very slightly. A slightly rotating grooved roll does not need a drive but it receives the movement force required for the rotation from the fabric.
Advantageously all grooved rolls located within the fabric loop are non-driven.

In the system 10 according to the invention shown in Figure 5a, the diameter d of the grooved roll 22 is less than 1000 mm. The grooved roll diameter depends as such from the machine's operating speed and width. Grooved rolls are provided with bearings at the ends. In prior art, instead of grooved rolls of this size class, suction rolls are used for generating a vacuum. The airflow needed for generating the suction roll aspiration is brought through the suction roll bearing, in which case the bearings are dimensioned according to the suction flow. When the grooved roll diameter is less than 1000 mm, the bearings included in the grooved roll heads have an inner diameter of less than 300 mm, advantageously less than 150 mm. Using a grooved roll in place of a suction roll of this size class enables significant cost savings as the bearings can be dimensioned according to stresses because it is not necessary to bring a suction flow through them.

Figure 6 shows the system 10 according to the invention provided with a vertical impingement unit 38. The vertical impingement unit 38 is equipped with a hood 39. The use of a grooved roll 22 in a vertical impingement unit 38 enables a vertical impingement unit that operates with notably higher energy efficiency than before. In addition, such impingement unit can be implemented in a considerably simpler way since it is not necessary to create a vacuum using separate vacuum generation means, but the grooved roll generates the required vacuum.

In the system according to the invention shown in Figure 6, the web 14 supported by the fabric 12 covers the grooved rolls 22 for more than 2°, advantageously for more than 6°. Then the grooved rolls 22 receive the movement force required for the
rotation from the fabric 12, which allows to implement the grooved rolls 22, functioning as guide rolls, non-driven. When the grooved rolls used in a vertical impingement unit are implemented as non-driven, the vertical impingement unit becomes notably simpler as a whole. Advantageously, the runnability components 32 located in the vertical impingement section 38 are passive, in which case they do not require an external suction or airflow blow.

A central advantage achieved with grooved rolls is that a vertical impingement unit can be implemented with a simpler and more compact design than before. A vertical impingement unit that fits better even in a limited installation space is enabled particularly by the lack of applying external vacuum and non-driven grooved rolls. When the vertical impingement unit is more compact, it can be positioned in the dryer section more freely than before. The grooved rolls and further the runnability components can be positioned even between machine beams without making holes in the machine beams for suction and drive connections. The grooved rolls can thus be positioned in a completely new way.

Figure 7 shows the system 10 according to the invention in which the runnability component 32 includes at least one active zone in the cross direction of the web forming machine. This active zone can be as wide as the entire web forming machine or it may cover only a part of the cross direction of the web forming machine. The runnability component includes a blow channel 40, through which an airflow blow is directed to the runnability component for generating a vacuum based on the ejector principle. For generating a vacuum, a suction flow could also be brought directly to the runnability component. The airflow blow directed to the runnability component is strong and creates a significant vacuum, so that the runnability component is in this case an active runnability component. Advantageously, active zones are located on the
sides of the web forming machine in which case they can be used to increase the vacuum for preventing flutter. The runnability component can also be an active zone over its entire range.

An airflow blow is directed to the runnability component 32 through the blow channel 40 included in the runnability component 32 shown in Figure 7 for generating a vacuum by means of ejector flows 41. Ejector flows are discharged particularly from the ends of the runnability component, i.e. from the sides of the web forming machine, creating a significant vacuum in the runnability component. The purpose of the ejector flows 41 is to generate a vacuum in the runnability component 32.

Through the blow channel 40 included in the runnability component 32 shown in Figure 7, the runnability component also receives the airflow blow required by the blow 45. The blow 45 is used for creating a vacuum, because it improves the boundary layer flow. However, a blow based on improving the boundary layer flow does not make the runnability component active, because this airflow blow is very small. Improving the boundary layer flow functions mainly in the way of sealing with a small airflow. An airflow blow improving the boundary layer flow makes the runnability component semi-passive.

The runnability component 32 shown in Figure 7 includes air sealing means 42 on the side of the closing gap of the runnability component 32. Through the blow channel 40 included in the runnability component 32, the runnability component 32 also receives the airflow blow required by the sealing blow 46.

These air sealing means 42 are used to seal the edge of the runnability component 32 with the sealing blow 46 for avoiding that harmful airflows could affect the operation of the runnability component. The sealing blow 46, which is contrary to the boundary layer flow, does not make the runnability component active. Nevertheless, the runnability component 32 shown in Figure 7 is active because the vacuum generated with
the ejector flows 41 is present within this runnability component 32.

Figure 8 shows the system 10 according to the invention in which the runnability component 32 includes at least one semi-passive zone in the cross direction of the web forming machine. This semi-passive zone can be as wide as the entire web forming machine or it may cover only a part of the width direction of the web forming machine. The blow 45 coming from the airflow blow means 43 is parallel with the boundary layer flow on the roll surface, but it has mainly a sealing function. In addition, the airflow blow led through the blow channel 40 is used for generating sealing flows 46. A mechanical sealing means 44 is located on the side of the closing gap. The runnability component 32 is thus semi-passive due to the effect of intensifying the boundary layer flows.

Figure 9 shows the system 10 according to the invention in which the runnability component 32 includes at least one passive zone in the cross direction of the web forming machine. This passive zone can be as wide as the entire web forming machine or it may cover only a part of the cross direction of the web forming machine. When the passive zone measures the width of the entire web forming machine, the airflow blow brought to the runnability component 32 through the blow channel 40 is used completely for creating sealing blows 46. A mechanical sealing means 44 is located on the side of the closing gap. Such a passive runnability component is very advantageous with a grooved roll because it utilizes the vacuum generation capability enabled by the grooved roll. The passive zone of the runnability component thus refers to a zone in which the vacuum is not intensified with external airflows but the vacuum is based on the co-operation of the grooved roll and the runnability component.
Instead of sealing flows, mechanical sealing elements can be used in the runnability component, in which case no airflow is required to be brought to the runnability component. Then the design of the runnability component can be very simple. This embodiment enables manufacturing passive runnability components economically. In addition, these passive runnability components are inexpensive for their operating costs.

Figure 10 shows an embodiment of the system according to the invention provided with several grooved rolls 22. Passive runnability components 32 are located between the grooved rolls 22. When the machine speeds rise, remarkably high vacuums are generated at passive runnability components. The number of passive runnability components 32 is six in the example, i.e. a first runnability component 71, a second runnability component 72, a third runnability component 73, a fourth runnability component 74, a fifth runnability component 75, and a sixth runnability component 76. To mention as examples, in the connection with the first runnability component, the pressure is -198 or the vacuum is 198 Pa at speed 1045 m/min, and the vacuum is 234 Pa at speed 1504 m/min. In connection with the second runnability component, the vacuum is 151 Pa at speed 1045 m/min and 225 Pa at speed 1504 m/min. In connection with the third runnability component, the vacuum is 201 Pa at speed 1045 m/min and 296 Pa at speed 1504 m/min. In connection with the fourth runnability component, the vacuum is 236 Pa at speed 1045 m/min and 366 Pa at speed 1504 m/min. In connection with the fifth runnability component, the vacuum is 130 Pa at speed 1045 m/min and 204 Pa at speed 1504 m/min. In connection with the sixth runnability component, the vacuum is 180 Pa at speed 1045 m/min and 214 Pa at speed 1504 m/min. Too high a vacuum creates problems in that, for example, fabrics wear faster when friction increases between them and runnability components.

Figure 11 shows the system 10 according to the invention provided with a passive runnability component 32. A mechanical
sealing means AA is located on the side of the closing gap. An air deflector 86 is located on the side of the opening gap 86. For a passive runnability component, air is not led for generating sealing flows or a vacuum. When operating speeds rise to a level of 1300 - 1700 m/min and above, an unnecessarily high vacuum is generated in connection with a passive runnability component. This runnability component 32 includes means 78 for partially discharging the vacuum, i.e. flow channels for reducing/adjusting the vacuum. The means 78 for partially discharging the vacuum comprise a flow channel 84 of the opening gap, a flow channel 82 of the closing gap, and a flow channel 80 of the box. Through these means for partially discharging the vacuum, i.e. the flow openings, air flows to the passive box for reducing the vacuum to a suitable value. When the means 78 for discharging the vacuum include three flow channels, it is possible to reduce the pressure of the runnability component exactly where the reduction is needed. In other words, the pressure affecting in the runnability component can be profiled as desired. In the cross direction of a fiber web forming machine, the vacuum can be profiled as desired, for example, using a pipe with holes between the flow channels. When the holes of the pipe are located at more frequent intervals at the center of the fiber web forming machine, the pressure affecting in the runnability component can be decreased at the center of the web forming machine. The means 78 for discharging the vacuum, i.e. flow channels, are advantageously passive flow channels, which means that air is not blown to them or air is not aspirated from them. In other words, the flow channels are openings through which air can flow to the runnability component by the effect of the vacuum present in it.

The passive runnability component included in the system shown in Figure 11 includes means 78 for discharging the vacuum. The means 78 for discharging the vacuum can include several flow channels of which one is the flow channel 80 of the box. This is typically the largest of the flow channels included in the
means 78 for discharging the vacuum. The vacuum discharge means 78, which is advantageously the flow channel 80 of the box, includes a control element 88. The control element 88 can be, for example, a control baffle 89 with a very simple operation. A counter force is generated for the control element, more specifically for the control baffle, with a passive loading means, which can be a spring, for example. When the pressure falls too low within the runnability component, the control baffle opens and lets air flow to the runnability component.

When the pressure falls too low, the limit force required for opening the control baffle is exceeded. The control baffle opens and closes according to the pressure affecting in the runnability component. A control baffle 89 is also included in connection with the flow channels 82 and 84. This control baffle can be simply a baffle hinged on the inner surface of the side wall of the runnability component. When the runnability component does not have a significant vacuum relative to the environment, a spring closes the flow channel with the control baffle. When the vacuum reaches the level required by the limit force, air starts flowing to the runnability component from the flow channel.

Figure 12 shows a grooved roll 22 used in the system according to the invention. This grooved roll 22 includes several zones 50 in the cross direction of the web forming machine. The zones 50 are supported to a frame construction 51, at their center part, with bearings 52, in the cross direction of the web forming machine. The bearing assembly is advantageously implemented as an air or magnet bearing assembly, which avoids soiling. The bearing assembly can also be implemented with traditional lubricated bearings with appropriate sealing. This grooved roll composed of separate zones can be manufactured in a simple way with the grooved roll zones being non-driven. When the web-supported fabric covers the grooved roll for more than 2°, the grooved roll receives the energy required for the
rotation from the fabric. A grooved roll composed of several zones, i.e. sections, in the cross direction of a web forming machine, enables assembling grooved rolls from short components, which allows a simpler manufacture than at present. When the grooved roll includes short zones, i.e. partial rolls, each partial roll needs to support its own mass less than before. A smaller support of own mass enables, for its part, partial rolls with a lighter design than before. At the same time, also complete grooved rolls can be made with a lighter design than before.

In one embodiment, in the same position in which a grooved roll composed of several zones is used, it is desired to direct energy for the fabric rotation using the grooved roll. In this case the edge-most zones of the grooved roll can be driven.

Figure 13 shows a top view of the system according to the invention. The web 14 is visible on the top and a fabric 12 below it. The fabric 12 and the web 14 are shown as cut at the grooved rolls 22 to make the grooved rolls 22 visible. The grooved roll 22 includes several separated zones 50 in the cross direction of the web forming machine. The zones 50 are not in the immediate vicinity of each other; that is, remarkable gaps 54 or intervals may be present between the zones.

In the system according to the invention shown in Figure 13, flow suppression components 56 can be placed between the zones 50 forming the grooved roll 22. Thus it is possible to form a continuous runnability component which can be used to extend the vacuum almost in a corresponding way as with a runnability component used in connection with a full-width grooved roll. The flow suppression components are, for example, mechanical sealing elements which prevent air from flowing along with the fabric. In addition, runnability components are typically included in connection with grooved rolls although not shown in the figure.
The system according to the invention shown in Figure 13 has two grooved zone rolls 60, 62 implemented in a different way. In the grooved zone roll 60, the zones 50 are mounted on the journal 58 with bearings. In the grooved zone roll 62, in contrast, the zones are mounted to the frame constructions 51 with bearings (Figure 12).
1. A system in a dryer section of a web forming machine for guiding a fabric (12) and further the web (14) with guide rolls (16), and at least one of the guide rolls (16) is covered by the web (14) supported by the fabric (12) for less than 90°, characterized in that at least one guide roll (16) that is covered by the web (14) for less than 90° is a grooved roll (22), and in the cross direction of the web forming machine, the grooved roll (22) has adjacent grooves (24) which grooves (24) are separate vacuum zones over the area covered by the web (14), and the grooved roll (22) is adapted as such to create a vacuum.

2. A system according to claim 1, and the grooves (24) present in the grooved roll (22) have a depth (f) and a width (e), characterized in that the depth (f) of the grooves (24) is greater than the width (e).

3. A system according to claim 2, characterized in that the depth (f) of the grooves (24) is 2–15 times, advantageously 3–8 times the width (e) of the grooves (24).

4. A system according to any of claims 1–3, characterized in that the depth (a) of the grooves (24) present in the grooved roll (22) is at least 10 mm, advantageously at least 20 mm.

5. A system according to any of claims 1–4, characterized in that the grooved roll (22) includes two groove zones (21).

6. A system according to claim 5, characterized in that the number of groove zones (21) is 2–6, advantageously 3–4, in a half of the roll.
7. A system according to any of claims 1 - 6, characterized in that the two adjacent guide rolls (16) are grooved rolls (22).

8. A system according to any of claims 1 - 7, characterized in that the system (10) includes a runnability component (32) between the two guide rolls (16), of which at least one is a grooved roll (22), and which guide rolls (16) are on the same side of the web (14) supported by the fabric (12).

9. A system according to any of claims 1 - 8, characterized in that the system (10) includes a runnability component (32) between the two guide rolls (16), which are both grooved rolls (22), and the grooved rolls (22) are on the same side of the web (14) supported by the fabric (12).

10. A system according to claim 8 or 9, characterized in that the runnability component (32) in connection with the grooved roll (22) is passive.

11. A system according to any of claims 8 - 10, characterized in that the runnability component (32) includes means (78) for partially discharging the vacuum.

12. A system according to claim 11, characterized in that the means (78) for partially discharging the vacuum include a control element (88).

13. A system according to any of claims 1 - 12, characterized in that at least one grooved roll (22) is non-driven.

14. A system according to any of claims 1 - 13, characterized in that the diameter (d) of the grooved roll (22) is less than 1000 mm.
15. A system according to any of claims 1 - 14, in which bearings (52) are included at the ends of the grooved roll (22), characterized in that the bearings (52) included at the ends of the grooved roll (22) have an inner diameter of less than 300 mm, advantageously less than 150 mm.

16. A system according to any of claims 1 - 15, characterized in that the web (14) covers the grooved roll (22) for less than 30°.

17. A system according to any of claims 1 - 16, characterized in that the web (14) covers the grooved roll (22) for less than 9°.

18. A hood of a dryer section of a fiber web forming machine, and in the dryer section, a fabric (12) and further the web (14) are adapted to be guided with guide rolls (16), and at least one of the guide rolls (16) is covered by the web (14) supported by the fabric (12) for less than 90°, characterized in that at least one guide roll (16) which is covered by the web (14) for less than 90° is a grooved roll (22), and in the cross direction of the web forming machine, the grooved roll (22) has adjacent grooves (24) which grooves (24) are separate vacuum zones over the area covered by the web (14), and the grooved roll (22) is adapted as such to create a vacuum, and the hood includes blow zones (92) on both sides of the grooved roll (22) and an exhaust zone (94) at the grooved roll (22).

19. A hood (39) of a dryer section of a fiber web forming machine according to claim 18, characterized in that the blow zones (92) on both sides of one grooved roll (22) cover a longer distance of the web (14) than the exhaust zone (94) located at the same grooved roll.
20. A hood of a dryer section of a fiber web forming machine according to claim 18 or 19, characterized in that the blow openings included in the blow zone (92) are smaller than the exhaust openings included in the exhaust zone (94).
**INTERNATIONAL SEARCH REPORT**

**International application No.**

PCT/FI2008/050020

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### A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

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### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IP 8: D21F, F16C

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

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**Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)**

EPO-INTERNAL, WPI

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### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 4361466 A (WONG GEORGE H et al.) 30 November 1982 (30.1.1.1982) figures 1 and 7; column 5, lines 52-60</td>
<td>1, 7-9, 11, 12, 14-17 2-6, 10, 13</td>
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[ ] Further documents are listed in the continuation of Box C.  [X] See patent family annex.

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**Date of the actual completion of the international search**

27 March 2008 (27.03.2008)

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