April 27, 1971 G. P. THOM ET AL 3,576,714

APPARATUS FOR HIGH SPEED WEB PICKUP

Filed July 12, 1968 4 Sheets-Sheet 1

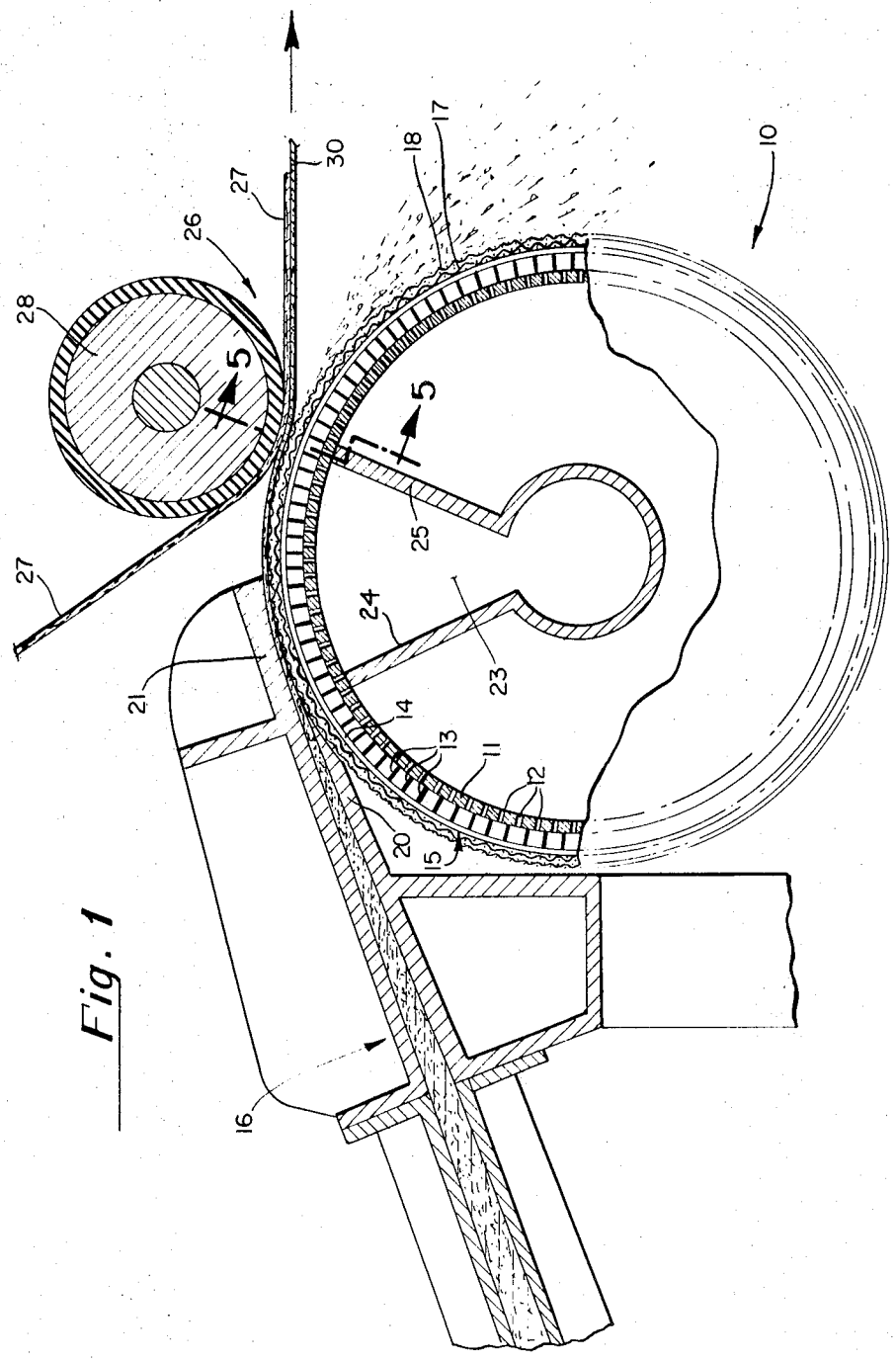


Fig. 1

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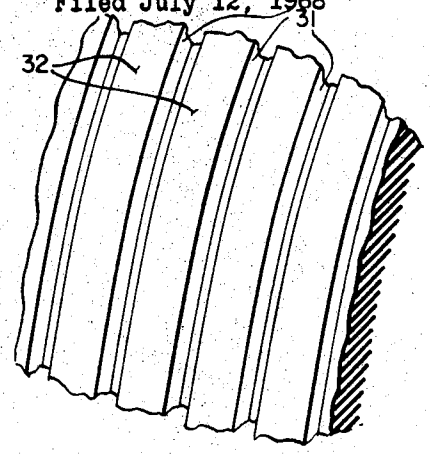


Fig. 2A

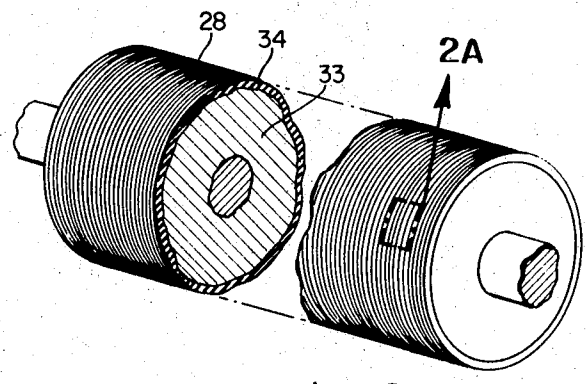


Fig. 2

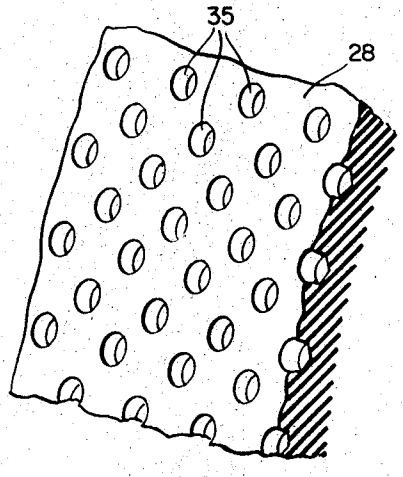


Fig. 3A

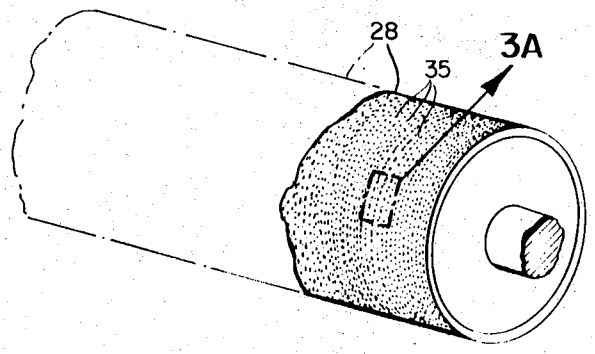


Fig. 3

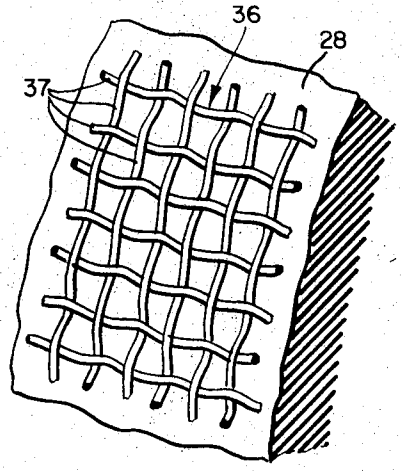


Fig. 4A

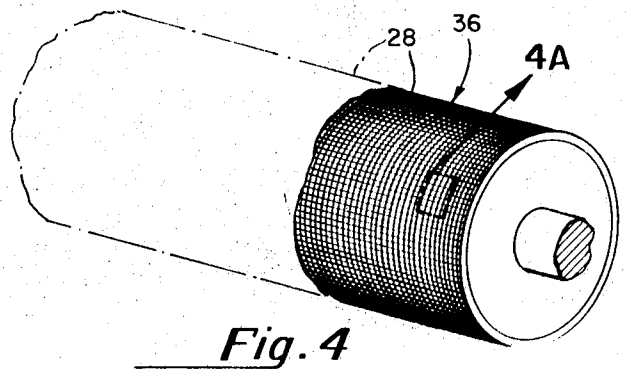


Fig. 4

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APPARATUS FOR HIGH SPEED WEB PICKUP

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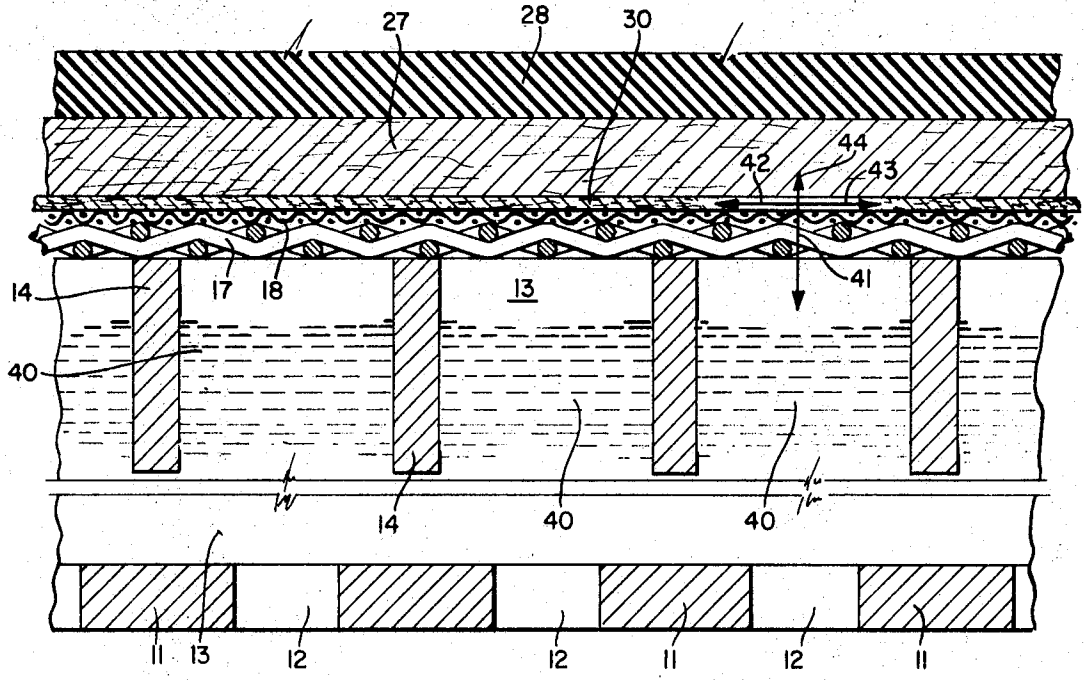


Fig. 5

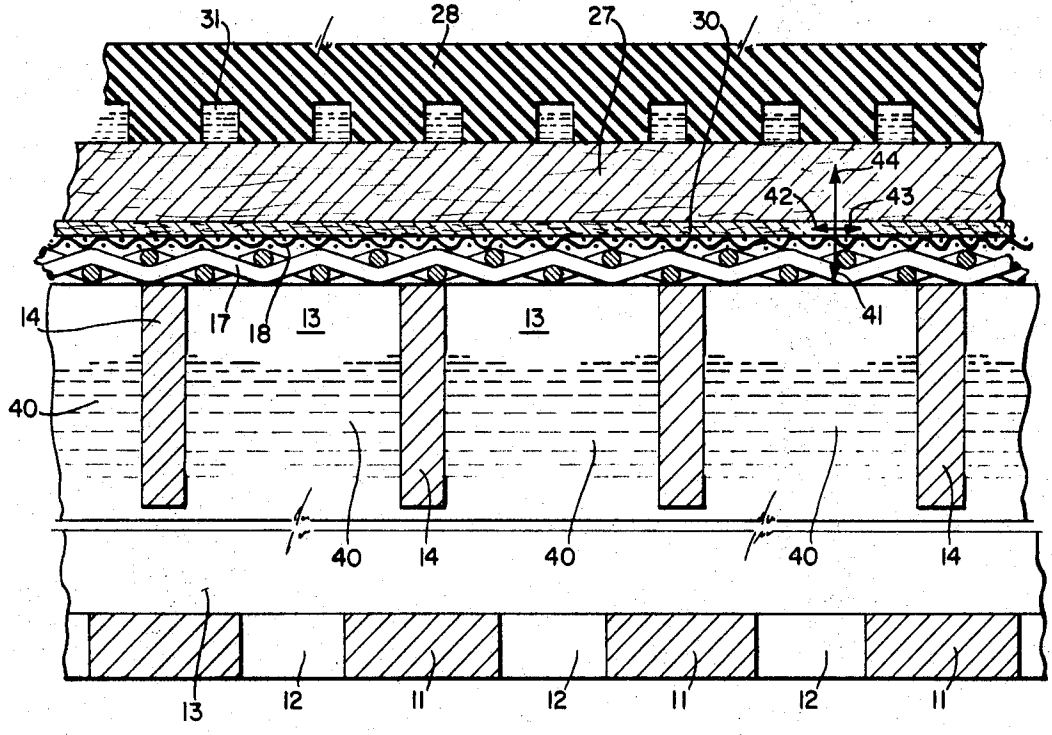


Fig. 6

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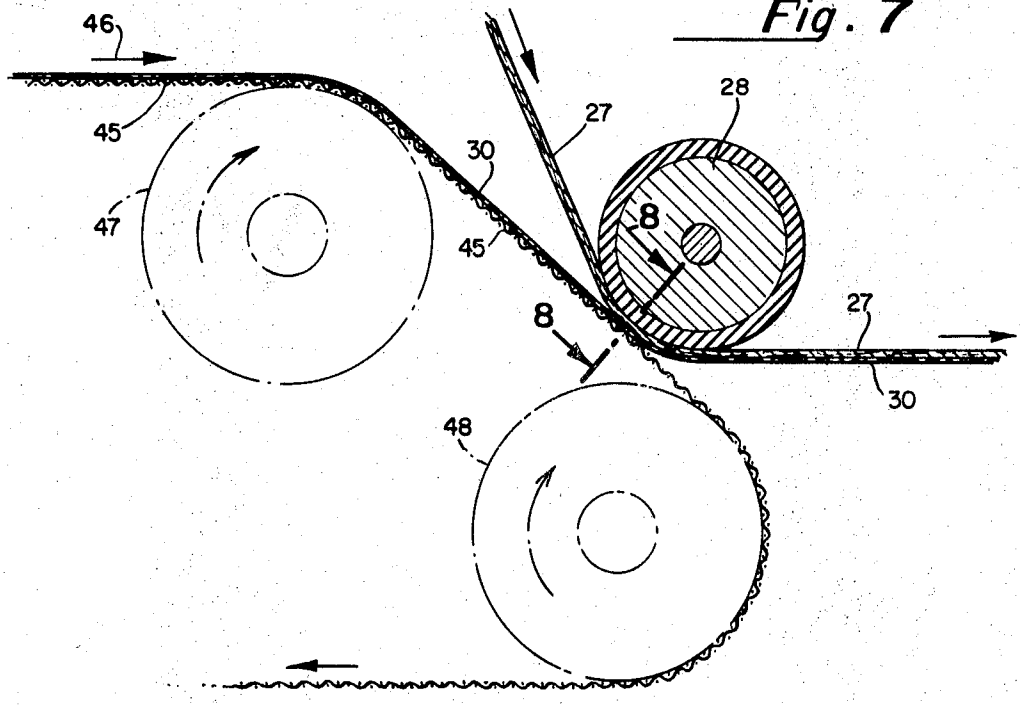
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APPARATUS FOR HIGH SPEED WEB PICKUP

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Fig. 7



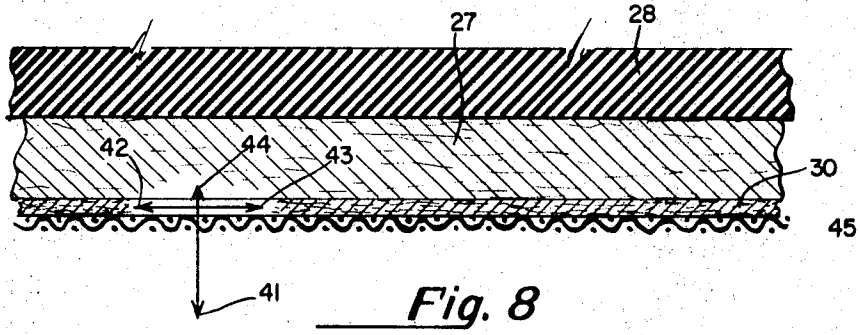


Fig. 8

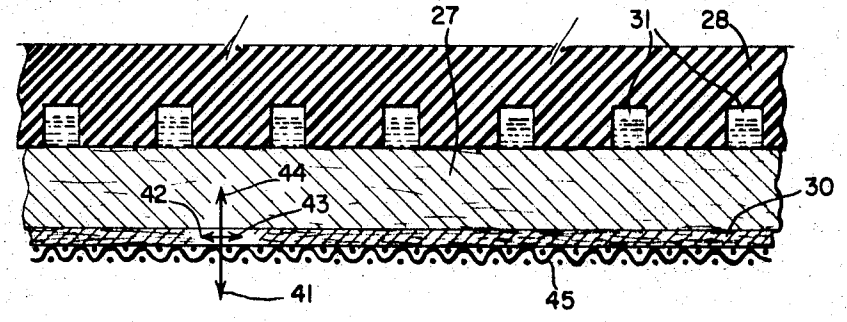


Fig. 9

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Patented Apr. 27, 1971

3,576,714

APPARATUS FOR HIGH SPEED WEB PICKUP

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Filed July 12, 1968, Ser. No. 744,492
Int. Cl. D21f 2/00
U.S. Cl. 162—306 11 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus is disclosed for accomplishing high speed pickup and transfer of a wet paper web from a web-forming surface to a pickup felt while reducing or eliminating hydraulic forces acting on the web, which, for pressing the pickup felt into engagement with the web, utilize a pickup roll having an outer cylindrical surface containing a plurality of fine recesses between land areas that support the felt. The apparatus disclosed reduces or eliminates drop-off problems experienced at higher operating speeds of papermaking machines, and are a particular benefit in the higher speed operation of certain cylindrical-former type papermaking machines.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to papermaking and, more particularly, to a new and improved apparatus for accomplishing pickup and transfer of a wet paper web from the web-forming surface of a papermaking machine to a pickup felt for conveying the web to a remote position.

The apparatus of this invention has utility in conjunction with both Fourdrinier and cylindrical-former type papermaking machines and are especially beneficial when these papermaking machines operate at higher speeds. The apparatus of the invention is particularly advantageous when used in connection with the higher speed operation of a papermaking machine of the type disclosed in U.S. Pat. 3,252,853 entitled "Cylindrical Former Type Papermaking Machine and Method of Operation," issued May 24, 1966, to S. G. Holt et al. and assigned to Scott Paper Company.

(2) Description of the prior art

Commercial processes for the manuracture of paper generally involve the introduction of a slurry of fibers and water to the surface of a foraminous drainage member, such as a woven wire screen, which provides a web-forming surface. Some of the water is removed from the slurry by drainage, resulting in the formation of a wet paper web. Water removal is usually promoted by employing suction boxes and hydrofoils beneath the web-forming surface. Generally the web is then transferred to a pickup felt which conveys it to a drying unit associated with the papermaking machine, often first conveying the web through one or more presses where additional amounts of water are removed from the web.

Transfer of the wet paper web from the web-forming surface to the pickup felt may be accomplished in a variety of ways but is conventionally accomplished by lightly pressing the pickup felt into engagement with the web by means of a rotating support or guide roll, commonly referred to as a "pickup" roll. The pickup felt and the drainage member generally are arranged to move at substantially the same speed. Sometimes the pickup roll is arranged to form a nip with a support roll carrying the drainage member through which nip the drainage member, the wet paper web and the pickup felt pass, in which

case the arrangement is referred to as a "hard" pickup. Sometimes the pickup roll is arranged to form a nip with a portion of the drainage member running between two support rolls with the wet paper web and the felt running through that nip, in which case the arrangement is referred to as a "soft" pickup. The pressure exerted at the pickup nip in either arrangement is generally relatively light (generally less than 30 lbs. per linear inch) when compared with the pressure created between press rolls in press assemblies (generally greater than 250 lbs. per lineal inch).

Generally one of two types of pickup rolls is employed: either a suction pickup roll or an imperforate smooth-surfaced roll. Suction pickup rolls apply a positive force to the web being transferred to urge it into contact with the pickup felt as well as to remove water therefrom. The suction is applied to the felt through a perforate pickup roll shell. Besides involving considerable installation expense as well as operational expense, largely because of the need to maintain a partial vacuum adjacent a portion of the roll shell, suction pickup rolls often cause "shadow marking" especially in lighter basis weight webs. Such "shadow marking" is believed to be due to pressure differentials at the nip area as by the application of greater suction to portions of the web overlying the apertures in the perforate roll shell than to adjacent portions of the web. In addition, suction pickup rolls are not satisfactory for the removal of webs from papermaking machines of the type disclosed in U.S. Pat. 3,252,853 referred to above since water held in the receptors in the cylindrical shell thereof by partial vacuum would be prematurely withdrawn from these receptors by the partial vacuum in the suction pickup roll and would disrupt the web before it could be transferred from the web-forming wire.

In instances where a papermaking machine of the type described in the above-identified patent is employed or where suction pickup rolls are not employed, imperforate smooth-surfaced rolls are usually employed having a solid roll shell, generally of either metal or rubber. In the absence of a positive force to urge the web from the web-forming surface to the pickup felt, such as that provided by a suction pickup roll, it has long been thought that a solid or imperforate roll surface adjacent the pickup felt was necessary to accomplish web pickup and transfer. The theory, very generally stated, has been that when the pickup felt and the web are slightly compressed at the pickup nip, water is expressed through the web-forming surface and, upon emergence of the pickup felt and the web from the nip, the resiliency of the felt and its subsequent expansion after the slight compression creates a partial vacuum within it which tends to attract the web to the pickup felt and to hold in contact with the surface of the pickup felt with sufficient force to pull it off of the web-forming surface.

Several problems have been experienced with pickup rolls of the type described above. "Drop-off" is a problem which generally occurs when a paper machine is operated at higher speeds, particularly at speeds higher than 3500 feet per minute. "Drop-off" is a term used by papermakers to describe the condition where portions of a recently formed wet paper web fail to transfer from the web-forming wire to the pickup felt. This phenomenon, of course, results in unacceptable web product in that the web formed contains holes of varying size and number, the size being anywhere from fractions of an inch to several inches or more in diameter.

"Crushing" occurs to a lesser degree than "drop-off" but is still a significant problem with some pickup arrangements. "Crushing" is a term applied by papermakers to describe the formation of lines of fracture within the

web. The result of this condition is that the substantially unbonded but interlocked fibers in the web become separated at these lines of fracture causing the ultimately formed paper web to be weaker than desired and the appearance to be mottled or disrupted.

Both of the above-mentioned problems occur at the pickup nip predominantly when an imperforate smooth-surfaced pickup roll is employed. Drop-off has often been attributed to surface characteristics of the pickup felt, and efforts to reduce it have included modifying the weave of the felt and varying the amount of moisture in the felt. None of these efforts has been satisfactory in entirely eliminating the problem of drop-off, especially at higher operating speeds. Crushing has often been attributed to excessive hydraulic pressures within the web, perhaps accompanied by and resulting from excessive water flow within the web in the plane of the web as it passes through a pressure nip. Even though nip pressures at the pickup nip are much lower than those at a press nip, as pointed out above, the wet paper web generally contains large quantities of water, on the order of 92% water by weight, at the pickup nip. In addition, considerable amounts of water are carried in the web-forming wire as well as in the pickup felt.

Much work has been done to reduce or eliminate crushing in press nips. Press rolls, such as grooved press rolls and blind drilled press rolls, having recesses in their surface for at least temporarily receiving water expressed from the web and through the felt at the press nip, have been widely employed at press positions to reduce or eliminate crushing. Such rolls were specifically designed for press positions throughout the paper machine where nip pressures to which the web was subjected were on the order of 200 lbs. per lineal inch and generally higher. Because of the expense of such rolls and the belief that they would not be of benefit or would not operate properly at positions on a paper machine involving lower pressures, such rolls have not been heretofore utilized as pickup rolls. Indeed, as mentioned above, it was believed necessary to use imperforate smooth-surfaced pickup rolls in order to accomplish pickup and transfer, and it has widely been thought that rolls having recesses in their surface would not accomplish pickup and transfer unless a partial vacuum was employed therewith as in a suction pickup roll.

It has been found that the apparatus of the invention substantially reduce or eliminate the problems of drop-off and crushing when used with papermaking machines operating at these higher speeds. In addition, "shadow marking" problems often experienced with suction pickup rolls are not experienced with the method and apparatus of the invention. Thus, extremely reliable pickup and transfer of webs to a pickup felt from the web-forming surface of a papermaking machine operating at a higher speed is provided. Moreover, the apparatus of the invention enables improved pickup and transfer of a wet paper web from the web-forming surface of papermaking machine of the type described in the above-identified patent.

SUMMARY OF THE INVENTION

In the invention, a wet paper web is supported on a web-forming surface. The web is contacted with a rapidly moving pickup felt to which the web is to be transferred. Hydraulic forces acting on the web are substantially minimized while it is pressed between the web-forming surface and the pickup felt, and the web is conveyed to a remote point on the surface of the pickup felt. A preferred method involves removing water from the web through closely spaced areas on each surface thereof while it is pressed between the web-forming surface and the pickup felt, thereby minimizing the flow of water within the web in the plane of the web. This also reduces the flow of water toward the web-forming surface.

The apparatus of the invention involves certain elements utilized in a papermaking machine for removing a wet paper web from the web-forming surface and for transferring it to a remote position. A looped pickup felt is utilized with a pickup roll which is adapted to press the looped pickup felt into contact with the wet paper web formed on the web-forming surface. In accordance with the invention, the pickup roll has an outer cylindrical surface containing a plurality of fine recesses between land areas that support the pickup felt. In a preferred embodiment of the invention, the recesses are of sufficient size and number so that as the outer cylindrical surface presses the looped pickup felt into contact with the wet paper web formed on the web-forming surface, water expressed from the web and the felt may be received within the recesses. In some embodiments, the recesses are in the form of generally circumferentially aligned grooves separated by generally circumferentially aligned ridges. In other embodiments, the recesses comprise holes directed radially inward toward the axis of the pickup roll or an outer sleeve of woven material having interwoven strands separated by interstices where the interstices comprise the recesses.

A preferred embodiment of apparatus of the invention involves the above-described elements as pickup means in a paper machine comprising a hollow cylindrical shell having a plurality of receptors therein communicating with the outer periphery of the shell and with the interior of the shell, a web-forming wire disposed on and completely encircling the periphery of the shell outwardly of the receptors, a slice having top and bottom lips to convey a slurry of water and fibers to the outer surface of the forming wire, the above-mentioned pickup means disposed adjacent the wire beyond the slice to remove the web from the wire, and vacuum means within the shell between the bottom slice lip and the pickup means to withdraw water from the slurry through the wire into the receptors thus forming a web of fibers on the wire and to hold water in the receptors, the vacuum means being constructed and arranged to release the water in the receptors to permit that water to move outwardly through the forming wire under centrifugal force after the web has been removed from the wire.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional side elevation view of a portion of a papermaking machine illustrating a preferred form of apparatus of the invention;

FIGS. 2, 3 and 4 are perspective views showing several different embodiments of a pickup roll in accordance with the invention;

FIGS. 2–A, 3–A and 4–A are greatly enlarged fragmentary perspective views illustrating the specific nature of the surface of each of the several different embodiments of the pickup roll shown in FIGS. 2, 3 and 4;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 1 illustrating the arrangement of apparatus in FIG. 1 where a conventional pickup roll is utilized;

FIG. 6 is a sectional view taken along line 5—5 of FIG. 1 illustrating the arrangement of apparatus shown in FIG. 1 when a pickup roll of the invention is employed;

FIG. 7 is a sectional side elevation view of an alternative embodiment of apparatus of the invention utilizing a soft pickup;

FIG. 8 is a sectional view taken along line 8—8 of FIG. 7 illustrating the arrangement of apparatus shown in FIG. 7 when a conventional pickup roll is employed;

FIG. 9 is a sectional view taken along line 8—8 of FIG. 7 showing the arrangement of apparatus in FIG. 7 when a pickup roll of the invention is employed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 of the drawings, a paper machine of the cylindrical former type described in U.S. Pat. 3,252,853, the disclosure in which is hereby incor-

porated by reference, is shown. The paper machine includes a rotatably mounted forming roll, indicated generally by reference numeral **10**, having an outer cylindrical web-forming surface. Forming roll **10** includes a hollow cylindrical shell **11** which has a multitude of holes **12** extending radially therethrough. The outer cylindrical surface of shell **11** carries an openwork or is made more open as by countersinking the holes **12**. More preferably, such openwork is provided by mounting axially extending fins **13** on the shell **11** with a circumferential winding tape or tapes **14** mounted on edge in slots in fins **13** so as to form an open grid of receptors or cells **15** spaced from the outer cylindrical surface of shell **11**. Such receptors **15** are typically on the order of ⅜ inch square with a depth of about ⅜ inch.

Winding tapes **14** and fins **13** support a backing wire **17** which is tautly drawn about the forming roll **10** and into contact with the tapes **14** and fins **13** as shown in FIG. 1. Backing wire **17** is typically coarsely woven of wires or strands of relatively large diameter on the order of 0.040 inch and is typically of a plain weave. A forming wire **18** is disposed about the forming roll **10** in contact with the backing wire **17** and clamped on the ends of the forming roll **10**, as shown in the above-identified patent, so as to provide a taut rigid web-forming surface supported by the tapes **14** and fins **13** on which a web may be formed. Forming wire **18** may be of any type weave and is generally formed of wires or strands of lesser diameter, on the order of 0.015 inch. Forming wire **18** is preferably woven of diagonally disposed wires so as to prevent slack from occurring in the wire during wear thereof, thereby eliminating any problems resulting from a loose wire.

A slice, indicated generally by reference numeral **16**, is provided adjacent the outer cylindrical surface of the forming roll **10** and extends axially therealong. Slice **16** is connected to a headbox (not shown) and is arranged to receive paper stock, that is a slurry of dispersed paper fibers and water from the headbox and to deposit it on the outer cylindrical surface of forming roll **10** along a line parallel to the rotational axis thereof and extending generally along the axial length of forming roll **10**. Slice **16** includes a lower lip **20** terminating adjacent the web-forming surface of forming roll **10**, that is, the outer surface of forming wire **18**, and an upper lip **21**, terminating at a point spaced from the end of lower lip **20** along the path of travel of forming wire **18**. Upper lip **21** is preferably adjustably mounted in the manner well known to those skilled in the art, permitting the distance between upper lip **21** and the surface of forming wire **18** to be adjusted as desired.

A suction box, indicated generally by reference numeral **22**, is disposed within the shell **11** of the forming roll **10**. Suction box **22** is preferably arcuately adjustable within the shell **11** so that its position relative to slice **16** may be altered as desired. Suction box **22**, includes a leading edge **24** and a trailing edge **25** which extend into sliding contact with the inner surface of shell **11**, thereby defining a chamber **23** between them which connects to a source of vacuum through the shaft of forming roll **10**. Although only one relatively large chamber is shown, it should be clearly understood that several successive chambers **23** could be employed within the scope of the invention, having either the same or a different partial pressure within them. Suction box **22** is disposed directly within shell **11** with the leading and trailing edges, **24** and **25** respectively, positioned so that the partial vacuum in the chamber **23** may be transmitted directly to the cells **15** formed by fins **13** and tapes **14** through the holes **12**, whereby water is withdrawn from the paper stock through the forming wire **18** and the backing wire **17** to the cells **15**, leaving a wet paper web **30** on the forming wire **18**. Thus, the paper web **30** is formed on the web-forming surface of the forming wire within a few inches following the termination of the upper lip **21** of the slice **16**.

Pickup means **26** are provided including a looped pickup felt **27** which is arranged to travel along a fixed path, during a portion of which it momentarily contacts the wet paper web **30** formed on the web-forming surface of the forming roll **10**, and a pickup roll **28** which is arranged to guide and lightly press the pickup felt **27** into contact with the wet paper web **30**. Pickup felt **27** is arranged to contact the forming wire **18** or the wet paper web **30** carried on the forming wire **18** at a point disposed along a path of the forming wire **18** a short distance beyond the end of the upper lip **21** of the slice **16**. The wet paper web **30** is transferred to the pickup felt **27** while the water therefrom is retained in the cells **15**. This is insured by positioning the trailing edge **25** of the suction box **22** at a point adjacent shell **11** along the path of web **30** at least beyond a line connecting the rotational axis of forming roll **10** with the rotational axis of pickup roll **28**.

With this arrangement, immediately after pickup and transfer of the web **30** from the forming wire **18** to the underside of the pickup felt **27**, the force imposed on the water within the cells **15** by the suction box **22**, which force has heretofore drawn the water into the cells **15** and held it there, is released. This water is rapidly discharged otuwardly from the cells **15** by centrifugal force as they move beyond the trailing edge **25** of suction box **22** from which it may be removed without undue diffi- the forming wire **18** and is thrown beneath and away from the run of the pickup felt **27**. Typically, this released water is caught in a deflector pan (not shown) and transferred to a remote point. Since pickup and transfer of the wet paper web **30** to the pickup felt **27** takes place either prior to or substantially simultaneously with the breaking of the vacuum holding the water in the receptors **15** of the forming roll **10**, due to the position of the trailing edge **25** of the suction box **22** relative to the line of contact of the pickup felt **27** with the forming wire **18**, the release of water and the transfer of the web **30** may be accomplished with control and without any danger of the web **30** being disrupted by the released water. In some instances a minor portion of the water withdrawn from the paper stock may be drawn into the suction box **22** from which it may be removed without undue difficulty but in all instances the major portion of the water, and preferably at least about 80% of the water, withdrawn from the paper stock is discharged back out through the forming wire **18**.

In accordance with this invention, the pickup roll **28** has an outer cylindrical surface containing a plurality of fine recesses between land areas that support the felt **27**. These recesses should be of sufficient size and number so that, as the outer cylindrical surface presses the looped pickup felt **27** into contact with the wet paper web **30** formed on the web-forming surface, water expressed from the web **30** and the felt **27** may be received within the recesses. It is not essential that all of the water expressed from the web **30** and the felt **27** during pickup be received within these recesses but only an amount of such water sufficient to prevent the creation of a harmful imbalance of hydraulic pressure within the web **30** such that the web **30** is pressed into the interstices of forming wire **18** or the web **30** is disrupted or its integrity is disturbed due to movement of water within the web **30** in the plane of the web.

In operation, the pickup roll of the invention makes possible the removal of water from the web through closely spaced areas on the surface of the web adjacent the pickup felt, as well as through similar areas on the surface of the web adjacent the web-forming surface, as the web is pressed between the web-forming surface and the pickup felt. This minimizes the flow of water through and within the web in the plane of the web, thereby reducing or eliminating any hydraulic force or imbalance in the web and the problems associated therewith.

It should be clearly understood that the function of the pickup felt and the pickup roll is the pickup and transfer of a wet paper web from a web-forming surface to the pickup felt, and is not the removal of water from the web. In this regard, the purpose and manner of operation of the roll and the felt are different than those of the similarly constructed rolls used at press positions through a papermaking machine for water removal. Generally, only about 3% to about 4% by weight of the water in a web is removed at the pickup position whereas up to about 60% by weight of the water in a web is commonly removed at a press position.

However, some similar problems occur at the pickup position as occur at the press position, even in spite of the tremendously different pressures experienced at each point, largely because of the substantial amounts of water present, carried both on the web-forming wire and the pickup felt. Hydraulic pressures build up in the felt if the water contained therein has no place to travel, and these pressures build up even though the void volume of the felt is only partially filled with water, if the air in the remainder of the void volume is trapped due to backing of the felt by a solid, impervious pickup roll shell. Thus, pickup rolls of the invention reduce or eliminate this trapping of air and/or water in the felt, and the resultant pressure buildup which is believed to cause many of the problems discussed above. In addition, it has been found that such pickup rolls accomplish pickup and transfer of wet paper webs in a more reliable manner.

Pickup rolls in accordance with the invention preferably have, in any particular surface segment thereof, recesses of a number, size and distribution such that they provide a void volume sufficient to receive water which is expressed from areas of the felt overlying that surface segment as the felt passes through the nip. As a guide, noticeable improvement can be observed with a cylindrical outer surface having a void volume of between about 10% and 200% of the void volume of the portion of the pickup felt momentarily in wrapping engagement therewith. It is preferable that such recesses are vented to areas outside the nip as this prevents any buildup of presure due to air entrapped in such recesses and slightly compressed due to water flowing into the recesses. Venting is provided where the recesses are circumferential grooves, for example. However, provision for venting is not essential to obtain the benefits and advantages of the method and apparatus of the invention.

Even though the web **30** is substantially formed prior to pickup, it still contains a considerable amount of water, on the order of 92% by weight of the wet paper web **30**. Additional water travels with the web-forming wire **18** and more is contained within the pickup felt **27** also. The web **30** is quite fragile at this point as little if any interfiber bonding has occured. It is believed that rapid movement of water within the web **30** in the pickup nip, due to hydraulic forces generated during pressing, tends to disrupt the web somewhat. In addition if the pickup felt **27** is somewhat wet before contacting the web **30** and lacks capacity to receive additional water from the wet paper web **30**, some of the water from the web **30** is driven toward the forming wire **18** and the force of this also embeds the web **30** in the forming wire **18** making it difficult to release when pickup and transfer occurs. This is believed to at least contribute to, if not cause, "drop-off" problems where holes are created in the web **30** due to failure of portions of the web to transfer. Such drop-off problems are reduced or eliminated when a pickup roll **28** constructed in accordance with the invention is utilized behind the pickup felt **27** to guide and press it into engagement with the wet paper web **30** to be transferred.

FIG. 2 illustrates a preferred form of pickup roll **28** in accordance with the invention. The surface of this pickup roll **28** has a plurality of fine recesses in the form of generally circumferentially aligned and spaced-apart grooves **31** which may be in the form of separate grooves or one continuous helical groove. The latter is preferred for ease of formation of the roll. The roll is generally formed by a rigid center **33** of metal wrapped by an outer layer **34** of rubber into which a desired pattern is cut. The rubber employed is preferably fairly hard so as to provide a long-wearing surface, and has a hardness of between about bone hard and about 200 P & J plastometer reading.

FIG. 2–A is a greatly enlarged fragmentary sectional view illustrating the nature of the surface of the pickup roll **28** shown in FIG. 2. Thus, the surface of the roll **28** contains a plurality of alternating generally circumferentially aligned grooves **31** and ridges **32**. The ridges **32** should be of such a size, number, and spacing one from another that they will support the pickup felt **27** during pressure contact with the wet paper web **30** without buckling of the web **30** and the felt **27** in areas overlying the grooves **31** sufficient to cause shadow marking. These criteria will of course vary depending upon such factors as the nip pressures between the felt and the web, and the basis weight of the web being transferred.

Additionally, the grooves **31** in any particular surface segment of the roll **28** are preferably of a number, size and distribution such that they provide a void volume sufficient to receive water which is expressed from areas of the felt **27** overlying that surface segment as the felt **27** passes through the nip. This insures that hydraulic forces generated within the web **30** as it passes through the nip between the pickup felt **27** and the web-forming surface **18** will be substantially reduced or eliminated. It has also been found that when pickup is accomplished at speeds heretofor unobtainable under commercial operations, this method and apparatus substantially reduces or eliminates drop-off problems where holes or other defects were heretofor formed in the web **30** being transferred due to failure to transfer segments of the web which adhered to the web-forming surface **18**.

The precise configuration and spacing of the grooves has not been found to be critical. However, grooves of a rectangular cross-section have been found quite easy to cut into a roll surface. Such grooves typically have a depth of from about 0.010 to about 0.10 inch, a width of from about 0.010 to about 0.075 inch, and are spaced from one another by a distance equal to the width of the land area or ridge between them of from about 0.020 to about 0.15 inch.

FIG. 3 is a perspective view of an alternative form of pickup roll **28** in accordance with the invention, the nature of the surface of which is shown in FIG. 3–A. The surface of this roll **28** has a multitude of small holes **35** drilled radially inwardly of the roll surface and is normally referred to as a blind drilled roll. The holes may be of suitable depth, diameter and spacing to provide the desired void volume while leaving sufficient land area adjacent the holes to support the felt **27** in a manner preventing buckling of the felt **27** into the holes **35** in areas thereof overlying the holes **35**. Such rolls typically have holes of from about $\frac{3}{32}$ to about $\frac{3}{16}$ inch in diameter, with depths of from about 0.5 to about 1.5 inch, and spaced from one another (center to center) by a distance of from about 0.25 to about 0.50 inch.

FIG. 4–A is a perspective view of a still further embodiment of the pickup roll **27** of the invention in which a conventional pickup roll **28** having a smooth surface, preferably a hard rubber outer layer, is wrapped by a woven wire or screen **36** formed of strands of metal or plastic material. The screen **36** may be of any one of a variety of types of weave and relative coarseness but should possess sufficient void volume in the interstices between the strands **37** thereof to prevent drop-off problems in accordance with the invention. Of course, the screen **36** should not be so coarse as to impart a pattern

of embossing to the wet paper web **30** through the felt **27**.

It has been found preferable for the recesses provided in the surface described above to be of sufficient size, number and distribution such that they give any particular portion of the outer cylindrical surface of the pickup roll **28** a void volume of from about 10% to about 200% of the void volume of the portion of the pickup felt **27** momentarily in wrapping engagement with that portion of the surface. That is, the portion of the felt **27** running against the roll surface is considered without regard to actual contact as, of course, the felt **27** does not actually engage the bottom portions of the recesses but rather it bridges the recesses.

FIGS. 5 and 6 are sectional views taken along line **5—5** of FIG. 1. FIG. 5 illustrates the phenomena occurring during maximum compression of the wet paper web **30** in the pickup nip in an arrangement of apparatus of conventional construction, that is, when a smooth-surfaced pickup roll **28** without surface recesses is employed. Here it can be seen that water **40** is held in the cells **15** of the forming roll by partial vacuum exerted from the suction box **22** within shell **11**. In addition flow of water in the web **30** caused by the pressure exerted at the pickup nip is promoted largely in one direction, indicated by the vector line **41** from the web **30** into the forming wire **18**. In addition, water flows within the web **30** in the plane of the web **30** in a number of directions depending upon hydraulic pressures within various areas of the web, the magnitude of such flows being generally indicated by vector lines **42** and **43**. Probably the greatest flow of water in the plane of the web occurs as the web passes beneath the line of greatest pressure within the nip as portions of the web which have passed through the nip have slightly less water and, because of the release of pressure, have lower hydraulic pressures. Some flow occurs in the direction of vector line **44**, toward the felt, the amount of such flow depending upon the amount of water removed from the felt prior to its passage through the pickup nip. However, this flow is limited in amount to the void volume of the felt which in any practical operation is quite limited as most of it has been filled by water already.

The flow of water in the directions indicated by the vector lines **41–44**, and the hydraulic forces exerted on the web thereby, tends to force the web **30** into the interstices of the forming wire **18** so that it becomes somewhat entangled with the forming wire **18** or at least more securely gripped by the forming wire **18**, and also causes any bonds between portions or fibers of the web **30** to be broken by frictional forces of the water moving through the web **30**. The result is that portions of the web **30** will be only weakly attached to the remainder of the web **30** and the entire web **30** will be generally more firmly attached to the forming wire **18** resulting in failure of at least portions of the web **30** to transfer and sometimes failure of the complete web **30** to transfer to the pickup felt **27**.

FIG. 6 illustrates, by means of a sectional view of apparatus similar to that of FIG. 5 but with a pickup rol in accordance with the invention, the nature of water flow in accordance with the invention. It can be seen that the relieved surface of the pickup roll **28**, that is, the plurality of grooves **31** in the pickup roll **28** permit water carried within the web **30** to be moved substantially as freely toward the pickup roll **28** and into grooves **31**, as indicated by vector line **44**, as they move toward the forming wire **18**, as indicated by the vector line **41**, so that hydraulic forces caused by water moving from the web **30** into the forming wire **18** are substantially reduced or eliminated. By the same token, movement of water within the web **30** in the plane of the web **30**, as indicated by vector lines **42** and **43**, is substantially reduced or eliminated since the more closely packed fibers in the web **30** present a greater resistance to water movement than that presented by either the felt **27** backed by the recessed surface of the pickup roll **28** or the forming wire **18**.

This arrangement results in an improved web **30** in that the forces within the web exerted by hydraulic pressure are sufficiently low or non-existent so that no crushing occurs. In addition, the flow of water from the web **30** toward the forming wire **18**, as indicated by vector line **41** is substantially reduced, thereby reducing the force tending to press the web **30** into the forming wire **30**, making it easier to remove and reducing or eliminating drop-off problems.

In each of the above embodiments, a pickup roll **28** having a recessed surface in accordance with the invention has been employed in conjunction with a forming roll type of papermaking machine as described with reference to FIG. 1. The advantages of a pickup roll **28** of the type described above with this type of papermaking machine can clearly be seen over the use of a conventional pickup roll having a solid, unrelieved surface. On the other hand, it should be clearly apparent that a suction pickup roll sometimes employed with other types of papermaking machines would be unsuitable for use with the forming roll type of machine described above since the application of a partial vacuum thereby through the pickup felt **27** to assist pickup and transfer of the wet paper web **30** would result in the premature withdrawal of water held within the receptors or cells **15** of the forming roll **10** before pickup and removal of the wet paper web **30** formed thereon. This causes disruption if not destruction of a web being transferred. As pointed out above, one of the primary features of the type of papermaking machine described with reference to FIG. 1 is the accurate removal of water from the paper stock to form a web, where the water is held in an outer peripheral segment of the forming roll within receptors or cells **15** by partial vacuum from within the forming roll **10** and then released into a well-defined and controlled path in a direction away from the surface of the recently formed wet paper web **30** which has been picked up and transferred.

However, the apparatus of the invention may be advantageously employed in connection with the pickup and transfer of a wet paper web from any one of many other types of papermaking machines, for example, from the Fourdrinier wire of a Fourdrinier type of papermaking machine. The pickup arrnagement may involve either a hard pickup or a soft pickup, with improved results being obtained at higher speeds in either arrangement. That is, when used in conjunction with a Fourdrinier wire in either a hard pickup or a soft pickup arrnagement, the apparatus of the invention reduces or eliminates drop-off problems experienced at the upper limits of speed of operation of these machines.

FIG. 7 illlustrates a typical arrangement of apparatus on a Fourdrinier type of papermaking machine in which a soft pickup is used. In this instance, a felt **27** is pressed into contact with a wet paper web **30** carried on a Fourdrinier wire **45** by means of a rotatably mounted pickup roll **28**. The Fourdrinier wire **45** is moving in the direction indicated by arrow **46** and is contacted by the felt **27** along a transverse area in a stretch of the wire **45** running between a wire turning roll **47** and a lower couch roll **48**.

FIG. 8 is a greatly enlarged sectional view taken along line **8—8** of FIG. 7 and illustrates the flow of water within the web **30** when a conventional pickup roll **28** having a solid, smooth surface is employed. Again, in a manner similar to that illustrated in FIG. 5, it can be seen that the web **30** is pressed firmly into engagement with and into the interstices of the Fourdrinier wire **45** by flow of water in the direction of vector line **41** in a manner making its pickup and transfer more difficult. In addition,

hydraulic forces generated within the web **30** due to the compression of the felt **27** and web **30** during pickup force the substantial amounts of water involved through the Fourdrinier wire **45** as well as causing water to move within the web in the plane of the web **30**, as shown by vector lines **42** and **43**. The latter movement of water in the plane of web **30** tends to cause bonds between areas of the web to be broken and lines of weakness to be formed, causing drop-off problems and imparting other defects to the web. Very little movement occurs in the direction indicated by vector line **44**, that is, toward the felt, as indicated with reference to FIG. 5, and for the same reasons.

FIG. 9 is a greatly enlarged sectional view similar to FIG. 8 but illustrating apparatus of the invention in which a pickup roll **28** having a relieved or recessed surface is employed behind the felt **27** to guide and press it into movement with the wet paper web **30** carried on the Fourdrinier wire **45**. In a manner similar to that described with reference to FIG. 6 it can be seen that hydraulic forces within the web in any one direction, stemming from the flow of water within and through the web as indicated by vector lines **41** through **44**, are reduced or eliminated due to the ability of the water within the web **30** and the felt **27** to freely move into the recesses or grooves **31** in the surface of the pickup roll **28**.

There has accordingly been shown and described herein a new and improved method and apparatus for removing a wet paper web from a web-forming surface and for transferring it to a remote position. It is apparent from the above description that the invention provides novel pickup means including a pickup roll having an outer cylindrical surface containing recesses in its outer surface which supports the pickup felt. As indicated above, the use of this form of pickup means enables the operation of papermaking apparatus at a higher speed while reducing or eliminating crushing and drop-off problems.

From the above description of the invention, it will be apparent that various modifications in the method and apparatus described in detail herein may be made within the scope of the invention. Thus, the size, number, shape and distribution of the plurality of fine recesses in the outer cylindrical surface of the pickup roll might be varied quite widely depending upon many factors mentioned above and others well known to those skilled in the art. In addition, such pickup rolls might have a construction different from any of the structures shown and described above. Therefore, the invention is not to be limited to the specific details of the apparatus described herein, except as may be required by the following claims.

We claim:

1. In a papermaking machine, apparatus for removing a wet paper web from a web-forming surface and for transforming it to a remote position, comprising

a looped pickup felt, and

a pickup roll adapted to press said looped pickup felt into contact with the wet paper web formed on said web-forming surface,

said pickup roll having an outer cylindrical surface having a plurality of alternating generally circumferentially aligned grooves and ridges, said ridges presenting to said pickup felt smooth generally cylindrical closely axially spaced land areas for supporting the pickup felt to bridge said gooves, and said grooves being vented to ambient atmosphere at the on-running and off-running sides of the line of contact between the wet paper web and the pickup felt.

2. Apparatus according to claim **1**, wherein said web-forming surface comprises a Fourdrinier wire.

3. Apparatus according to claim **2**, wherein said pickup roll is adapted to press said looped pickup felt into contact with the wet paper web carried on the Fourdrinier wire within a stretch of the wire running between two support rolls.

4. Apparatus according to claim **1**, wherein at least the outer layer of said pickup roll containing said recesses comprises a resilient material.

5. Apparatus according to claim **4**, wherein said resilient material has a hardness of between about bone hard and about 200 P & J plastometer reading.

6. Apparatus according to claim **1**, wherein said grooves have an axial dimension at the roll periphery of between about 0.010 inch and about 0.075 inch, and said ridges have an axial dimension at the roll periphery of between about 0.020 inch and about 0.15 inch.

7. In a papermaking machine comprising a hollow cylindrical shell having a plurality of receptors therein communicating with the outer periphery of the shell and with the interior of the shell, a web-forming wire disposed on and completely encircling the periphery of the shell outwardly of the receptors, a slice having top and bottom lips to convey a slurry of water and fibers to the outer surface of the forming wire, pickup means adjacent the wire beyond the slice to remove the web from the wire, vacuum means within the shell between said bottom slice lip and said pickup means to withdraw water from the slurry through the wire into the receptors thus forming a web of fibers on the wire and to hold water in said receptors, said vacuum means being constructed and arranged to release the water in said receptors to permit that water to move outwardly through the forming wire under centrifugal force after the web has been removed from the wire, the improvement wherein

said pickup means comprise a looped pickup felt and a pickup roll adapted to guide said looped pickup felt into engagement with said web formed on said forming wire, said pickup roll having an outer cylindrical surface having a plurality of alternating generally circumferentially aligned grooves and ridges, said ridges presenting to said pickup felt smooth generally cylindrical closely axially spaced land areas for supporting the pickup felt to bridge said grooves, and said grooves being vented to ambient atmosphere at the on-running and off-running sides of the line of contact between the wet paper web and the pickup felt.

8. The improvement in a papermaking machine according to claim **7**, wherein at least the outer layer of said pickup roll containing said recesses comprises a resilient material.

9. The improvement in a papermaking machine according to claim **8**, wherein said resilient material has a hardness of between about bone hard and about 200 P & J plastometer reading.

10. The improvement in a papermaking machine according to claim **7**, wherein said grooves have an axial dimension at the roll periphery of between about 0.010 inch and about 0.75 inch, and said ridges have an axial dimension at the roll periphery of between about 0.020 inch and about 0.15 inch.

11. In a papermaking machine, comprising a Fourdrinier wire loop, a plurality of rotatably mounted rolls supporting said wire loop for movement along the path of said loop, at least one of said rolls being driven, a slice having top and bottom lips to convey a slurry of water and fibers to the outer surface of said Fourdrinier wire loop, and pickup means adjacent the wire beyond the slice to remove the web from the wire and to transfer it to a remote position, the improvement wherein

said pickup means comprise a looped pickup felt and a pickup roll adapted to press said looped pickup felt into contact with the web formed on said wire, said pickup roll having an outer cylindrical surface having a plurality of alternating generally circumferentially aligned grooves and ridges, said ridges presenting to said pickup felt smooth generally cylindrical closely axially spaced land areas for supporting the pickup

felt to bridge said grooves, and said grooves being vented to ambient atmosphere at the on-running and off-running sides of the line of contact between the wet paper web and the pickup felt.

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