Aug. 3, 1965 E. J. JUSTUS 3,198,693

SCAVENGING MEANS FOR GROOVED PRESS ROLLS

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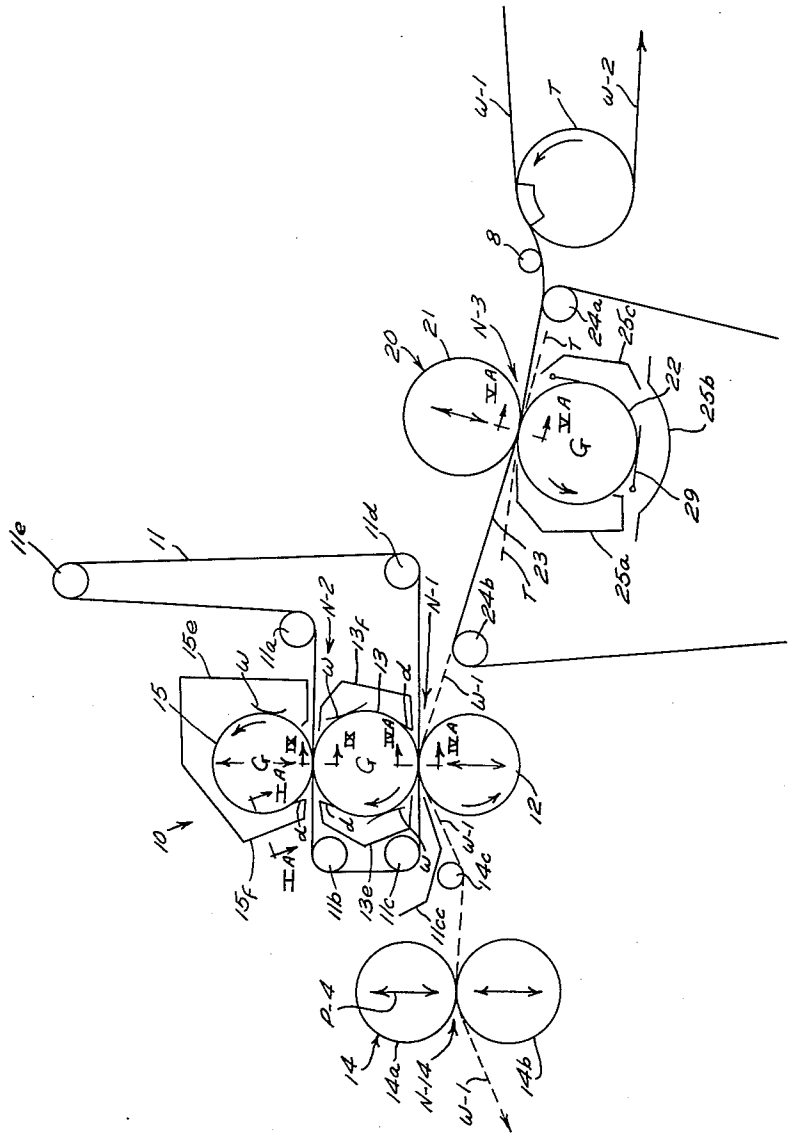


FIG. 1

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FIG. 1A

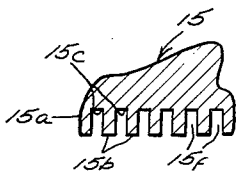


FIG. 2 (PRIOR ART)

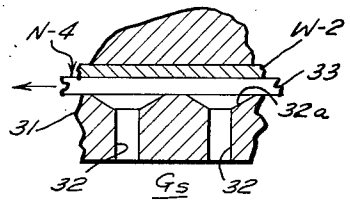


FIG. 3 (PRIOR ART)

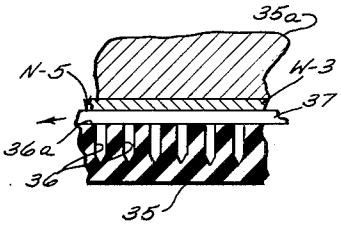


FIG. 4

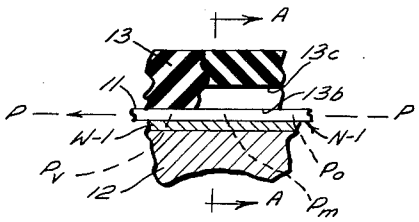


FIG. 4A

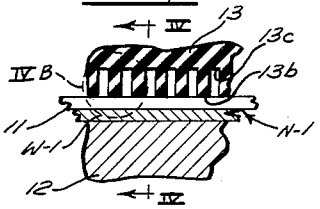


FIG. 4B

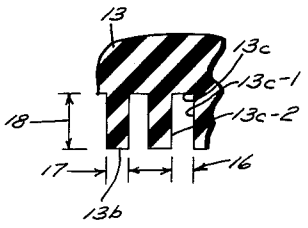


FIG. 5A

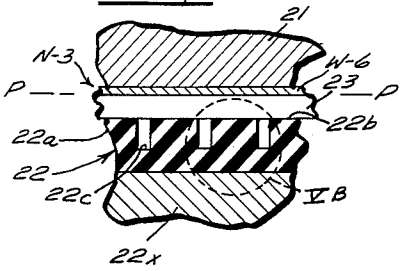
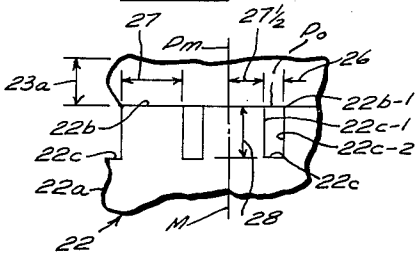


FIG. 5B



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SCAVENGING MEANS FOR GROOVED PRESS ROLLS

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FIG. 6

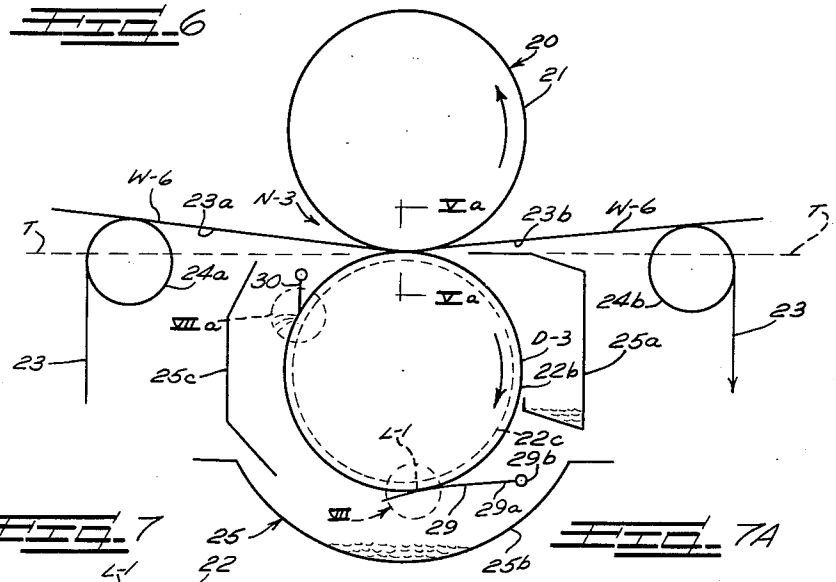


FIG. 7

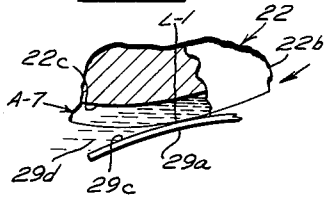


FIG. 7A

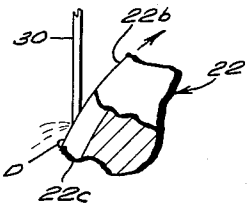


FIG. 9

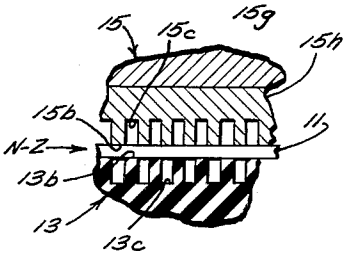


FIG. 9A

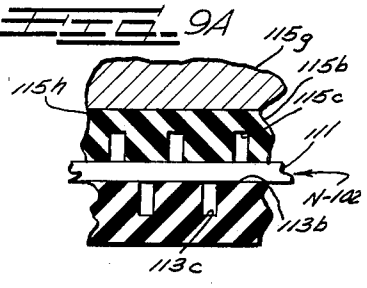
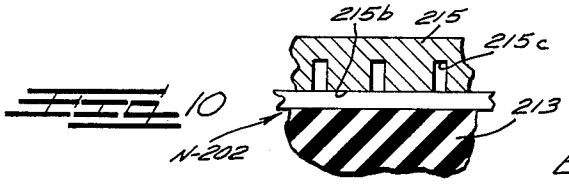


FIG. 10



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FIG. 7B

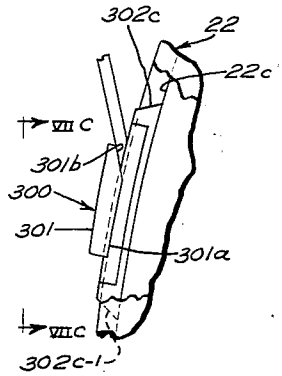


FIG. 7C

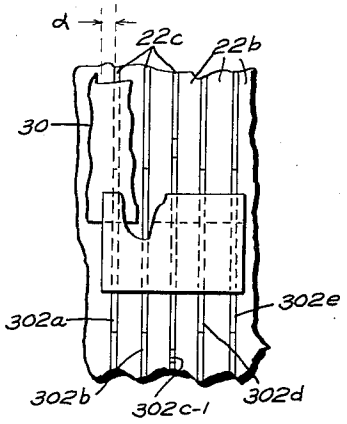


FIG. 14

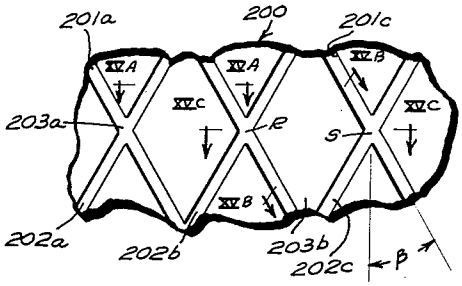


FIG. 15A

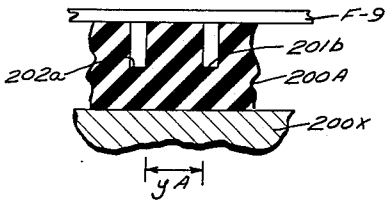


FIG. 15B

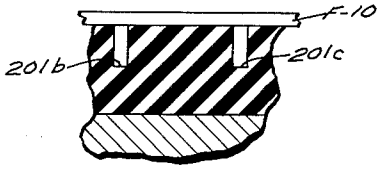
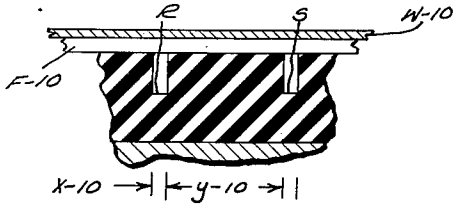


FIG. 15C



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SCAVENGING MEANS FOR GROOVED PRESS ROLLS

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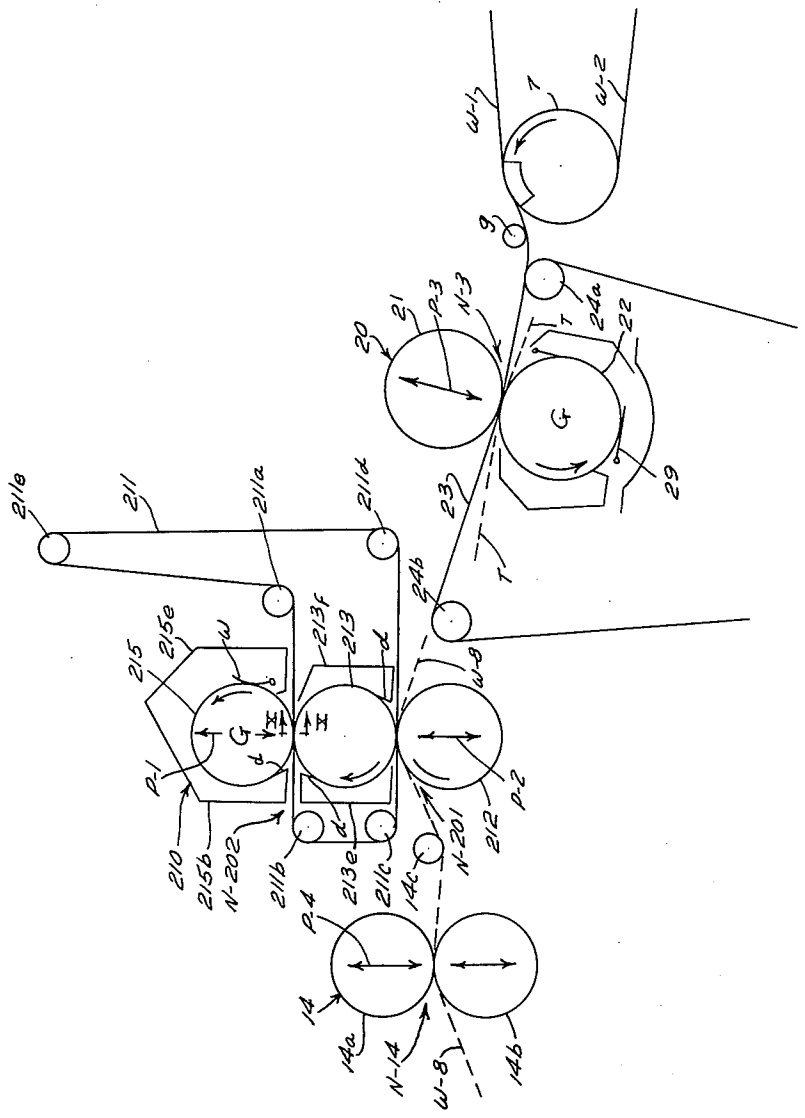


FIG. 8

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Aug. 3, 1965 E. J. JUSTUS 3,198,693

SCAVENGING MEANS FOR GROOVED PRESS ROLLS

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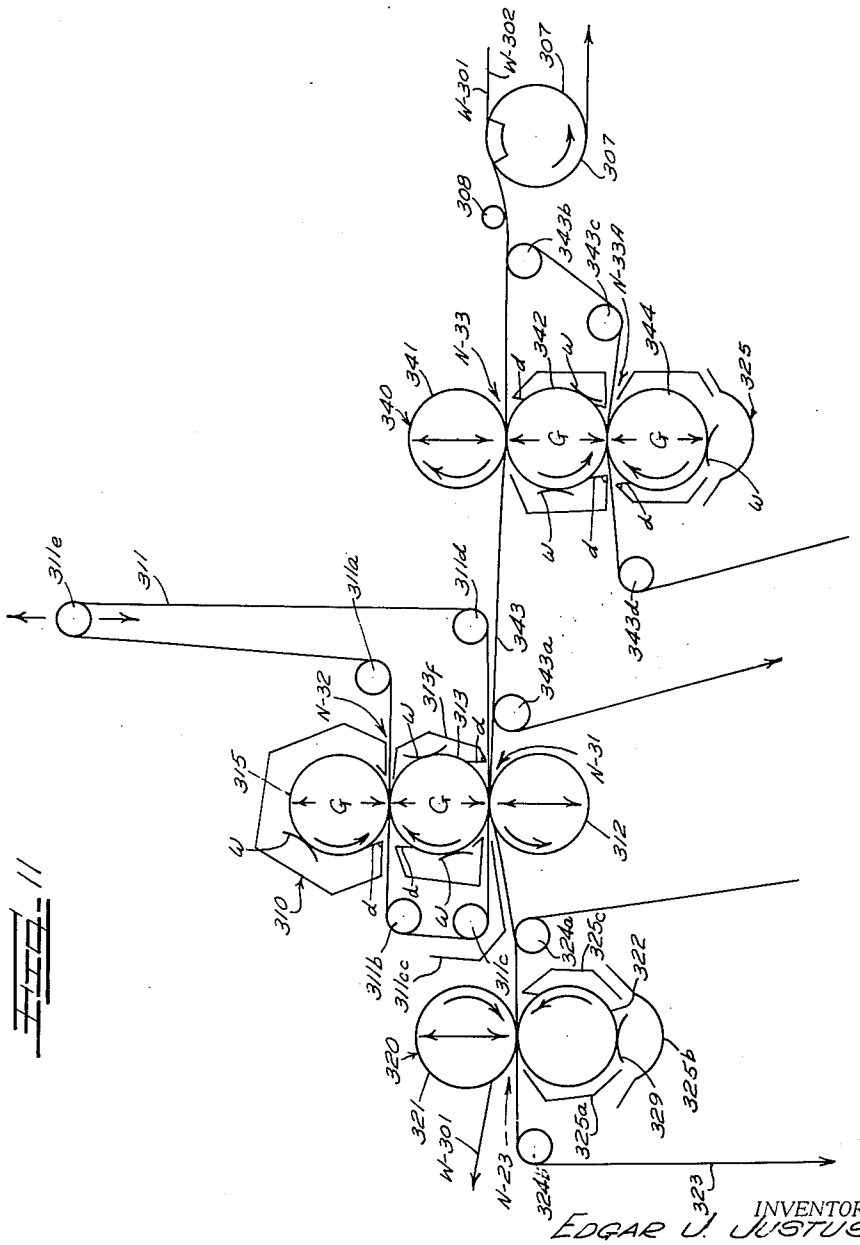


FIG. 11

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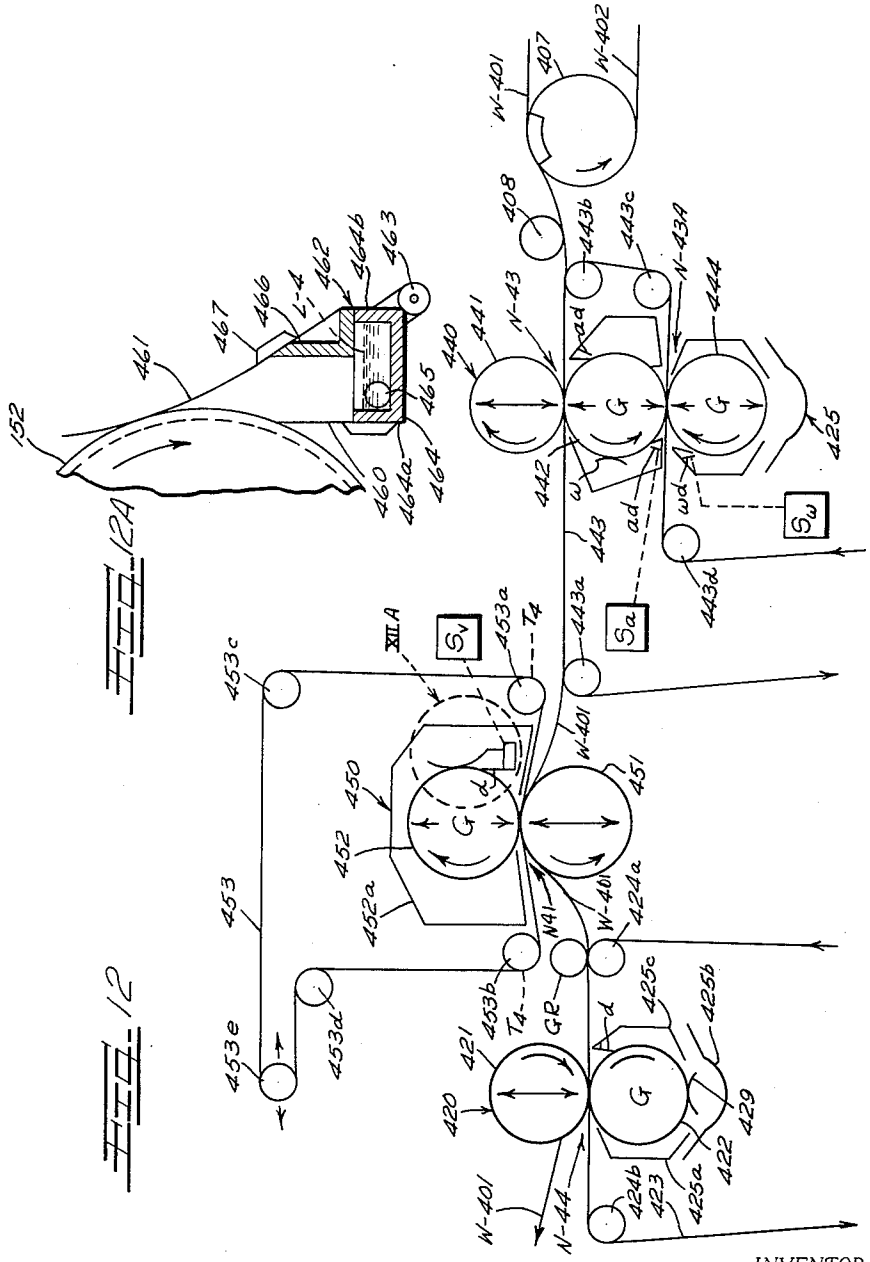


FIG. 12A

FIG. 12

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SCAVENGING MEANS FOR GROOVED PRESS ROLLS

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FIG. 13

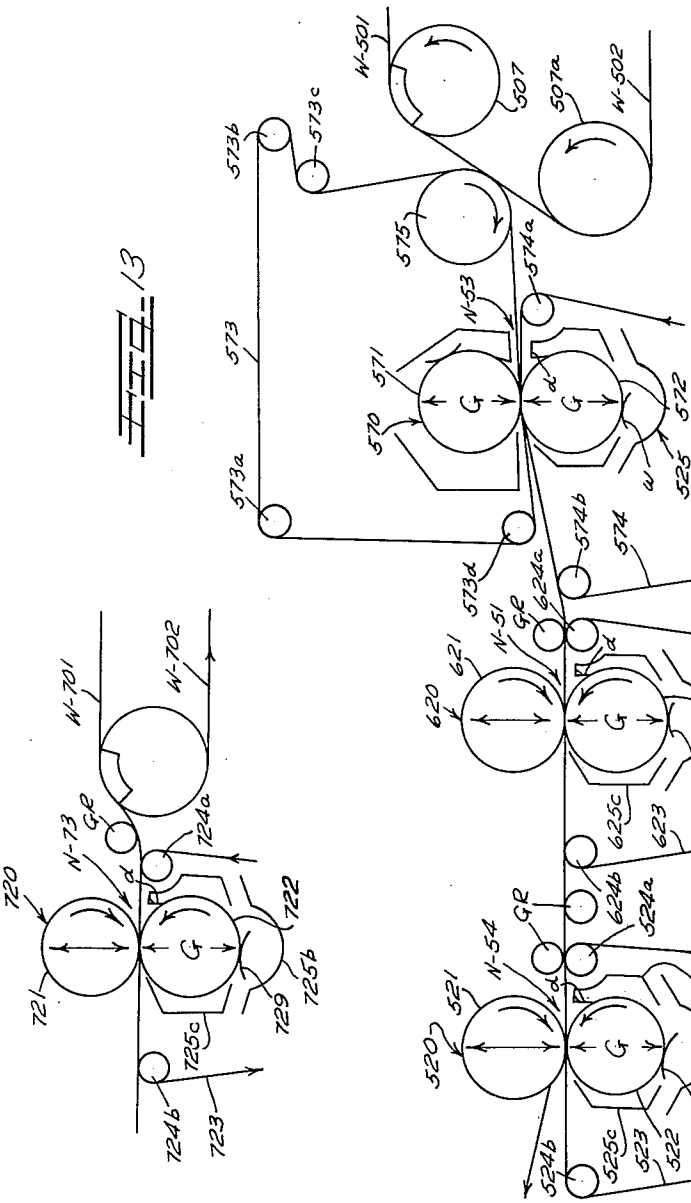


FIG. 13A

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United States Patent Office 3,198,693 Patented Aug. 3, 1965

3,198,693

SCAVENGING MEANS FOR GROOVED PRESS ROLLS

Edgar J. Justus, Beloit, Wis., assignor to Beloit Corporation, Beloit, Wis., a corporation of Wisconsin

Filed Aug. 21, 1964, Ser. No. 391,160
15 Claims. (Cl. 162—272)

This case is directed to scavenging means and devices for use with grooved rolls to clean the narrow grooves, continuously or intermittently, while the grooved press roll is in operation; and this case is a continuation-in-part of my applications Serial Nos. 214,589, filed August 3, 1962; Serial No. 258,391, filed February 14, 1963; 302,423, filed August 15, 1963; 305,713, filed August 30, 1963; 302,371, filed August 15, 1963; 302,270, filed August 15,1963; 302,422, filed August 15, 1963; 302,421, filed August 15, 1963; 305,992, filed September 3, 1963; and 378,217, filed June 26, 1964.

The present invention relates to an improvement in devices for removing liquid from a liquid-containing web material, and more particularly, to improved paper machine presses.

Although the instant invention may have a number of uses in different fields, it is used to particular advantage in the art of paper making and will be described primarily in connection therewith. In a web press, as used in a paper machine, a "web" nip is formed between opposed press rolls, and a traveling paper web in engagement with a felt is passed through the nip. In prior art structures, the press rolls used have been plain, or the roll covered by the felt at the nip may be provided with a perforate shell having a suction gland opposite the nip for aiding in the removal of moisture from the web through the felt, as in the case of the conventional suction press. In other instances, as indicated in Walker U.S. Patent No. 3,023,805, the felt covered press roll may be provided with an imperforate shell having a blind drilled rubber cover thereon for at least temporarily receiving water expressed from the web and through the felt at the web nip. In still other web presses, the felt covered press roll may be provided with other types of "blind" recesses or fine porous structure, or structures in the form of a woven wire or fabric wrap on the roll cover or surface portion of rolls provided with imperforate shells, and in such instances the felt ordinarily functions as a drying felt for the web and carries away a substantial amount if not all of the water that is to be removed from the web at the web nip. This then requires a separate procedure and/or apparatus for dewatering the felt before returning the same to the web press nip. In my copending application Serial No. 214,589, filed August 3, 1962, and Serial No. 258,391, filed February 14, 1963, certain improvements in devices for dewatering the felt at a separate, felt only press nip are described in detail. In addition, certain press roll structures were described in said application for dewatering the felt at the felt only press nip in a divided press and also for assisting in dewatering the felt at the web press (i.e. assisting in removal of water from the felt that has been pressed from the web through the felt at the web press nip).

Heretofore, press arrangements have been used for attempting to remove water from the felt at the web nip. Each of these arrangements has required an alteration of structure as compared with a plain press nip, by either incorporating additional materials in the nip or modifying the plain press roll which supports the felt in the nip, for example, by replacing this roll with a suction roll. The suction roll is capable of excellent performance in certain uses, but it must be appreciated that the manufacture of the perforated suction roll shells, plus the auxiliary equipment essential to the maintenance of the desired subatmospheric pressures in the suction roll gland, is relatively expensive. Moreover, the use of the suction roll gland within the perforate suction roll shell does not make it possible to use conventional or improved anti-deflection roll means mounted within the interior of the shell for maintenance of the most uniform nip pressures. The relatively large size of the suction roll perforations (plus the pressure differential created by the suction gland at the suction roll periphery) facilitates water removal from the felt, but in situations involving the use of lightweight felts and/or the production of comparatively sensitive paper webs or high quality papers webs, there is a tendency for the webs to develop what is known as "shadow marking" as a result of such suction roll perforations, even though they are covered by a felt at the suction press nip.

In the more recently developed so-called "divided press", efforts have been made to dispense with the use of the suction press roll at the web press nip, by replacing the same with a plain press roll or with rolls of this general type having imperforate press roll shells but covered with a myriad of blind drilled holes, small blind recesses, pores, etc. These rolls with such recesses thereon are employed primarily to avoid overloading the web press nip with water and to permit a portion of the water load to be received in the recesses at the nip, although the water load in the recesses is generally returned substantially to the felt at the off-running side of the web nip. Various other press roll means, including suction press rolls, are then employed at a separate felt only press to dewater the felt to the extent necessary to prepare it for reentrance into the web press nip in such divided press structure. The instant invention is directed to improvements not only in the web press structure but also in the felt only press structure, which are brought about primarily by the use of certain grooved press rolls in these press structures. A significant advantage of such press rolls, having generally peripherally or circumferentially aligned grooves, is that the roll surfaces at the press nips are vented via the grooves to ambient atmosphere so as to facilitate the dewatering function of the press roll at the press nip. It will be appreciated that in such a grooved press roll, the grooves are applied to an imperforate shell which is capable of mounting with anti-deflection means and without expensive auxiliary suction roll equipment. Still other significant advantages are obtained by the use of specific grooved roll structures and auxiliary equipment which will be described in greater detail herein.

The instant invention thus has as its primary object the provision of an improved press assembly for the removal of liquid from a liquid-containing web material (which might be a moist felt alone or a felt and web combination).

Another object of the instant invention is to provide an improved divided press structure wherein the press rolls at the web press and/or the felt only press have improved structure and function.

Yet another object of the instant invention is to provide an improved press structure wherein the advantages of anti-deflection roll mountings may be used, inexpensive roll structures are used, and simplified structures are provided for water removal from a moist web or felt material and/or from the surface of the press roll itself.

A further object of the instant invention is to provide an improved grooved press roll structure, that is inexpensive to manufacture, particularly useful and reliable in its water removal function, and readily maintained in functional operation. An additional object of the inven-

tion includes the provision of improved devices for cooperation with such grooved roll to clean and maintain the same, dewater the same during operation, and take advantage of the improved dewatering function of the same.

Other and further objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawings attached hereto and made a part hereof.

On the drawings:

FIGURE 1 is an essentially diagrammatic side elevational view of a press mechanism embodying the instant invention;

FIGURE 1A is a fragmentary detail view taken substantially along the line A—A of FIGURE 1;

FIGURE 2 is a fragmentary detail sectional view showing a portion of a suction press nip of the prior art;

FIGURE 3 is a view comparable to FIGURE 2 showing a portion of a press nip embodying blind drilled holes in one roll, as used in the prior art;

FIGURE 4 is a view comparable to FIGURES 2 and 3, but showing a portion of a press nip embodying the instant invention;

FIGURE 4A is a fragmentary detail sectional elevational view taken substantially along the line A—A of FIGURE 4;

FIGURE 4B is a sectional fragmentary enlargement taken substantially at the encircled portion designated IVB in FIGURE 4A;

FIGURE 5A is a fragmentary sectional elevational view comparable to that of FIGURE 4A but taken substantially along the line VA—VA of FIGURES 1 and 6 showing another embodiment of the instant invention;

FIGURE 5B is a fragmentary enlargement taken from FIGURE 5A at substantially the encircled portion marked VB;

FIGURES 6, 8, 11, 12, 13 and 13A are essentially diagrammatic elevational views of press assemblies embodying the instant invention;

FIGURES 7 and 7A are enlarged fragmentary detail views taken substantially from the encircled portions of FIGURE 6 marked VII and VIIA, respectively;

FIGURE 7B is a slight enlargement of the view of FIGURE 7A showing a cleaning device of the invention and FIGURE 7C is a view of FIGURE 7B taken along the line VIIC—VIIC;

FIGURE 9 is a fragmentary secetional elevational view taken substantially along the line IX—IX of FIGURE 1;

FIGURE 9A represents an improved embodiment in a view comparable to FIGURE 9;

FIGURE 10 is a fragmentary sectional elevational view taken substantially along the line X—X of FIGURE 8;

FIGURE 12A is an enlarged fragmentary detail view taken from the encircled portion marked XIII of FIGURE 12;

FIGURE 14 is a top plan view of another grooved press roll design concept, the use of which involves certain principles of the invention; and

FIGURES 15A, 15B and 15C are essentially fragmentary detail views taken, respectively, along the lines XVA—XVA, XVB—XVB and XVC—XVC of FIGURE 14.

As shown on the drawings:

Referring to FIGURE 1, it will be seen that this figure shows a press section wherein a paper web W–1 is processed after it is removed from a forming wire W–2 turning about a couch roll 7. The paper web W–1 passes through a very short open draw beneath a web guide roll 8 and then through a first press 20, a second press 10 and a third press 14 in the sequence shown in FIGURE 1. It will be noted that the first press 20 is composed of an upper plain roll 21 and a lower grooved roll 22 in a press assembly which is shown (from the reverse side of the machine) in FIGURE 6 hereof in considerable detail and will be discussed in detail in connection therewith.

The second press 10 is composed of a vertical stack of rolls 12, 13 and 15, which rolls are generally superimposed or mounted one above the other in the manner indicated in FIGURE 1, but are preferably in the substantially vertical stack arrangement shown in FIGURE 1. In the second press 10, the rolls 13 and 15 are grooved press rolls which will be described in detail hereinafter.

The web W–1 passes from the second press 10 beneath another web guide roll indicated generally at 14*c* and into the third press nip N–14, which could, if desired, have the general structure of the first press 20, but which may also be defined merely by a pair of plain rolls 14*a* and 14*b* as shown in FIGURE 1, when the function of the third press 14 is primarily that of further smoothing or finishing the wet paper web rather than effecting substantial additional dewatering thereof. If the additional dewatering were desired, then the third press 14 could be replaced by a third press having the structure of the first press 20, so that the advantages of dewatering the web further, using a grooved roll in a press, could be obtained.

Referring first specifically to the three roll divided press assembly 10 of FIGURE 1, it will be seen that there is provided a felt 11 mounted on guide rolls 11*a*, 11*b*, 11*c*, 11*d* and a tensioning roll 11*e*. The paper web W–1 enters the nip N–1 of the press 10 at what is called a "web nip" N–1 with the felt 11 which is wrapped around the middle grooved roll 13 of the press assembly 10. At the off-running side of the nip N–1 the felt 11 is guided generally tangentially from the nip N–2 and away from the web W–1 which follows the lower plain roll 12 briefly and is then guided away from the plain roll 12.

The press roll 13 is within the loop of the felt 11 and the press rolls 12 and 15 are outside of the loop of the felt 11 and the two press rolls 13 and 15, define a felt only press nip N–2 whereat the felt 11 is dewatered to the extent desired and necessary to prepare it for re-entry into the web nip N–1 for further dewatering of the traveling web W–1.

Both the middle press roll 13 and the upper press roll 15 are formed of a generally imperforate shell or base structure (such as in the case of the prior art blind drilled rolls such as are shown in Walker U.S. Patent No. 3,023,805, and my aforesaid applications recited herein, the disclosures of which are incorporated herein by reference.

The press rolls 13 and 15 are thus contrasted to the conventional perforate suction roll (which has perforations such as are indicated in FIGURE 2 hereof), and the rolls 13 and 15 have a cover containing a plurality of fine water-retaining recesses between land areas which support the felt 11 at the nips N–1 and N–2 respectively.

More specifically, referring to FIGURE 1A, the cover structure for the rolls 13 and 15, which is indicated in cross section at 15*a* in FIGURE 1A, comprises a plurality of peripherally (or generally circumferentially) aligned land areas 15*b* with relatively fine or narrow grooves 15*c* between the land areas for receiving the water from the felt 11 at the nip (e.g. at the nip N–2 for the roll 15). It will be appreciated that the land areas 15*b* are of sufficient width and the grooves 15*c* are sufficiently narrow to permit the felt 11 to be readily supported at the nip N–2 (or at the corresponding nip N–1 by the roll 13), so that water may be expressed under superatmospheric pressure from the felt 11 into the grooves 15*c*, but the felt 11 itself will not be pressed into the grooves 15*c* to any significant extent; and in the case of the nip N–1, the felt 11 will not be deformed or otherwise temporarily modified in passing through the nip N–1 so as to cause substantial or significant shadow

marking on the web W–1 as a result of the land and groove pattern on the surface of the roll 13.

Referring first briefly to FIGURE 9, which shows a fragmentary cross sectional view (in the cross-machine direction) of the nip N–2, which is the felt only nip, it will be seen that the felt indicated in full view at 11 for purposes of simplifying the drawing is pressed between the land areas 15*b* and the land areas 13*b* of the two grooved press rolls; and it will further be seen that the land areas are offset or out of alignment to some extent for better control of water removal. The sizes of the grooves 13*c* and 15*c* are, of course, exaggerated in the view of FIGURE 9, but it will be apparent that the grooves 13*c* and 15*c* provide ample space for water to be expressed from the felt 11 and because this is a felt only press nip N–2 any nominal deformity or change in configuration of the felt 11 at the nip N–2, so long as it does not unduly accelerate the wear of the felt 11, can be tolerated because there is no web in this felt only nip N–2 and there is no problem of marking of the web. The pair of grooved rolls 13 and 15 may thus be used to maximum advantage in the felt only nip N–2 for the most effective control of water removal to the extent desired at the felt only nip N–2.

Referring also briefly to the auxiliary equipment which will be described in considerably greater detail in connection with FIGURE 6, it will be seen that the grooved roll 13 is so mounted that the grooved surface thereof moves away from the web nip N-1 toward a close running saveall indicated at 13*c* diagrammatically, the grooves then pass beneath a wiper sheet *w* and then past a doctor *d* which wipes the land areas dry at the immediate oncoming side of the felt only nip N–2. At the off-running side of the felt only nip N–2, the grooved surface of the roll 13 again passes beneath a close running saveall 13*f*, under another pumping type of wiper *w* and then past still another doctor *d* to dry the land areas at the immediate oncoming side of the felt and web nip N–1.

Referring briefly to the auxiliary equipment of the grooved roll 15, it will be seen that the grooved surface of the roll 15 is moved away from the felt 11 generally tangentially aligned with the felt only nip N–2 past a close running saveall 15*e*, past a pumping wiper *w* at the uprunning side of the grooved roll 51 and then around to a doctor *d* carried in a saveall section 15*f* at the downrunning side of the grooved roll 15 immediately ahead of the felt only nip N–2 to dry the land areas just before the land areas come into contact with the felt 11 at the felt only nip N–2.

In this respect, it should be noted that herein the "longitudinal" direction will always be the direction of travel of the web or felt or other article referred to in connection with this direction; whereas the "transverse" or "cross-machine" direction will be at right angles to the longitudinal direction generally in the plane of the felt or web referred to. With respect to each nip (e.g. N–1 or N–2) the "oncoming" side of the nip is the side of the nip which the traveling web and/or felt approach; whereas the off-running side of the nip is the longitudinal direction from the oncoming side of any given nip and it is at the side of the nip where the web or the felt travels longitudinally away from the nip. Likewise, the oncoming or off-running sides of any piece of auxiliary equipment, such as the doctor *d* for the roll 15 will be, respectively, the direction from which the rotating surface of the roll approaches and the direction toward which the rotating surface of the roll leaves such doctor *d*. Thus, for example, the pumping wiper *w* for the grooved roll 15 is positioned at the off-running side of the felt only nip N–2, but actually at the oncoming side of the doctor *d*, which in turn is at the oncoming side of the nip N–2. In each of the drawings hereof, the arrowheads indicate the direction of travel of elements on which such arrowheads are placed.

Referring again briefly to FIGURE 9, it will be seen that the grooved roll 15 is indicated therein as being a metal roll (actually having a steel shell 15*g* with a stainless steel cover 15*h*) and the grooved roll 13 is indicated as being formed of a metal shell (not shown) with a rubber cover in which the appropriate grooves have been cut. It will be appreciated that it is definitely preferred to provide press nips with at least one of the press rolls having a resilient rubber or similar type of solid elastomer cover thereon to minimize the chances of damage to the machinery. In the practice of the instant invention, it will further be appreciated that the grooved roll 13 is shown here as being the roll with the resilient rubber surface, so the plain roll 12 then is a relatively non-resilient granite or "Microrok" roll. It will further be appreciated, however, that the roll 12 in another embodiment of the instant invention is a plain roll having a rubber cover and in such instance the roll 13 will be provided with a stainless steel cover and the roll 15 could optionally be provided with a rubber cover.

Referring now to FIGURE 4A and FIGURE 4, it will be seen that FIGURE 4A is a detail sectional view comparable to FIGURE 1A, except that it is taken generally along the line IVA—IVA of FIGURE 1 at the nip N–1, so as to show fragmentarily the roll 12, the roll 13, the web W–1 (all in section) and the felt 11 in full view for simplification of the drawing. It will be seen that the roll 13, like the roll 15 of FIGURE 1A is provided with substantially equally sized and formed grooves 13*c* and land areas 13*b* (which form the generally cylindrical peripheral surfaces of ridges also designated by the reference numeral 13*b*). FIGURE 4 is another fragmentary detail sectional view taken substantially along the line IV—IV of FIGURE 4A and FIGURE 4 shows the upper roll 12, the lower roll 13 (with parts shown in section and parts broken away), the web W–1 and the felt 11 (in full view, with an arrow indicating the longitudinal direction). The groove 13*c* is indicated in FIGURE 4 as part of the alternating generally circumferentially aligned ridges 13*b* and grooves 13*c* on the roll 13, but the detail of FIGURE 4 is taken of such a small overall portion of the press assembly that the curvatures of the rolls 12 and 13, as well as the bottoms of the grooves 13*c* are not emphasized. Referring to FIGURE 4B, however, it will be seen that the grooves 13*c* each have a very small or narrow axial dimension 16 at the mouth or peripheral portion thereof aligned with the generally cylindrical exterior surfaces 13*b* or land areas of the ridges, which ridge land areas have an axial dimension 17 that is shown in FIGURE 4B to be substantially the same as the axial dimension 16 of the grooves 13*c* at the outer periphery or mouths thereof. It will also be seen that the grooves 13*c* are defined between generally radial walls 13*c*–1 and 13*c*–2 which extend in generally parallel relationship spaced apart at least the axial dimension 16 for a substantial radial distance of their depth 18 which is greater than the axial dimension of the mouths of the grooves 16 and the axial dimension 17 of the land areas (in fact, being substantially twice either the axial dimension 16 or 17).

Referring now to FIGURE 6, it will be seen that (the run of the felt and web W–6, shown from the back side of the machine of FIGURE 1 does not conform exactly to the run of the web W–1, hence the different reference numeral, and) there is shown a press assembly indicated generally by the reference numeral 20 in FIGURE 6 which is a significant improvement over the embodiments of the invention indicated hereinbefore at the nips N–1 and N–2 of FIGURE 1. The press assembly 20 comprises an upper plain press roll 21 comparable in structure to the plain press roll 12, and a lower grooved press roll 22 comparable in some respects to the grooved press rolls 13 and 15 hereinbefore described. The press rolls 21 and 22 define a press nip N–3 which receives a moist web W–6 engaging the plain press roll 21 carried on a felt 23 trained

over guide rolls 24*a* and 24*b*, which felt 23 travels with the web W–6 in contact therewith at the oncoming side, at the pressure area, and at the off-running side of the nip N–3, as here shown. The grooved roll 22 is provided with saveall indicated generally at 25 and shown with three sections 25*a*, 25*b* and 25*c*.

The grooved roll 22 is shown in fragmentary detail in FIGURES 5A and 5B (FIGURE 5A being taken substantially along the line VA—VA of FIGURE 6), and it will be seen that the grooved roll 22 is provided with a solid elastomer (rubber) cover 22*a* on an imperforate ductile iron shell 22*x*. The cover 22*a* may and preferably in certain cases is formed of stainless steel which will also permit the cutting of fine grooves 22*c* between land areas 22*b*, in the dimension and configuration shown in FIGURES 5A and 5B. Referring more specifically to FIGURE 5B, it will be seen that the cover 22*a* of the grooved roll 22 is indicated in a view without section lines for ease in detailing the description thereof. The grooves 22*c* are here shown having a substantially uniform axial dimension 26 that is 0.025 inch between generally cylindrical (smooth) land areas 22*b* on ridges alternating with the grooves 22*c*, with such land areas 22*b* having an axial dimension 27 that is 0.100 inch, or substantially four times the groove mouth axial dimension 26, thereby giving an open area on the surface of the grooved roll 22 of substantially 20%. The grooves 22*c* extend radially inward to a depth 28 of ⅛ inch (or 0.125 inch) which is greater than both the groove axial dimension 26 and the land area axial dimension 27, and such groove 22*c* thus has a volume value expressed in the cross sectional view of FIGURE 5B as equal to 5 times the square of the groove mouth width, or $5x^2$, if x is the groove mouth width herein numbered 26. Such groove 22*c* is defined between generally radially extending, parallel walls 22*c*–1 and 22*c*–2, which are axially spaced the distance 26 of the axial groove mouth dimension or greater than that distance (by not more than about 100% because of the undesirability of undercutting the land areas 22*b*), so that water entering the peripheral mouths of the groove 22*c* will not be restricted in its flow radially inwardly into the groove 22*c*.

Referring again to FIGURE 6, it will be seen that the water expressed from the web W–6 through the felt 23 at he nip N–3 is received in the grooves 22*c* of the grooved roll 20 (each of which grooves 22*c* is vented directly to ambient atmospheric pressure on both the oncoming and off-running sides of the nip N–3) and to a substantial extent such expressed water is carried away from the felt 23 at the off-running side of the nip N–3. The first saveall section 25*a* is mounted in substantially the closest practical running relation with the off-running felt 23 and the off-running side of the roll 22 so as to capture droplets of water thrown by centrifugal force from the grooves 22*c* at the immediate off-running side of the nip N–3. The grooves 22*c* resist the tendency for centrifugal force to throw such droplets away from the roll 22, however, particularly at slower operating speeds. At higher operating speeds of 500 feet per minute and above, however, the tendency of the narrow grooves 22*c* to resist the release of water from the roll 22 because of centrifugal force is at least partly overcome and the saveall portion 25*a* functions to minimize rewetting of the underside of the web W–6 in this respect.

A substantial amount of water, however, remains entrapped in the narrow grooves 22*c* in the grooved roll 20 until this roll passes past a wiper 29, which is unique in its simplicity (and is indicated diagrammatically merely with reference letter "W" in other views), consisting merely of a generally flat sheet of moderately resilient material such as metal sheet 29*a* secured to a transverse cross bar 29*b* and urged as a continuously transverse sheet against the land areas 22*b* on the periphery of the roll 22. The wiper sheet 29*a* thus does not enter into the grooves 22*c* but merely presents a surface that is axially continuous for the transverse peripheral dimension of the roll 22 along the generally transverse line of contact (i.e. actually a limited peripheral area of contact), L–1, whereat the wiper 29 extends axially continuously from the off-running side of such line of contact L–1 so as to separate or diverge slowly from the off-running periphery of the grooved roll 22 so as to effect, by pumping action, a drawing of the water in the grooves 22*c* (which is actually swept out of the grooves 22*c* by air rushing in to fill the partial vacuum created by the pumping action of the wiper 29). The water in the grooves which has been held therein in resistance to the combination of centrifugal and gravitational forces at the down-running side of the grooved roll 22 is thus substantially swept out of the grooves 22*c* and to a substantial extent into the second, bottom saveall portion 25*b*.

Some of the water thus drawn from the grooves 22*c* remains on the land areas (as a meniscus), and the mist or droplets of water generally present in the immediate vicinity of high speed press rolls in paper machines will also tend to deposit on the land areas 22*b* of the uprunning side of the grooved roll 22, and such water on the land areas 22*b* is then removed by a conventional doctor means, preferably merely in the form of a conventional doctor blade 30 (which is indicated diagrammatically merely by the reference letter "*d*" in other views), which at high speeds will actually throw water droplets away from the roll surface as indicated in FIGURE 6 and against the third saveall portion 25*c* feeding into the bottom saveall portion 25*b*. The doctor blade 30 thus provides a doctor means in close proximity to the oncoming side of the nip N–3 to dry the land areas. Preferably the doctor means 30 coacts with the land areas 22*b* within what constitutes at least the last 120°, and preferably the last 90° of travel of the grooved roll 22 approaching the nip N–3, so that the land areas 22*b* will be dry at the immediate oncoming side of the nip N–3. If some droplets of water are driven by the doctor 30 from the land areas 22*b* into the bottom of the grooves 22*c*, it has been found that the particular function of the grooved roll 22 is not significantly impaired, whereas retention of moisture on the land areas 22*b* does make a significant difference in the operation of the grooved roll 22, for reasons which will be described in detail hereinafter.

Theory and advantages of invention

Although this particular case is concerned primarily with scavenging means for removing water from and/or otherwise keeping the grooves clean (and also keeping the land areas clean), the theory of the press system itself is important. As previously indicated, certain aspects of the embodiment of the invention shown in FIGURE 6 (which is the first press 20 of FIGURE 1) involve significant and distinct improvements over other aspects of the embodiment of the invention shown in the second press 10 of FIGURE 1; and although it is not desired to limit the invention to any particular theory, it is believed that certain theoretical considerations will explain the superiority of the embodiments of both FIGURES 1 and 6 over the prior art.

Grooved rolls in the art of pressing paper webs were considered and discarded several generations ago. For example, in 1915, U.S. Patent No. 1,123,388 issued to Schaaning and was directed to a grooved press roll allegedly intended to replace felt covered rolls and having grooves of such configuration that Schaaning alleged that they would retain water by capillary action. As early as 1905, Fletcher (U.S. Patent No. 800,845) proposed a grooved roll made of certain segmental portions. In the 1920's, Goodfellow (U.S. Patent No. 1,369,335) proposed a press roll with circumferential grooves as well as generally axial grooves interrupting the circumferential continuity of land areas, which were covered with the felt; and Wagner issued U.S. Patent No. 1,483,562 relating to grooved rolls used with a pair of press felts for cooperation with certain suction mechanisms outside of the press rolls. Wagner U.S. Patent No. 1,321,958 shows grooved rollers in a

couching mechanism. Wagner U.S. Patent No. 1,520,489 relates to a grooved jacketed roll. Wagner U.S. Patent No. 1,517,036 relates to a pair of press rollers intended to press a traveling paper web with their bare unprotected surfaces, with one of such rollers having grooves in the surface thereof. Wagner U.S. Patent No. 1,552,098 shows very shallow as well as narrow grooves intended to dewater pulp entering the same.

As late as 1958, however, Wagner issued U.S. Patent No. 2,858,747 which was directed to grooved press rolls functioning with a suction device mounted outside of the roll shell with sealing elements extending into the grooves; but with occasional exceptions such as this in the patent art, it will be found that substantially the entire paper making industry devoted its attention to the perforate shell type of suction roll for water removal at a press nip, once this structure was discovered and introduced in the industry. In fact, for the past thirty or forty years the drilled perforte shell type suction roll has been used predominantly and practically exclusively in the paper making industry for the removal of water in any significant quantities from moist paper webs in paper making machine press assemblies.

As indicated in FIGURE 2 hereof, in the suction press nip N–4, the roll shell 31 is "perforate," being provided with a multiplicity of holes 32, 32 of substantial size (i.e. at least about ¼ inch in diameter but sometimes smaller and usually having flared peripheral mouths 32*a* of greater size) which are drilled entirely through the roll shell 21 (having at least about 1 inch thickness) to communicate with the suction gland G_s extending the full width of the roll shell 31 interiorly opposite the nip N–4. At the suction press nip N–4, a press felt 33 is interposed between the web W–2 and the perforate suction roll shell 31 (primarily as a water-permeable protective layer for the web W–2), and water expressed from the web W–2 passes completely through the felt 33 and into these holes 32, 32 in the perforate shell 31. Some water continues into the gland G_s and some is usually retained in these holes 32, 32 at the off-running side of the nip N–4, where the subatmospheric pressure in the gland G_s tends to counteract centrifugal forces urging water droplets back out of the holes 32, 32 and against the felt 33 under ambient atmospheric pressure. The felt 33 may thus remain in contact with the web W–2 at such off-running side of the nip N–4 without substantial rewetting of the web W–2 (via water thrown back on the felt 33 from the suction roll holes 32, 32). Also, savealls (not shown) are conventionally positioned between the felt 33 and the perforate roll shell 31 at the immediate off-running side of the gland G_s to catch droplets released from the suction roll holes 32, 32, particularly after these holes pass beyond the limit (i.e., the off-running seal, not shown) of the interior suction gland G so there is no longer a pressure differential holding the droplets in the holes 32, 32. The off-running felt 31 must be guided to avoid such saveall and this often results in guiding the felt with or against the web at the off-running side of the nip N–4. The perforate suction roll with its suction gland, and with or without the saveall, thus functions to carry away substantially all of the water expressed from the web at the nip.

In spite of the excellence of the performance of perforate suction rolls for a number of uses in paper making, it must be conceded that these rolls and their auxiliary equipment are expensive to manufacture. The suction gland therein, also, substantially precludes the use of conventional anti-deflection roll structures for greater versatility and uniformity in nip pressure control. In addition, the substantial size of the perforation mouths 32, coupled with the pressure differential created by the suction gland against the unsupported portions of the felt 33 opposite such perforations 32, has a tendency to cause "shadow marking" of the web in certain instances.

Only in recent times, after many years of commercial use of perforate suction rolls, there has been developed what is referred to by applicant and his co-workers as the "divided press" type of structure which does not require the use of the perforate suction roll at the web press. In the divided press, the felt alone is cleaned, dewatered and conditioned at a separate press nip, and then fed with the moist web into what is called a "web" nip which is defined between rolls having imperforate shells (as contrasted to the perforate suction roll shells). As indicated in FIGURE 3, ordinarily the amount of water load at such a "web" nip N–5 is such that at least one of the press rolls 32, 35*a* is provided with recesses 36 on the surface thereof to temporarily take the load of water entering the web nip N–5 to prevent "crushing" of the web W–3 carried by the felt 37. As indicated in FIGURE 3, a preferred form of such recess 36 is provided by a rubber cover on a press roll 35 that contains a myriad of comparatively fine blind drilled holes (i.e. of approximately 1/16 to ¼ inch or even less diameter, as in the case of Walker U.S. Patent No. 3,023,805); and such fine holes 36, 36 will in the case of most conventional webs W–3 and felts 37 substantially avoid or eliminate the "shadow marking" characteristic of the performance of certain perforate suction rolls, but sometimes plugging of these fine holes presents problems. In the divided press, the water removal principle is substantially different. The water is not carried away from the nip N–4 by the suction roll shell 31 and, instead, the water pressed from the web W–3 into the felt 37 is carried away from the web W–3 substantially entirely by the felt 37 at the off-running side of the nip N–5. Excess water at the nip N–5 which is driven into the blind hole perforations 36, 36 to relieve the load at the nip N–5, ordinarily entraps a certain amount of air in the bottom of these blind perforations 36, 36 and this, coupled with the ability of the felt to absorb water when it expands at the off-running side of the nip N–5, results in a substantial removal of water from the system via the felt 37 which, as previously mentioned, is then passed through a felt only press where it is dewatered to the extent desired at a separate press nip. The principle of the water removal at the web press nip N–5 of the divided press also involves what amounts to a comparatively good force balance at the nip itself, whereat the web W–3 is squeezed so that it is dewatered but it is squeezed against a felt 37 that is maintained on a substantial amount of land area 36A inbetween the mouths of the myriad of perforations 36, 36 and the perforations 36, 36 are filled with water under a considerable amount of pressure (particularly when air is entrapped in the bottom of the blind holes 36, 36) so that the bridging or unsupported felt areas at the nip N–5 corresponding to perforation openings of as much as ⅛ or ¼ of an inch in diameter (or even less than ⅛ inch) are actually very well supported from beneath and there is little significant evidence of lack of support for such felt areas in the resulting pressed web W–3 ordinarily (i.e. little, if any, evidence in the form of "shadow marking"). In addition, the imperforate shells 35, 35*a* effectively defining the web press nip N–5 of such construction that they lend themselves readily to support by various anti-deflection means, so that the web press N–5 is afforded substantial advantages in versatility of nip pressure control and maintenance of generally uniform axial nip loads.

The grooved roll structure employed in the instant invention, however, as exemplified in the embodiments of FIGURES 4, 4A and 4B, as well as the improvements thereon represented in FIGURES 5A, 5B and 8 is based upon still another different and distinct fundamental principle of water removal at press nips. For one thing, the instant invention provides a unique improvement in the divided press assembly (FIGURE 1) whereby a grooved roll is used in the place of the roll 35 described in connection with FIGURE 3 (or as will be explained here-

inafter at the felt only nip) so as to obtain either a number of distinct advantages over the divided web press structure just described (at some sacrifice in other advantages), or to obtain all of the advantages of the divided press just described, plus a number of additional advantages.

One of the essential concepts of the instant invention involves that of using a grooved roll with land areas 13*b* and 22*b* (of the FIGURE 4 and FIGURE 5 series) that are substantially circumferentially continuous so that the land areas present continuous generally cylindrical, smooth exterior or peripheral outer operating surfaces for engaging the web material or felt 11, 23 and supporting the same. Circumferentially discontinuous land areas are substantially impossible to clean during rotation of the roll. Also essential in consideration of this first concept is the use of such land areas having a very narrow axial dimension 17, 27 between the alternating grooves 13*c*, 22*c* which are also of small axial dimension 16, 26 but which are vented (peripherally) to ambient atmosphere so that water pressed at the press nips, N–1, N–2 and N–3 will have no resistance in this respect to flow through the web material or felt axially as well as radially and into such vented groove mouths (which are wide enough to readily receive the water under pressure). The grooves are provided in a size of sufficient magnitude to receive the water load at the press nip, while being vented to ambient atmosphere and thus in a manner so as not to resist flow into the grooves, by virtue primarily of the groove depth (as comprised to increased groove axial dimensions 16, 26 to accommodate increases in water load). The groove depth 18, 28 in most paper machine uses must thus be substantially greater than the groove opening 16, 26 at the roll periphery, so that the very essential venting function is accommodated. In practical embodiments of the instant invention, the ratio of groove depth 18, 28 to groove axial dimensions 16, 26 at the roll periphery is preferably at least about 2:1 and may be as much as about 10:1 or more depending upon practical, additional consideration such as roll strength, ease of cutting the groove, etc. In addition, it has been found important to make sure that the groove is able to readily receive the water load in that it is provided with side walls 13*c*–1, 13*c*–2 or 22*c*–1, 22*c*–2 which are (generally radially aligned) at least as far apart axially as the groove mouth 16, 26 for at least an initial groove depth substantially equal to the axial dimensions of 16, 26 of the groove mouth (or a minimum of about 0.05 inch, and preferably ⅛ inch) and preferably for substantially the entire groove radial dimension 18, 28. It will be seen that a minimum groove cross sectional area may be computed as $2x^2$ on the basis of the example of 0.025 inch groove width "*x*" and 0.050 inch groove depth, although a greater area is preferred in the neighborhood of $5x^2$ for a depth of 0.125 inch. This concept would permit interior groove axial dimensions greater than the mouth axial dimensions 16, 26, if the forming of the same is practical and does not subtract from the strength and other commercial considerations such as cleaning of the roll but this concept would preclude shallow tapered grooves which would be intended to resist the entrance of water therein (and/or the venting thereof) but a taper between the walls of relatively deep grooves, such that the walls would be functionally parallel (for the operating purposes described) would not be precluded.

In addition to the ability of the grooves 13*c* and 22*c* to vent to ambient atmosphere at the press nip and thus readily accommodate the receipt of water (by the roll thus contacted, touched or, in the language of the art "wrapped" by the felt), an even more important consideration has now been found to be a part of this concept, and this is the consideration which involves the use of a minimum axial dimension 17, 27 to the smooth genererally cylindrical land area on the ridges between the grooves. As indicated in FIGURE 5B, the maximum axial distance which water must travel through the felt 23 (in compressed form) is from approximately the midpoint M of the land area 22*b* to the edge of the groove 22*c* adjacent thereto. Such midpoint M lies in a generally radial plane bisecting the individual ridge and land area 22*b* and the axial distance 27½ to the groove is approximately ½ of the land area 27.

Liquid per se in any medium, such as water in the web type of medium provided by the felt 23, resists flow under any circumstances, and in the compressed felt 23, which has a dimension within the range of about 1/16 to ⅛ inch (0.0625 to 0.125 inch) the resistance to water flow is sufficiently great to cause considerable care to be taken in defining this dimension 27½ so as to maintain maximum dewatering efficiency at the nip. (Lightweight felts are often to 1/32 inch thickness; in such instances the axial land dimension 17, 27 may be 3:1 to 10:1 in relation to felt thickness.) In this respect, the axial land dimension 17, 27 should be about 25% to 200% (i.e. up to about 200% of ⅛ inch or 0.25 inch) of the radial felt thickness 23*a* in compression for the best performance in water flow axially laterally through the compressed felt and into the grooves 22*c* on either side of each land area 22*b*. The range of axial land dimension 17, 27 to felt thickness 23*a* in compression may thus be 1:5 to 3:1 but preferably is within 1:2 to 1:1.

Still another important consideration in the practice of the instant invention with respect to the axial groove dimension 16, 26 at the mouth thereof is that of "shadow marking" in the case of webs passing through the nip. It will be appreciated that shadow marking per se is not of any consequence in connection with a felt only press, nor is it a significant factor in the case of certain types of lower quality webs or in the case of certain paper machines wherein extra heavy felts are used. In such instances, it might be possible to use grooves having substantial axial dimensions 16, 26 up to as much as about ⅛ inch, above which the felt would tend to enter the grooves to too great an extent, causing unnecessary additional wear of the felt, possible plugging of the water flow and/or venting effect, etc. A careful study of this matter has revealed, however, that axial groove dimensions 16, 26 which are significantly greater than about 0.035 inch tend to cause undesirable marking on certain webs and/or the undesirable temporary entrance of the felts of most weights into the grooves under the nip load, so as to increase the wear of the felts; and a maximum groove dimension of 0.035 has been found to be a very significant cutoff point for most pressing operations. The minimum practical axial groove dimension 16, 26 which accommodates receipt of water and the essential venting function, is in the neighborhood of about 0.005 inch. As previously indicated excellent results are obtained using a groove axial dimension of substantially 0.025 inch, although more recent work indicates a distinct preference for 0.020 inch.

The foregoing venting concept which is essential to the practice of the instant invention is based upon certain fundamental theories which involve the design of grooves having the best ability to receive water and vent the nip pressure, plus the design of land areas having superior ability to effect axial or transverse flow of water through the compressed felt and into the grooves with a minimum amount of interference and a minimum amount of pressure gradient across the land areas. In the case of a web nip such pressure gradient is a function of the fluid pressure existing at the interface between the felt and the web, and it is important in pressing to vent or relieve such fluid pressure in the felt to as low a level as possible, which is best done by opening up the "back side" of the felt so that water need travel only substantially the thickness of the felt in compression to ambient atmosphere in the grooves.

Another aspect of the instant invention which has been found to be very important is that of minimizing such

flow of water through the compressed felt and into such grooves, by preparation of the land areas at the oncoming side of the nip. In this respect, attention is directed to FIGURE 7A, which shows in a transversely directed view the outer peripheral land areas 22*b* alternating between the grooves 22*c* but with droplets D of water (in the form of a meniscus) adhering to the land areas 22*b*. It will be appreciated that in the operation of paper machinery involving press sections, a substantial amount of water is being handled and this water includes droplets in mist in the air as well as the water actually remaining in droplet form on the roll surface, so that the roll surface ordinarily tends to be continuously wet. It must be appreciated, however, that any such droplet D carried on the land areas 22*b* into the nip N–3 (or N–1, N–2) is first immediately pressed into the body of the felt and then must travel the aforesaid axial dimension through the compressed felt and into the vented grooves on either side of the land area 22*b*. This is a phenomenon which is avoided in accordance with the practice of the instant invention by a very simple expedient. In FIGURE 1, the doctor means *d* (in the form of the doctor 30 of FIGURE 6) wipe such droplets off the land areas to dry the same at the oncoming side of the nips N–1, N–2 (within at least approximately about 120° at the oncoming side of the nip on the grooved press rolls, and preferably within substantially the last quarter or 90° of rotation of the groove approaching the nip). Although an "air" doctor could be used (FIGURE 12), the press assembly 20 of FIGURE 6 demonstrates the use of a more simple, sturdy, inexpensive and advantageous doctor means for accomplishing the result desired with greater ease, and without the necessity of atomizing or blowing droplets into the ambient atmosphere for redeposit on other operating members. This is done essentially by the use of the doctor blade 30 which is a conventional doctor blade in all other respects and has this advantage. It is mounted, however, at the immediate oncoming side of the nip N–3 so as to make sure that the land areas 22*b* are dry approaching the nip N–3. In this respect, it will be seen that the doctor 30 which presents what constitutes an axially continuous surface urged against (or in very close running relation to) the roll periphery is a greatly simplified structure in that it is not complicated by devices for reaching into the grooves 22*c*.

An important aspect of the invention resides in the fact that devices for reaching into the grooves 22*c* at this particular location are not essential, since the grooves 22*c* are designed with sufficient depth 28 to accommodate the return of at least a small amount of water into the nip N–3 in the grooves without interfering with the overall operation of the press 20. The important point to consider here is that of avoiding an unnecessary additional flow of water axially through the compressed felt by the introduction of water at the land areas 22*b* at the nip N–3.

Still another very important point to consider is that in the press roll 22 which is the preferred embodiment of the instant invention, the generally circumferential, alternating grooves 22*c* and ridges 22*b* are in the form of continuous spirals, as contrasted to exactly circumferentially aligned and axially spaced grooves and ridges throughout the entire roll periphery. This latter roll structure can be used in the practice of the instant invention with a number of desirable results, and the spiral grooving is distinctly superior from the point of view of manufacture and use as will be demonstrated hereinafter. Machine tools are available for cutting the desired grooves (in the form of spiral threads) on the surface of such rolls with considerably greater ease and accuracy than can be done in the practical shop operation involving the cutting of grooves that are exactly circumferential. Moreover, the doctor 30 presents an axially continuous surface which is uniquely capable of cooperating with the spiral grooving for dewatering the land areas only, whereas any device reaching into the grooves of spiral grooving could not be retained as a fixed simple functioning device such as the instant doctor 30.

Referring now to FIGURE 7, it will be seen that the wiping device 29 also provides a unique arrangement for dewatering grooved rolls generally, and particularly for dewatering the spiral groove rolls of the type just described. The wiping device 29 does not enter into the grooves 22*c*, but carries out its function of pumping water from the grooves 22*c* by virtue of its unique, simple structure and it carries out this function at the oncoming side of the doctor 30, so that it will not take water from the grooves 22*c* and put it on the land areas 22*b* such that the water will be conveyed into the nip N–3 on such land areas. In essence, the wiper 29 has an axially continuous surface portion 29*a* extending from close proximity to (actually being urged against) the roll surface 22 at the peripheral surface portions or land areas 22*b* thereof, which surface portion 29*a* extends gradually away from such roll surface or land areas 22*b* (from the region of contact L–1) so as to define with the off-running roll periphery a gradually diverging pair of surfaces for pumping liquid out of the grooves 22*c* as it moves past the wiper means 29. As indicated in FIGURE 7, the combination of centrifugal force, gravitational force and the reduced atmospheric pressure that is created at the underside 29*c* of the sheet 29*a* for the wiper 29 results in the drawing of the water (indicated at 29*d* diagrammatically) out of the grooves 22*c* and off in the general direction of the underside 29*c* of the sheet 29*a*. This is done, of course, to an appreciable extent by the sweeping or inrushing of air A–7, as indicated diagrammatically, along the peripheral surfaces of the grooves 22*c* to compensate for the partial vacuum that is being created by this pumping effect. It will be appreciated that the wiper structure thus shown is unique in its simplicity, ease of assembly, installation, operation, repair, etc., and in addition it is unique in its function with respect to generally spiral grooves 22*c* in that it will dewater the same without reaching into such grooves and thus having the inherent axial travel motion imparted to the wiper device 29 that would result from continuously riding in spiral grooves. It has been found that the fundamental and simple wiper 29 and doctor 30 structures cooperate in a unique manner in connection with the press assembly 20 for obtaining the best operating results. The doctor 30 per se has the unique function of improving the efficiency of the press at the nip N–3, and the wiper 29 per se has the unique function of drawing water out of the grooves 22*c* by a very simple structure and phenomenon. Both of these devices 29 and 30, individually and in combination, are uniquely superior for operation with the preferred spirally grooved press roll in improving the basic operation thereof.

In addition to the previously mentioned advantages of spiral grooving on the roll 22, which include the more inexpensive and foolproof cutting of such rolls on a lathe, there is a unique cooperation between the spiral land areas 22*b* and the doctor 30 and/or wiper 29 which is not injurious to the felt 23. At the nip N–3 the spiral grooves 22*c* and ridges 22*b* come into momentary contact with the felt 23 under compression (moving truly circumferentially) and for such momentary contact the grooves 22*c* and ridges 22*b* are substantially (and practically) circumferentially aligned in their travel and the axial extent of the travel is so extremely minute that no felt damage is caused thereby. Just the opposite function between the ridges 22*b* and the doctor 30 and/or wiper 29 is obtained, however, because these latter devices remain in fixed position engaging the ridges 22*b* so that their spiral (axial motion) component has the net effect of continuously cleaning, wiping and/or scraping the engaged surfaces of the doctor 30 and/or wiper 29.

In many respects, the foregoing structures of the

grooved rolls 13 and 22 are particularly useful even though the groove mouths 16, 26 may be rather substantial in size (e.g. up to 0.1 inch or more at the felt only nip N–3), even to the extent of causing some marking at one of the web nips N–2 or N–3. In the preferred embodiment of the instant invention, however, marking is avoided by the use of very narrow groove openings 16, 26, of an axial dimension that is not greater than about 0.035 inch (and preferably about 1/32 inch). This axial dimension, as a maximum, has been found to be distinctly superior for use in the practice of the instant invention. It has been found that axial dimensions significantly greater than this do not give significantly better performance in any of the ordinary uses of the instant roll, whereas such bigger axial dimensions do have a tendency to cause web marking in most instances. In the manufacture and sale of grooved press rolls for the uses contemplated in the practice of the instant invention, it has thus been found particularly desirable to maintain groove axial dimensions of 0.035 or less. Among other things, this has the advantage of avoiding any special instructions in connection with mill use by the grooved rolls, since such grooved rolls can be used at felt only presses, as well as web presses involving different felt weights and different qualities and types of webs. In fact, most recent work has indicated that a preferred maximum is about 0.020 inch with 0.1 or 0.105 inch lands (the preferred ranges being 0.020 to 0.025 inch grooves with 0.08 to 0.1 or 0.105 lands).

Within the limitations hereinbefore set forth, it will be understood that certain relationships between the grooves and ridges in the felt covered press roll (e.g. 15 of FIGURE 1) of a web press in a divided press may not be so critical because the felt 11 is adapted to carry away most of the water expressed from the web W–1 and re-wetting of the web is avoided in FIGURE 1 by guide means separating the web and felt at the immediate off-running side of the nip N–1. The ratio of axial groove dimension 16 to axial land dimension 17 is at least about 1:1 and preferably at least within the range of 1:2 to 1:3 (i.e. 1/32 inch to about 1/16 to 3/32 inch) for satisfactory removal of water from the web, which actually involves open area ranges of 50% to about 33⅓% and 33⅓% to 20–25% or less, which latter range is the preferred open area and is actually used on roll 22.

Extensive research has revealed, however, that distinctly superior performance is obtained using a substantially smaller open area of not more than about 25% (e.g. not more than 1/32 inch grooves with 3/32 inch lands). This is a significant difference between the rolls 13 and 22. This is notwithstanding the fact that an essential aspect of the invention involves ease of reception in the grooves of substantial quantities of water. The reason for the preferred open area upper limit of about 25% (and preferably 20% with the 0.025 inch grooves and 0.100 lands of FIGURE 5B) is that it has been found that this comparatively low open area does not significantly impede water removal from the web (via the felt) at the nip pressures used while it does carry out perhaps the second most important function that provides great versatility for the grooved roll of the invention. This function is that of minimizing re-wetting of the felt at the off-running side of the nip N–3. Although this function greatly assists the dewatering operation in the web (divided) press nip and reduces or minimizes the water load carried away by the felt from the web in the divided press, it is actually capable of effecting substantially all water removal (via the grooved roll at a web press nip) so as to replace a conventional suction roll web press, as indicated in FIGURE 6 (at the first nip N–3 as well as the third press nip N–14 in the particular embodiment of FIGURE 1).

Referring now to FIGURES 7B and 7C, it will be seen that an additional aspect of the instant invention involves a means for cleaning a spirally grooved roll such as the roll 22 while it is operating. This device 300 is reliable and quite simple in structure, comprising a backing member 301 which may be made of wood and which has rigidly mounted or embedded on the underside 301*a* thereof a plurality of spaced, thin, relatively short substantially parallel guide means in the form of metal strips 302*a* through 302*e*. Each of the strips 302*a* through 302*e* is adapted to ride in adjacent grooves 22*c* between the lands 22*b* on the periphery of the roll 22. The outer guides 302*a*, 302*b*, 302*d* and 302*e* are comparatively shallow in their (radial) dimension so that they do not reach the bottoms of the grooves 22*c* but merely ride therein for guiding the element 300. The central element 302*c*, however, is preferably the element which does the cleaning and this element has a greater thickness or radial dimension so that it will ride along the bottom of one of the grooves 22*c*, as indicated in FIGURE 7B and clean the same as it rides in this groove. The backing member 301 is also provided with a leading edge 301*b* which generally defines an acute angle with the backs of the guide elements 302*a*, etc. (or the general plane in which they all lie), so that the leading edge of the doctor blade 30 will fit against this leading edge 301*b* and permit relative axial movement between the doctor blade 30 and the backing member 301. In this fashion, the generally spiral grooves 22*c* will effect an axial movement of the chaser 300, as the roll 22 operates continuously urging the chaser 300 against the doctor 30. The grooves 22*c*, will of course, be positioned in the roll 22 so as to extend beyond the axial dimensions of the doctor 30 or to the complete edge of the shell for the roll 22, so that the chaser 300 can be started at one edge of the roll 22 and then taken off the doctor 30 at the opposite end of the roll 22 when the chaser 300 has traversed the full width of the roll 22 (in the transverse direction). It will be appreciated that the angle of the overall spiral of the grooves 22*c* is only a very few degrees, so that substantially straight guides 302*a*, etc. will ride easily in the grooves 22*c*, although they will be moved axially in the manner hereinbefore described, while the cleaning guide 302*c* effects the removal of undesirable material from the groove in which it rides along its leading edge indicated at 302*c*–1.

It will thus be seen that the chaser 300 is the device for cleaning continuously rotating generally cylindrical press roll shells having a peripheral surface portion presenting alternating generally circumferentially aligned grooves 22*c* and ridges 22*b*, with the grooves 22*c* defining a continuous spiral on the periphery of the roll 22. The device 300 is adapted to slidably engage the edge of the doctor 30 for relative axial movement carrying a plurality of spaced peripherally aligned parallel guide means 302*a*, *b*, etc. slidably receivable in the grooves on the roll periphery, with the guide means 302*c* engaging the bottoms of the grooves 22*c*.

It will thus be seen that the instant chaser 300 affords a unique, sturdy and foolproof device for easily cleaning the grooved (spirally grooved) rolls of the invention during operation, which can be used with any doctor blade, e.g. the doctor blade 30, or can be used with a separate guide element presenting an edge comparable to the doctor blade edge, preferably at the oncoming side of the doctor and preferably for a number of operations on the down-running side of one of the grooved rolls, so that the chaser will be urged against such device not only by the frictional or dragging effect of the grooved roll, but also by gravity and there will be less chance for the chaser to travel off the end of a doctor, when the operator is not watching, and perhaps drop into operating parts of the machinery. The skilled operator will be able to provide safeguards against such a situation, and the essential structural requirement in the cooperation between the roll and the cross piece is that the spiral groovings on the roll must extend transversely beyond the fixed cross piece or doctor, or the spiral grooves must extend to the end of the roll shell, so that the chaser de-

vice can be started and taken off without movement of the doctor or other cross piece to be used for guiding the same in axial movement.

Referring to the grooves **22***c* shown in FIGURE 7C to be substantially vertical in parallel alignment in the small portion of the roll surface shown in this view, it will be appreciated that the spiral angle or the angle of these grooves **22***c* to the centroidal axis of the roll shell should be comparatively small angle, alpha, which might be expressed for a 20 inch diameter (i.e. 10 inch radius) press roll as tangent alpha equals approximately 0.125 divided by 10, or 0.0125. The range for tangent alpha should be within about 0.003 to about 0.03, preferably It will be appreciated that spiral angles up to 20° or 30° may be used, particularly if it is desired to have the spiral grooves intersect from time to time, as explained hereinafter with reference to FIGURE 14 and the FIGURE 15 series.

In general, the simple generally circumferential grooves (with a slight helix) have already been described as being preferred for use in the practice of the invention and grooves of this type are distinctly superior for a number of reasons. Nevertheless, there may be instances when it might be desirable to use other grooved structures and such other grooved structures are indicated in FIGURE 14, in top plan view of a fragmentary, small portion of a roll surface, with the views **15A**, **15B** and **15C** indicating fragmentary sections taken in these structures.

For example, in the view of FIGURE 14, it will be seen that the roll surface indicated generally by the reference numeral **200** is provided with a first plurality of helical grooves **201***a*, **201***b*, **201***c*, etc., which are shown as having a helix angle substantially greater than that previously described in connection with the preferred generally circumferentially aligned grooves and ridges. Likewise, the structure of the roll **200** is provided with a second set of generally helical grooves indicated in part at **202***a*, **202***b* and **202***c* which have a comparable helix angle to the grooves of the 201 series, but are reversed in direction so as to intersect the grooves of the 201 series thereby obtaining generally diamond-shaped land areas indicated at **203***a* and **203***b*. It will be appreciated that the maximum axial dimension of such land areas is represented in FIGURE 15C as extending from a groove intersection R to a groove intersection S shown in plan view in FIGURE 14. The groove width of *x* compared to the land axial dimension *y* shown in FIGURE 15C is still within the scope of the instant invention, being on the average about a ratio of *x*:*y* to 1:6 or 1:7, and the groove width *x* that is adapted for use in a web press in the practice of the instant invention will still be within the groove width range hereinbefore specified (i.e. about 0.005 to about 0.035 inch). The land width *y* in FIGURE 15C is, of course, closer to the upper limit of about 0.25 inch hereinbefore specified for the land width, in order to minimize cross-machine flow in the plane of the web, here indicated diagrammatically at W–9 and thus minimize cross-machine crushing flow. The grooves of the intersections R and S are thus sufficiently close together to avoid the necessary venting to ambient atmosphere at the underside of the felt F–14 for the purposes already described herein.

In FIGURE 15B, it will be seen that the generally parallel (although slowly helical) grooves **201***b* and **201***c* have a more narrow land width *y*B therebetween in the section shown in FIGURE 15B, so that crushing flow in the web is avoided in the direction of the section line XVB—XVB for the reasons hereinbefore described. In the section of FIGURES 15A, it will further be seen that a still more narrow land area *y*A even in the cross-machine direction of the section line XVA—XVA is afforded between the grooves **202***a* and **201***b*, as there shown. It will thus be seen that the overall average land width *y* is within the parameters already set forth, and the grooves of the 201 and 202 series may thus function in the manner hereinbefore set forth, i.e. the overall open area does not exceed 33⅓% and/or the overall average land to groove ratio is 2:1 or more in the cross-machine direction. The previously described pumping wiper may also be used to remove water from the grooves of this type also, but a rotary brush such as the brush **133***x* in FIGURE 10 of my application Serial No. 378,217, filed June 26, 1964, would also be preferred for use in conjunction with the pumping type wiper in order to maintain the grooves in a relatively clean condition for best operation. Also, it will be noted that the roll itself is provided with a rubber cover **200**A on a ductile iron shell **200***x*; and in forming the surface structure indicated in FIGURE 14, it is normally necessary to run the rubber covered roll **200** through a first cutting operation to cut, for example, the helical grooves of the 201 series in one direction and then process the roll **200** a second time to cut the helical grooves of the 202 series in the opposite direction.

The grooves of the 201 and 202 series of FIGURE 14 are actually vented peripherally before and after any nip and on the underside of the felt indicated diagrammatically at F–14 at such nip and they are sufficiently narrow to carry out many of the other functions hereinbefore described. Having such a large helix angle, however, these grooves **201** and **202** are not vented to ambient atmosphere through the shortest distance, as would be the case in the previously described generally circumferential grooves.

Also, assuming that the dimensions *y*B between the generally parallel helical grooves **201***b* and **201***c* is approximately 0.1 inch and the grooves are 0.020 inch, it will be appreciated that this would (in the absence of the other set of helical grooves **202**) form a basis for an open area of 16%; but the inclusion of the other set of grooves **202** increases the open area to at least about 20%, using grooves **202** of the same size as the grooves **201**. Actually, the open area in patterns such as that of FIGURE 14 may be as much as about 33%, particularly if the machine is to be operated relatively slowly and the grooves are themselves cut with substantial volume so that they may function as water troughs. In such instances, land areas of approximately ⅔ of the total area may effect the desired pressing and the initial open area for grooves receiving water flowing away from the nip may be useful. Likewise, the land areas of maximum dimension, such as the land area *y* of FIGURE 15C may be as much as 0.3 inch in its maximum dimension. It will be appreciated that this maximum happens to be in only one particular direction (i.e. exactly the cross-machine direction) whereas the land sizes here are so small compared to the overall nip size that in a relatively slowly operating machine, the escape routes for the water to the grooves **201** or **202** may well be much shorter, as indicated in FIGURES 15A and 15B, and satisfactory venting of the upper side of the felt W–14 is readily accomplished to afford the function of water troughs for the groove system here described.

In FIGURE 6, it will be noted that the felt **23** is aligned substantially at (or preferably slightly above) a nip-tangent plane T—T at both the oncoming **23***a* and off-running **23***b* sides by means of the upper surfaces of the guide rolls **24***a*, **24***b* which are positioned on the side of the tangent plane T—T opposite the roll **22** so that the felt **23** will have minimum contact with the roll **22** (only at the nip N–23), will not tend to have portions entrapped in the grooves **22***c*, wil not tend to close off ambient atmosphere at the oncoming or off-running sides of the nip N–3, will undergo minimum wear from contact with the land edges (e.g. at **22***b*–1 of FIGURE 5B which are preferably rather sharply cut to obtain the other advantages described herein), will undergo minimum wear from the limited axial movement of the spiral lands **22***b* at the nip N-3, will permit the proper positioning of the saveall **25**, and will withdraw or receive a minimum

amount of water from the grooves 22*c* at the off-running side 23*b* of the nip N–3. The grooves 22*c*, of course, resist release of water by centrifugal force (particularly more at the uprunning or top of the roll 22 than at the downrunning side when gravity adds to the centrifugal force) but whatever is released (at D–3) is substantially thrown against the upper part of the saveall 25*a* at the immediate off-running side of the nip N–3 between the roll 22 and the felt 23*b*.

Although the travel of the felt 23*b* at the off-running side is important for many uses, the open area is still very important because some re-wetting of the felt 23*b* at the off-running side of the nip N–3 is almost instantaneous as the felt expands when the nip pressure is released and the felt is then very absorptive. At this instant the water "path" is reversed back out of the grooves 22*c* toward the most remote portion of the absorptive felt 23, which would be along the center line or plane M (FIGURE 5B) above each land 22*b*. It has now been found that in the preferred structure of the roll 22 this reversal of water travel is minimized by the use of a ratio of groove width 26 to land width 27 of a practical minimum of 1:2, and preferably 1:3 to a practical maximum of about 1:20 below which de-watering of the web and/or felt is unduly hampered at the press nip N–3 (and permits a maximum practical open area of 33⅓%, but preferably an open area from about 25% to about 10% for practical purposes).

Particularly using the combination of the foregoing (groove-to-land) ratio of 1:2 or 1:3 to 1:20, lands of substantially 0.05 to 0.15 or 0.25 inch width, and grooves of 0.01 to 0.035 inch width, one obtains an unusually versatile press roll for use throughout a press assembly (e.g. at any and preferably all of the grooved roll positions indicated in the drawings hereof). Excellent results have been obtained using substantially the exact dimensions disclosed for the roll 22 (i.e. 0.025 but preferably about 0.02 inch grooves with about 0.1 inch lands). Groove depths 28 at least sufficient to carry the water load are used, and preferably the foregoing combination includes (substantially radial) groove depths of at least about 2 to 10 times the groove width, at least about equal to the land width, and at least about 0.1 inch, with maximum groove depth being defined primarily by practical considerations, although square or rounded groove bottoms not substantially deeper than about ¼ inch are generally superior to other structures for the combination of strength, cleaning and manufacturing purposes.

Within the foregoing parameters, open areas of 33⅓% (but preferably 25%), 20% and 15% (successively) may be used in the first, second, and third web presses of a machine, taking off less water at each press (e.g. 0.020 inch grooves with 0.030 inch lands typical for 20% and 0.020 inch grooves with 0.105 inch lands typical for about 16%). Using the press roll 22 of the invention in a divided press (e.g. at the positions of the rolls 13 and 15 of FIGURE 1 with a resulting nip cross section of FIGURE 9A with corresponding parts indicated by the same reference numerals in the 100 series), one obtains advantages in moisture content control and minimized felt wear, among others. One obtains superior control of the felt condition entering the web press nip with guide means 11*a*, 11*b*, 11*c*, 11*d* maintaining the felt at least substantially tangential with the nips N–1, N–2, and with additional guide means 24*b*, 14*c* separating the web W–1 from the felt 11 at the immediate oncoming and off-running sides of the web press nip N–1 for better control of the water transfer from the web W–1 to the felt 11 and vice versa.

Referring briefly now to FIGURE 8, it will be seen that FIGURE 8 shows a somewhat different embodiment of the invention, showing an overall press assembly in a view which corresponds generally to the view of FIGURE 1. Parts shown in FIGURE 8 which are substantially identical to parts shown in FIGURE 1 are designated by the same reference numeral. Parts which do not correspond exactly to those of FIGURE 1, however (which parts are primarily in the second press designated by the reference numeral 210) are designated by reference numerals in the 200 series whenever there is a general correspondence between the parts of this second press 210 and the parts of the second press 10 of FIGURE 1. Thus the felt and guide rolls are indicated in the 211 series. Also, the stacked press rolls are designated as a Microrok plain bottom roll 212, an intermediate *plain* press roll 213 defining the web press nip N–201 which receives the web W–8 and the felt 211; and the top grooved roll 215 is indicated in FIGURE 8 as having a grooved roll surface, but this grooved roll surface is that of the previously described roll 22 (particularly with respect to the land and groove relationship). As indicated in FIGURE 10, the felt only nip N–202 is thus defined between a plain rubber covered and felt wrapped intermediate or middle roll 213 and a stainless steel clad grooved upper roll 215, having the land and groove relationship previously indicated in FIGURES 5A and 5B hereof. The advantage of this particular press assembly 210 includes the fact that the only grooved roll used 215 is a metal clad roll and the groove arrangement will thus have long wear characteristics. Another advantage is that the metal roll 213 is rubber covered so as to accommodate pressure variations from both the top and bottom. In this respect, the upper grooved roll 215 is mounted with suitable pneumatic pressure positioning and adjusting means of the type known in the art and indicated generally by the double headed arrow P–1. The lower Microrok roll 212 is also mounted by pneumatic positioning and pressure applying means of P–2 of the type now well known in the art. The middle roll 213 may thus be mounted in fixed position and the top and bottom rolls 215 and 212 may be movable for the purposes ordinarily desired in maintenance and operation.

In the arrangement of the press 210, it will be seen that the web W–8 passes through the second press nip N–201 between two plain surfaced rolls 212, 213, so that there is absolutely no opportunity for any marking whatsoever of the web W–8, but because of the divided press arrangement for the press 210, the water expressed from the web W–8 is transferred at the first press nip N–201 immediately to the off-running felt 211 which is guided away from the web W–8 and guided into the felt only nip N–202 where it is dewatered by virtue of the grooved roll 215 which is equipped with auxiliary wiper and doctor and saveall elements substantially identical to those employed with the roll 15 of the press 10 in FIGURE 1.

In addition, since it will be appreciated that a certain amount of water will have a tendency to travel on the surface of the plain intermediate roll 213, the roll 213 is provided with an off-running saveall 213*e* (with doctor *d* at the oncoming side of the felt only nip N–202), and an oncoming doctor *d* for the web nip N–201 mounted with a conventional saveall 213*f*.

It will also be noted that in the first press 20 and in the third press 14 of FIGURE 8 pneumatic positioning and pressure applying means indicated diagrammatically at P–3 and P–4 are provided for the top rolls in each of these presses (and the bottom rolls 14*b* and 22 in these two presses may thus be mounted in a comparatively more fixed position).

Another important feature of the invention involves the use of anti-deflection mounting means, which may be used in the practice of the instant invention to advantage in the mounting of either movable or fixed rolls, although there are certain advantages in mounting the fixed rolls on anti-deflection arrangements or means. Hence, fixed rolls indicated at 13, 213, 14*b* and 22 may be advantageously mounted on anti-deflection means such as are shown in U.S. Patent Nos. 2,684,122; 2,651,103; and 2,651,241. In addition, in my copending applications Serial No. 102,571, filed April 12, 1961, and Serial No.

154,801, filed November 24, 1961 (now, respectively, U.S. Patent Nos. 3,097,590 and 3,097,591), and also in my U.S. Patent No. 3,119,324, preferred embodiments of anti-deflection roll mounting means for such rolls are disclosed, and the anti-deflection roll mounting means involving mounting on rubber sandwiches on a through shaft as shown in my application Serial No. 102,571 are employed for mounting the rolls **13**, **213**, **14***b* and **22** in the embodiments illustrated herein. The deflection control oil-cover shoe system of my U.S. Patent No. 3,119,324 may instead be used in the rolls **13**, **213**, **14***b* and **22**, and such structure is used in subsequently described grooved rolls **422**, **452**, **442**, **622** and **723**, which deflection control subject matter is incorporated herein by reference.

In addition, such grooved press rolls with imperforate shells and mounted on anti-deflection means hereinbefore described, may be employed in automatic, semi-automatic or operator controlled press assemblies for varying the pressures of the various press nips and such controls may include conventional moisture content sensing devices such as the known moisture measuring (beta gauge) devices.

Referring to the grooves **22***c* which are indicated, for example, in FIGURES 5A and 5B as having a generally helical or spiral configuration (which cannot actually be shown in the views of FIGURES 5A and 5B), it will be appreciated that the spiral angle or the angle of these grooves **22** with the centroidal axis of the roll shell should be a comparatively small angle, alpha, which might be expressed for a 20 inch diameter (i.e. 10 inch radius) press roll as tangent alpha equals approximately 0.125 divided by 10, or 0.0125. The range for tangent alpha should be within about 0.003 to about 0.03, preferably. This is also the approximate range for a plurality of (continously parallel) helical grooves which may be conveniently cut in the roll surface simultaneously (such that the cross section would still look like that of the FIGURE 5 series); but as previously mentioned greater helical angles can be used (not only for the just mentioned purpose but also) when it is desired to have the grooves intersect from time to time as in the FIGURE 15 series.

It will be noted that in certain views herein (e.g. FIGURE 6) the grooves in a grooved roll are indicated diagrammatically by dashed lines whereas in other views (e.g. FIGURE 1) grooved rolls are indicated merely by a G centered or within the diagrammatic showing of the roll itself.

Also, in connection with the discussion of the rolls **13** and **15** and their relative covers, as described in connection with FIGURE 9, it will be appreciated that the versatility of the invention is represented therein in that the grooved covers or surfaces for rolls used in the practice of the instant invention are shown as being composed of either the resilient yieldable solid elastomer (i.e. rubber) cover for the roll **13** as well as the non-resilient, non-yieldable, durable, non-corrosive stainless steel cover for the roll **15**. It will be appreciated that in the case of any of the rolls used in the practice of the instant invention, which are the so-called "grooved rolls," the manufacture of such rolls involves expense substantially less than that ordinarily associated with the manufacture and installation of a suction roll, but it is still a manufacturing expense that is somewhat greater than the expense involved in the manufacture of a plain roll which is to be used as a press roll. In fact, the manufacturing expense of the instant "grooved" rolls is substantially less expensive than that of the blind drilled rolls, such as the structure indicated in FIGURE 3 hereof, even though the structures are comparable in this respect in that the cover for the roll is, in each case, applied to a generally imperforate roll shell structure which is mounted on anti-deflection means and which may be mounted also with fluid actuated mounting means or other essential equipment for press roll operation. The cutting of grooves is simply less expensive and less complicated than the drilling of the blind drilled holes.

On the other hand, it will be appreciated that, in paper making press assemblies, it is ordinarily considered practical to define press nips with at least one of the rolls having a yieldable surface, so that damage to the two rolls is minimized during operation, in the event of some operating accident which might involve passage of foreign material or even a sudden change in web or felt thickness through the nip. On the other hand, it will be appreciated that the stainless steel cladding on the surface of a normal imperforate roll shell is ordinarily more expensive than a conventional rubber cover; but the stainless steel cladding is much more durable and the somewhat greater expense which might be involved in machining the grooving therein is ordinarily more than compensated for in the practice of the instant invention by the much greater wearing life of the grooved stainless steel clad roll as compared to a grooved or rubber covered roll. Thus, the grooved roll **15** would be expected to be (and, in fact, is) much more durable in its wearing characteristics and much longer lasting in life in the operation of the press assembly than the corresponding rubber covered roll **13**; but the rubber covered roll **13** affords the distinct advantage of being the so-called yieldable or yielding roll that is between two rolls **12** and **15** which have comparatively non-yielding surfaces. This affords the additional advantage of the use of the grooved roll **13** in conjunction with a granite or Microrok roll **12**.

In FIGURE 9A, it will be seen that a view comparable to that of FIGURE 9 is shown (although slightly enlarged for purposes of clarification), but the improvement contemplated in the practice of the instant invention is shown in FIGURE 9A, in that the improved structure of land to groove area is shown in FIGURE 9A. It must be appreciated that FIGURE 9A is representative of the structure which results if FIGURE 1 is modified by the replacement of the rolls **13** and **15** with grooved rolls **113** and **115**, respectively, having the groove structure of the roll **22**, already described. It will be seen that the rolls **113** and **115** are indicated as both having rubber covered surfaces, and this is still another concept of the invention, although it will be readily appreciated that in the embodiment of FIGURE 9 the upper roll **115** may well have a stainless steel cover in place of the rubber cover **115***h* with the advantages already described. An essential aspect of the showing of the view in FIGURE 9A relates in the advantage of offsetting the grooves **115***c* and **113***c*, respectively, so that web damage at the felt only web nip N–**102** is minimized and various other advantages are achieved in load balance and the like. Also, the effective distance of one-half of the land area (corresponding to the distance **27½** of FIGURE 5B) is now cut in one-half in the arrangement of FIGURE 9A for the simple reason that the total axial dimension of land area between grooves (even though it will be between a pair of opposed grooves **115***c* and **113***c*) has been cut in half.

It must also be appreciated that whenever the grooves **113***c* and **115***c* are *truly* circumferential (as contrasted to generally spiral), the alignment of the grooves **115***c* and **113***c* in a generally offset relationship is easily done and is, of course, preferred. On the other hand, if the grooves **115***c* and **113***c* are cut in the generally spiral configuration hereinbefore described as being preferred, then the continuous maintenance of an offset relationship between the grooves of the two rolls is somewhat more difficult to accomplish in that the relationship between roll size, rotation speed, relative land to groove area relationship in each roll, and the like, must be carefully controlled so as to obtain the maintenance of a truly continuous offset relationship in the area of the press nip N–**102**. On the other hand, it will be appreciated that a substantially continuous offset relationship at the nip pressure area can readily be maintained in the arrangement shown in FIGURE 9A merely by the use of different relationships between the land and groove areas in the two rolls. Thus, the groove widths or openings

in each of the two rolls may be maintained substantially equal (or they may also be different), but the open area of the two rolls may be different and in such situations the grooves of the two rolls will generally be continuously offset at the nip area. For example, in the embodiment of FIGURE 9A, the open area for the roll **113** is substantially 20%, whereas the open area for the roll **115** is substantially 25%.

This relative relationship between the open areas of the two rolls **115** and **113** is employed, notwithstanding the fact that the grooved rolls in each case separate from the nip at which dewatering is carried out along the top side of such nip. Thus, the roll **113** separates from the location of the web nip N–1 (which for purposes of FIGURE 9A would be numbered N–**101**) along the top side of this nip, so the tendency for the roll to rewet the felt at the off-running side of the nip is somewhat greater than if the grooved roll were to be operating along the underside of the felt. It should be mentioned that the rewetting of the felt in a divided press and the subsequent possibility that the felt itself might throw water back down on the web W–1 is considered in the placing of the auxiliary saveall **11***cc* in FIGURE 1. Essentially, however, the limited open area of the roll **113** is such that this roll will retain a substantial amount of water collected at the web press nip and this water is then removed by the wiper *w* and doctor *d* in the saveall (indicated in FIGURE 1 at **13***e*). The felt will carry away an additional amount of water and this water is then removed at the felt only nip, which is indicated in FIGURE 9A as N–**102**, and wherein the open area of the upper roll **115** is approximately 5% greater than the open area of the lower roll **113** so that there is a tendency for water movement to take place primarily in the direction of the upper roll **115** and such water movement is preferred.

The movement of water in the direction thus indicated is preferred for the reason that the roll **115** is operating against the outer peripheral surface of the felt and thus the surface of the felt **111** which actually engaged the web at the earlier web nip and may thus have a tendency to pick up clay, fibers, and the like. Conditioning as well as dewatering of the felt is thus accomplished most advantageously by movement of water at least to a substantial extent from the interior of the felt **111** peripherally outwardly to the grooves of the roll **115**, to wash the outer peripheral face of the felt clean. A limited amount of dewatering in the opposite direction, is, of course, not harmful and has advantages in that a certain amount of conditioning of the inner peripheral surface of the felt loop is also desired.

Another aspect of the instant invention resides in the control of nip pressures not only at the first, second and third web press nips (i.e. N–3, N–1 and N–14, respectively of FIGURE 1) but also in control of the nip loads between a web press and the felt only press associated therewith in a divided press structure. Thus, it is preferred in the practice of the instant invention to employ an initial nip load at nip N–3 (of FIGURES 1 or 8) of about 200 pounds per lineal inch, and using an open area of about 25% on the roll **22**, so that maximum dewatering takes place without the use of maximum nip loads on the initial relatively delicate web. Next, at the second web press nip N–1, a higher nip load of 300 pounds per inch is used. Likewise, an open area of only about 20% in the grooved roll **13** is preferably used, as indicated in the arrangement described in connection with FIGURE 9A. It has previously been pointed out that the arrangement of FIGURE 9 which was described initially in connection with the roll **13** was described for purposes of showing one aspect of a grooved roll divided press arrangement embodying the instant invention and it was described initially for purposes of comparison with the superior operation of rolls having superior land to groove relationships such as the rolls **22**, **113** and **115**, etc. Nevertheless, the nip loads at the nips N–1 and N–2 will require that the felt only nip load N–2 should be at least as great as the nip load N–1 and preferably greater. The nip load used at N–2 is 325 pounds per inch. The nip load at N–**102** is also 325 pounds per lineal inch (using a nip load of 300 pounds per lineal inch for the corresponding web press nip N–**102**); whereas the nip load N–**202** in the divided press of FIGURE 8 is about 350 pounds per inch, using a web press nip load of 300 pounds per inch at N–**201**, for the reason that all of the dewatering must take place via the grooved roll **215** and the entire felt dewatering and reconditioning takes place by virute of the presence of the grooves **215***c* on the face of the roll **215**, which is employed with an open area of 20%. In such instances, the third web press nip N–**14** of FIGURE 8 may be operated as indicated, primarily as a smoothing and compacting nip between two plain rolls, or this third press nip N–**14** may be operated using a structure that is identical to the press structure **20** hereinbefore described in detail, including an upper plain press roll **21** and a lower grooved press roll **22**, with the sole exception that the lower press roll 22 would be operated with an open area of about 15% for the relatively minimum amount of mechanical dewatering required at this last nip N–**14** and for the use of maximum land area contact with the web protected by the felt, and the nip load at such last nip is thus preferably about 400 pounds per inch.

The advantages of the present invention in that a grooved roll may be substituted for a suction roll in a number of different positions, will be readily appreciated when one considers that the suction roll, because of the perforate suction roll shell and the necessary auxiliary equipment for suction rolls can be mounted for purposes of resisting deflection only by complicated and expensive mounting mechanism, if at all. Thus, in particular, in the case of the press couple **20**, a perforate suction roll in the position of the grooved roll **22** would necessarily have limitations in its operation with respect to the application of a uniform (axially applied) nip load, even though the average nip load employed at the first web press nip N–3 is comparatively low. It will further be appreciated that as the nip loads are increased, the advantages of the grooved roll become more and more apparent, for the reason that the suction roll has definite limitations in connection with the application of uniform nip loads axially at high average nip loads. Thus, if a grooved roll is used to replace the roll **14***b* at the underside of the third nip N–**14**, in the manner already described, the distinct advantage of the grooved roll over a suction roll will become readily apparent at the high nip loads used.

Referring now to the press assembly shown in FIGURE 11, it will be seen that the second web press nip N–**31** is formed of a three-roll divided press wherein the elements shown are substantially the same as those shown in second press **10** of the embodiment of FIGURE 1 and elements having the same structure and function as those shown in FIGURE 1 are designed by the same reference numeral in the 300 series. Thus, the second press is designated **310**. Also, the third press N–**23** is formed of an upper plan roll **321** and a lower grooved roll **322** having an open area of about 16% (i.e. 0.020 inch grooves with 0.105 inch lands); and the elements of the third press N–**23** which corresponds substantially in function and structure to those elements of the first press **20** of FIGURE 1 are designated by the same reference numerals in the 300 series in FIGURE 11. FIGURE 11 thus shows a press assembly wherein the third press N–**23** is also formed by press rolls which include a grooved roll **322**.

Referring now to the first web press nip N–**33** in FIG-

URE 11, it will be seen that the first press is designated generally by the reference numeral **340** and is a three-roll divided press defined by a top plain roll **341** and an intermediate grooved roll **342** contacted by a press felt **343** which carries the web W–**301** through the web press nip N–**33**. The bottom roll in **344** of the three-roll stack **340** is also a grooved roll and it defines with the intermediate roll **342** a felt only press nip N–33A. Appropriate felt guide rolls **343***a*, **343***b*, **343***c* and **343***d* maintain the felt runs in proper alignment, so that the felt **343** passes through the web nip N–**33** generally tangential to both press rolls **341** and **342**. In the case of the felt only press nip N–33A it will be seen that the guide rolls **343***c* and **343***d* are aligned so that the run of the felt **343** through the nip N–33A is generally below the tangent plane common to the two grooved rolls **342** and **344**, for the reason that minimum contact with the upper roll **342** at the off-running side of the felt only nip N–33A is desired. In this embodiment the grooved roll **342** has an open area of about 20% (i.e. 0.020 inch grooves with 0.080 inch lands) whereas the lower grooved roll **344** has a smaller open area of about 16% (i.e. 0.020 inch grooves with 0.105 inch lands) so as to provide somewhat less open area in the roll **344** which is wrapped to a slightly greater extent at the off-running side of the nip N–33A. The lower grooved roll **344** is provided with a saveall indicated generally at **325** and having substantially the structure of the saveall for the roll **322** in the third press. A double saveall arrangement is provided for the intermediate roll **343** comparable to the saveall arrangement provided for the intermediate roll **313** in the second three-roll divided press assembly of FIGURE 11. The doctors and wipers are indicated as usual. In the arrangement for the first press **340**, it will be appreciated that this press differs from, for example, the first press **20** of FIGURE 1 in that it is a divided press and is thus capable of substantial drying of the felt at the felt only press nip N–33A so as to afford removal of water from the web W–**301** via the felt **343** itself as well as the grooves in the grooved roll **342**. The divided first press **340** thus provides better control of the moisture movement in the system of the first press of the assembly, and this first press can be operated at a relatively high load of about 200 pounds per lineal inch.

Referring now to FIGURE 12, it will be seen that a first web press N–**43** is shown as being defined by substantially the same elements as are used for the first press **340** in FIGURE 11 and elements corresponding in structure and function to those shown in the first press **340** of FIGURE 11 are designated in FIGURE 1 by the same reference numerals in the 400 series except, of course, that the web nip is designated N–**43** and the felt only nip is designated N–43A. The function and operation of the first press **440** is substantially the same as that previously described for the first press **340** of FIGURE 11, except for the anti-deflection mounting for the roll **442** and the structures of the doctors. In the usual position for mechanical doctors for the middle roll **442**, there are air-doctors *ad* or axially continuous air-blast "knives" which wipe the water from the land areas. These air-doctors *ad* are connected to sources of compressed air, for example, as indicated diagrammatically at S_a. In addition, still another fluid pressure or fluid blast knife *wd* is used in the mechanical doctor position for the roll **444**, but this axially continuous fluid blast is in the form of a high pressure water blast (connected diagrammatically to a high pressure water source S_w) which when aimed as shown, much like an air knife, actually drives water droplets from the lands and leaves the lands on the roll **444** substantially dry going into the nip N–43A. The saveall **425** readily handles the water blast, or may be enlarged to do so.

Likewise, the function and operation of the third press here designated N–**44** in FIGURE 12 is substantially the same as that of the third press **320** of FIGURE 11 and parts corresponding in structure and function in FIGURE 12 are designated by the same reference numeral in the 400 series. It will be noted that the lower grooved roll **422** in the third press **420** has an open area of about 16% (i.e. 0.020 inch grooves with 0.105 inch lands) and this press **420** is operated at a top load of 450 pounds per lineal inch.

The second press, designated generally **450** in FIGURE 12, however, is defined by a lower plain roll **451** with a Microrok cover and an upper grooved roll **452** within the loop of a press felt **453** mounted on appropriate guide and tensioning rolls **453***a* through **453***e*. An appropriate saveall **452***a* is provided for the upper grooved roll **452** so as to be mounted in close running relation to the off-running side of the second web press nip N–**41**. It will be seen that the oncoming side of the nip N–**41** is provided with a conventional doctor *d* for the grooved roll **452** and also is provided with a combination doctor wiper XII, which is described in greater detail in connection with FIGURE 12A. The grooves are thus dewatered and the lands wiped dry on the upper grooved roll **452** before it reaches the web press nip N–**41**. It will further be seen that at the web press nip N–**41** the felt guide rolls **453***a* and **453***b* maintain the oncoming and off-running reaches of the felt **453** below the tangent plane T_4—T_4 defining the common tangent for the two rolls **451** and **452**. It will thus appear that the felt **453** is crossed to wrap slightly the web W–**401**, only briefly at the oncoming and off-running sides of the nip N–**41**; but this is done deliberately in order to effect minimum contact between the felt **453** and the surface of the grooved roll **452** at the off-runing side of the nip N–**41**. The nip load is 350 pounds per lineal inch and the open area is 16% on the grooved roll **452** (thus using 0.020 inch grooves with 0.105 inch lands).

One difference with respect to the rolls **442**, **452** and **422** in FIGURE 12 is that these rolls are equipped with the anti-deflection or deflection control means of my U.S. Patent No. 3,119,324, which affords excellent nip load control across the width of the machine. Also it has been found helpful to employ a paper guide roll GR to minimize web movement or "fluttering" at high speeds by controlling web movement directly from the bare roll **451** onto the felt **423**, in the region of the felt guide roll **424***a*; but such paper guide rolls GR function essentially to guide the web and do not carry out any press nip function with the associated felt guide roll (in this case **424***a*).

It is found that the three successive web nips N–**43**, N–**41** and N–**44**, each using successively higher nip loads, but each using grooves of only 0.020 inch width are capable of successively removing quantities of water from the web W–**401** without any evidence of shadow marking and with the advantage of pressing the wire side or bottom side of the web W–**401** against the plain roll **451** at the second press nip N–**41** so as to improve the quality of the paper sheet being formed.

It will be appreciated that this use of the reversed press **450** as the second press N–**41** in the embodiment of FIGURE 12 provides unusual advantages in the overall press assembly.

Referring briefly to FIGURE 12A, it will be seen that this view shows a combination doctor blade **460** and wiper foil **461** both mounted on the same frame designated generally **462** carried on a pivot **463** for movement of the doctor and wiper **460**, **461** toward and away from the downrunning side of the grooved roll **452**. The frame **462** is composed of an open-topped box **464** which extends the full cross-machine direction and which is shown with a level L–4 of water therein which is being withdrawn through a drain hole indicated at **465** (shown in FIGURE 12 diagrammatically as connected to a vacuum source S_v). The doctor **460** is clamped to the rigid forward wall **464***a* of the box **464** (which is actually made of structural material such as steel) to carry the loads and preferably clad with a corrosion-resistant material

in the interior to carry the liquid level L–4 without unnecessary corrosive action.

An angle iron 466 is mounted in the cross-machine direction along the top of the forward wall 464*b* of the box 464 (and preferably secured thereto by welds or other appropriate means). The wiper foil 461 is secured to the angle iron 466 by appropriate clamping means indicated at 467 of conventional types such as a clamping bar secured by bolts or the like. The wiper foil 461 extends the full width of the roll 452 and carries out its function of pumping water out of the grooves in the roll at the downrunning side of the roll 452 but at the oncoming side of the doctor 460. The doctor blade 460 touches and wipes the land areas dry after the wiper 461 has pumped the water out of the grooves and at the oncoming side of the nip N–41. In the view of FIGURE 12, an additional doctor *d* is shown, but the device of FIGURE 12A does not necessarily require an additional doctor *d* in this particular position for the reason that the region between the doctor 460 and the nip N–41 is a comparatively dry operating region and the lands will not be rewet therein.

Referring now to FIGURE 13, it will be seen that a simplified inexpensive press assembly is shown wherein the third press nip N–54 is essentially the same in structure and function as the previously described third press nip N–44 of FIGURE 12 and elements having the same structure and function in FIGURE 13 are designated by the same reference numerals in the 500 series. Likewise, in the case of the second press N–51 elements having the same structure and function are designated by the same reference numerals in the 600 series. The second press nip N–51 is operated at 300 pounds per lineal inch using a grooved roll 622 with an open area of about 20% (i.e. 0.020 inch grooves with 0.080 lands); whereas the third press nip N–54 is operated at 450 pounds per lineal inch using a grooved roll 522 with an open area of about 16% (i.e. 0.020 inch grooves with 0.105 inch lands).

It will be appreciated that FIGURE 13 shows a first web press N–53 which is primarly a transfer press between an upper grooved roll 571 within a felt loop 573 and a lower grooved roll 572 within a second felt loop 574. The lower grooved roll 572 has a conventional saveall arrangement comparable to that shown for the roll 522 and designated generally by the reference numeral 525, and this lower grooved roll 572 is capable of removing a considerable amount of water from the web W–501 at the press nip N–53. The felt 574 used on the lower grooved roll 572 is a close-weave felt, and a practical minimum area of about 16% is used on the grooved roll 572 (i.e. 0.020 inch grooves with 0.105 inch lands) to assist the web W–501 in preferential adherence to the bottom felt 574. The top felt 573 is operated as a relatively wet felt on appropriate guide rolls 573*a* through 573*d* and around a plain pickup roll 575. The wet felt 573 is brought into engagement with the web W–501 on the wire W–502 between the suction couch roll 507 and the turning roll 507*a* and because the wet felt 573 is relatively less permeable to air than the wire W–502, the web W–501 tends to adhere to the underside of the wet felt 573 and is thus conveyed into the first nip N–53 where it is transferred to the lower felt 574. Such transfer is assisted by the position of the felt guide roll 573*d* which tends to cause the felt 573 to wrap the web W–501 on the lower felt 574 against the lower grooved roll 572 briefly at the off-running side of the nip N–53. This arrangement effects the transfer of the web W–501, but it also has the disadvantage of permitting substantial reabsorption by the felt 574 from the grooves of the grooved roll 572, hence the minimum open area in the grooved roll 572. The upper grooved roll 571 is operated at a 20% open area (0.020 inch grooves with 0.080 inch lands) so as to effectively remove a substantial amount of water from the web W–501 at the first nip N–53, even though this nip is run with a relatively high load and the top felt 573 is operated deliberately as a relatively wet felt for the purposes hereinbefore described.

It will be noted from FIGURE 13A, however, that it may be desirable to employ only a small open draw from the wire W–702 and on to a bottom felt 723 at a first web press nip designated N–73, but otherwise having substantially the same press structure as the presses 520 and 620 shown in FIGURE 13. Elements of FIGURE 13A corresponding to those shown in FIGURE 13 are given the same reference numeral in the 700 series.

It will be appreciated that by substituting the first press 720 for the first press 570 of FIGURE 13, one also obtains a very simple inexpensive three-press assembly wherein the successive press nips N–73, N–51 and N–54 may be employed to dewater the web to the extent desired. The first press nip N–73 in this situation may be operated with 20 to 25% open area so as to afford maximum dewatering, using groove widths ranging from 0.020 up to as much as $\frac{1}{32}$ of an inch in order to accommodate the relatively large water load at the first press nip N–73, and since nip loads of only about 150 pounds per lineal inch are used at the first nip N–72, the larger groove widths can be used wthout expectation of any shadow marking effect in the web W–701 which would not be effectively erased using the successive second and third presses N–51, N–54 with the groove structure hereinbefore specified. It will also be noted that paper guide rolls GR of the type described in connection with FIGURE 12 are advantageously used in FIGURES 13 and 13A in association with the felt guide rolls 624*a*, 524*a* and 724*a*, respectively.

One of the problems in web pressing is avoidance of "crushing" of the web which is perhaps a poorly chosen but very meaningful word of the art—actually meaning "incipient fracture" of the web—caused by excessive, poorly directed water flow in the web at the nip. Thus, referring to FIGURE 4, it will be seen that at the oncoming side of the nip N–1 the pressure Po in the web as well as the felt or porous belt 11 is nominal (i.e. about 15 pounds per square inch absolute); whereas at the middle (or cross-machine center line) of the nip N–1 the pressure Pm is at a maximum (usually at least as great as the nip load in pounds per lineal inch or greater because the longitudinal dimension of the maximum nip load is often less than 1 inch); and, of course, at the off-running side of the nip N–1 the expanding felt 11 tends to create a sub-atmospheric (or vacuum) pressure Pv (e.g. from about 2 to 5 pounds per square inch absolute) depending to a great extent on the ability of the porous felt or belt 11 to receive ambient atmosphere (since the pressed web W–1 is substantially non-porous in this condition).

Generally in "crushing" Pm is so much greater than Po that in the case of a substantial total water load entering the nip N–1 there is created a flow of water in the web from Pm toward Po and this results not only in the visible collection of water as a pool at the oncoming side of the nip but also in a web product which will have many small cross-machine "cracks" or incipient fractures that can be observed in the final product. The grooves 13*c*, however, being vented to ambient atmosphere afford the easiest water flow path (backward and forward) in the nip, so even though the pools of water may be evidence in the present press nips, crushing of the web can be avoided because there is an avoidance of undesirable water flow in the web itself.

Referring to FIGURE 5B, it will thus be seen that the maximum pressure Pm actually occurs only at the machine direction center line M of each land area 22*b* (generally along the cross-machine center line of the nip N–3) and the minimum or nominal pressure Po is actually very closely adjacent thereto (along the cross-machine center line of the nip N–3) so that the net effect of the pressure application at the nip N–3 may appear to be

the same (or greater, depending upon the particular press position) nip load in pounds per lineal inch but the water flow from the moist web W–6 to the porous felt or belt 23 is essentially a non-crushing, normal or perpendicular to the plane P—P flow, with reference to the plane P—P between the web W–6 and the felt 23 (for example as shown in FIGURES 4 and 5A). There is no "crushing" flow of water in the web along the plane P—P in the direction *Pm* toward *Po*, nor is there in the nip N–3 of FIGURES 5A and 5B. Moreover, the extremely small axial dimension 27 of the lands 22*b*, 22*b* of FIGURE 5B avoids any cross machine "crushing" flow of water in the web in the direction indicated as *Pm* toward *Po*. Instead, in FIGURE 5B, there is presented a felt 23 which has theoretically a low "average" pressure of ½ of the total of *Pm* plus *Po* to readily receive water generally normal to the plane P—P at the web-felt interface, followed by a flow of water to a limited extent only within the felt 23 and for the limited dimension 27½ in the direction previously indicated. This affords an advantage of extremely high press nip loads, in pounds per lineal inch, when desired, without crushing.

It should also be noted that, even assuming that, in FIGURE 5B, *Pm* is equal to such desired high nip loads as 100, 200, 300 or even 450 pounds per lineal inch (although *Pm* in pounds per square inch will probably be much higher often because the longitudinal dimension of maximum nip pressure *Pm* is usually less than 1 inch), the driving force against the water is *Pm* minus *Po* which is usually in the range of several hundred pounds per square inch. The time this driving force is applied is very brief (i.e., for a machine speed of about 200 feet per minute and an oncoming nip side of perhaps ½ inch, such time being approximately 3×10^{-7} seconds) but the driving force is so great and the maximum water travel path 27½ so small that substantially all of the water is almost instantly driven into the deep grooves 22*c*, with substantial avoidance of a web crushing pressure gradient in the nip plane P—P either longitudinally or in the cross-machine direction. In particular, the very narrow (axially) lands 13*b* and 22*b* between narrow (but appropriately large) grooves 13*c* and 22*c* make the physical phenomenon possible. Hence axial land widths particularly for higher speed machines, in the neighborhood of 0.05 to 0.15 (and preferably 0.08 to 0.1 inch) are important.

The groove dimensions are also important in that 0.025 may be ideal for a given press whereas a reduction to 0.02 for the width 26 in FIGURE 5B in the same press has actually been found to produce a distinct reduction (or substantial elimination) of evidence of marking in certain webs, thereby demonstrating the criticality of superficially very small dimensional changes in this aspect of the structure.

Still another extremely important aspect of groove structure is the cross-sectional area or volume, which has already been expressed in terms of the mouth width of "*x*" is a practical minimum of twice the square of the mouth width (i.e. at least $2x^2$) and preferably four to five times the square of the mouth width. This volume is not necessarily so much for merely the desired capacity to receive water but more for the necessary ability to vent to the ambient atmosphere and maintain *Po* at substantially ambient atmospheric pressure of 15 pounds per square inch absolute. In pulp making machines, wherein the speeds are relatively slow and the water loads relatively high, the grooves actually function very satisfactorily as "flow troughs" using the dimensions of 0.02 to 0.25 inch groove mouths with a normal machine taper (e.g. about 7%) to a depth 28 of only 0.06 inch, i.e., a cross sectional area of two to three times the square of the mouth width. It is important to consider the groove volumes (i.e. cross sectional areas) on the basis of the groove mouth width "*x*" because shallow tapered grooves may be incapable of the necessary venting function and/or the necessary ability to resist the tendency for the felt to reabsorb all of the water in the grooves at the off-running side of the press nip.

The groove mouth width 26 has still another very important function, often expressed in terms of open area, and this pertains to the overall resistance to water return from the grooves to the subatmospheric felt at the off-running side of the nip. Again, using the previously described operating conditions, it will be appreciated that, during the very brief period of approximately 3×10^{-7} seconds in which the felt expands at the off-running side of the nip (cross-machine center line), the driving force *Po* minus *Pv* or about 10 to 12 pounds per square inch tending to return water from the grooves to the absorbent felt is comparatively much less than the several hundred pounds per square inch driving force pushing the water into the grooves of the oncoming side of the nip during a substantially equal time interval. Additional unfavorable factors include the effect of centrifugal force and the effect of perhaps a longer time interval (since it is difficult to separate the felt from the grooved roll surface at the very instant that the nip pressure is relieved); but all of these unfavorable factors are more than counteracted by (a) the very great difference in actual driving forces, (b) the reasonably rapid removal of the felt from the grooved roll surface, and (c) the water travel path, since the water must travel (1) first generally normally to the felt plane toward the groove mouth for (2) a rather substantial distance, particularly in the case of the water at the bottom of the deeper grooves, past closely adjacent groove walls tending to resist water movement both by (3) frictional drag and (4) molecular or capillary-like attraction between the water and the groove wall material and then through (5) a right-angle turn for (6) still another substantial distance 27½ shown in FIGURE 5B to the center line of the land area. Water removal is thus effected at conventional higher machine speeds and lower open areas here specified simply because the off-running time interval is wholly insufficient to permit the felt to withdraw all of the water from the grooves—or even, for that matter, to permit creation of equilibrium or balanced water conditions between the felt and grooves (which would allow for the retention of some water in the grooves anyway).

At slower operating conditions using the same structures, even if equilibrium conditions were reached, the grooves must hold and carry off substantial quantities of water. And at even slower conditions such as were indicated as a possibility with a pulp machine the comparatively larger land areas afford the necessary nip pressure application whereas the comparatively (axially) smaller grooves afford vented, free flow of water way from the nip and out of the system into conventional receptacles in any case, water removal is thus effected.

It will thus be seen that the shallow and/or sharply tapered grooves, having semicircular or triangular cross sectional areas which are functionally significantly below about twice the square of the groove mouth width in cross sectional area are either incapable of satisfactory venting, satisfactory resistance of return of water to the absorbent felt at the off-running side of the nip, or both. The suggested minimum of $2x^2$ is practical as well as functional, since it is conceivable that certain principles of the invention could be followed, for example, using so-called "shallow" grooves having the "general" cross section of perhaps as equilateral triangle (and hence a cross sectional area of only $\frac{1}{3}x^2$) but with a relatively deep but very narrow and hence small volume slot of only perhaps 0.002 inch width extending radially inwardly from the apex of such triangle; but such slot would have to have some functional volume because this would constitute essentially the only volume of water not reabsorbed by the felt from such shallow grooves in the normal operation, and again in slow operation the slot would still require some volume to afford the required venting function

(and to this end continuous cleaning to keep the slot functional would be difficult or impractical). The grooves have already been described as requiring substantial depth to accommodate these essential functions.

Occasional cross-machine slots on the lands (and/or conduits beneath the land surfaces) interconnecting the generally circumferential grooves would not be precluded by the basic principles of the invention, but such structures are not preferred primarily because whatever useful function they might have would ordinarily be impaired by practical considerations relative to maintaining such structures clean. In ordinary operation, for example, the cross-machine slots on the lands would probably fill up quickly and unless continuously cleaned by additional auxiliary equipment such as brushes, water jets and the like, functionally continuously cylindrical lands would result. In any event, whatever type of groove structure attempted (other than the hereinbefore described substantially circumferential structure) would be subject to the same basic limitations of groove width, open area, depth, cross sectional area and general contour hereinbefore described, plus the added requirement of rotary brushes, water jets or other generally less preferred auxiliary equipment for continuous cleaning.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. A device for cleaning a continuously rotating generally cylindrical press roll shell having a peripheral surface portion presenting alternating generally circumferentially aligned grooves and ridges, said grooves defining a continuous spiral on the periphery of said roll, said device comprising means adapted to present to said ridges a generally axially continuous edge and chaser means for slidably engaging said edge for relative axial movement carrying a plurality of spaced peripherally aligned guide means slidably receivable in closely adjacent grooves on the roll periphery.

2. A device for cleaning a continuously rotating generally cylindrical press roll shell having a peripheral surface portion presenting alternating generally circumferentially aligned grooves and ridges, said grooves defining a continuous spiral on the periphery of said roll, said device comprising means adapted to present to said ridges a generally axially continuous edge and chaser means for slidably engaging said edge for relative axial movement carrying a plurality of spaced peripherally aligned guide means slidably receivable in closely adjacent grooves on the roll periphery, at least one of said guide means extending to the groove bottoms from said chaser means slidably engaged by said edge.

3. In combination, generally cylindrical press roll shell having a peripheral surface portion presenting alternating generally circumferentially aligned grooves and ridges, said grooves defining a continuous spiral on the periphery of said roll, means for rotating the roll, means presenting to said ridges a generally axially continuous edge and chaser means for slidably engaging said edge for relative axial movement carrying a plurality of spaced peripherally aligned guide means slidably receivably in closely adjacent grooves on the roll periphery.

4. A device for cleaning a continuously rotating generally cylindrical press roll shell having a peripheral surface portion presenting alternating generally circumferentially aligned grooves and ridges, said grooves defining a continuous spiral on the periphery of said roll, said shell rotating in close proximity to an element presenting to said ridges an axially continuous edge, which device comprises chaser means for slidably engaging said edge for relative axial movement carrying a plurality of spaced peripherally aligned guide means slidably receivable in closely adjacent grooves on the roll periphery and having a back portion presenting a surface defining an acute angle with said guide means for holding the chaser means against said edge during rotation of the roll.

5. In combination, a generally cylindrical press roll shell adapted to be mounted for rotation about its centroidal axis and to press a peripheral rotary surface portion thereof against a liquid-containing web material; said surface portion having alternating generally circumferentially aligned grooves and ridges; said grooves having a narrow axial dimension at the roll periphery for receiving liquid pressed from the web material and tending to retain such liquid, being vented to ambient atmosphere at both off-running and on-coming sides of an axial line of contact between the roll shell periphery and the liquid-containing web material from which liquid is pressed into such grooves, and being interposed between lands on said ridges averaging in axial width substantially at least twice the axial widths of said grooves, and wiper means having an axially continuous surface portion extending from close proximity to said roll peripheral surface portion gradually away from such roll surface in the direction of roll rotation for pumping liquid out of the grooves moving past the wiper means.

6. In combination, a generally cylindrical press roll shell adapted to be mounted for rotation about its centroidal axis and to press a peripheral rotary surface portion thereof along an axial line of contact against a liquid-containing web material; said surface portion having alternating generally circumferentially aligned grooves and ridges; said grooves being vented to ambient atmosphere at both the off-running and on-coming sides of said axial line of contact and having a narrow axial dimension at the roll periphery for receiving liquid pressed at superatmospheric pressures from the web material but also tending to resist flow of liquid out of the grooves in response to rotation of the roll; said grooves defining at least one continuous spiral on the periphery of said roll; wiper means having an axially continuous surface portion extending from close proximity to said roll peripheral surface portion gradually away from such roll surface in the direction of roll rotation for pumping liquid out of the grooves moving past the wiper means; and doctor means presenting an axially continuous superatmospheric fluid blast against the roll periphery at the off-running side of said wiper means and the on-coming side of said line of contact for wiping the ridges clean.

7. In combination, a generally cylindrical press roll shell adapted to be mounted for rotation about its centroidal axis and to press a peripheral rotary surface portion thereof along an axial line of contact against a liquid-containing web material; said surface portion having alternating generally circumferentially aligned grooves and ridges; said grooves having a narrow axial dimension at the roll periphery for receiving liquid pressed from the web material but also tending to resist flow of liquid out of the groove in response to rotation of the roll; said grooves defining a continuous spiral on the periphery of said roll, said ridges presenting smooth generally cylindrical outer peripheral land areas, doctor means presenting a generally axially continuous doctor blade to said land areas for removing liquid from said land areas during rotation of the roll, and wiper means at the on-coming side of the doctor means in the direction of roll rotation for drawing liquid from the grooves and partially onto the land areas, said wiper means having an axially continuous surface portion extending from close proximity to said roll peripheral surface portion gradually away from such roll surface in the direction of roll rotation for pumping liquid out of the grooves moving past the wiper means.

8. The combination of claim **5** wherein the grooves are aligned in a plurality of spirals which are aligned to intersect from time to time on the roll periphery and at any given line taken along the roll periphery the ratio of groove width to land area width ranges from 1 to 7.

9. The device of claim **1** wherein the grooves are

aligned in a plurality of spirals which are aligned to intersect from time to time on the roll periphery and at any given line taken along the roll periphery the ratio of groove width to land area width ranges from 1 to 7 but the chaser guide means are substantially parallel for sliding engagement with grooves of at least one continuous spiral wherein the spiral angle of the grooves is essentially the same.

10. The combination of claim 7 including chaser means for slidably engaging the axially continuous doctor blade for relative axial movement carrying a plurality of spaced peripherally aligned guide means slidably receivable in closely adjacent grooves on the roll periphery.

11. In combination, a generally cylindrical press roll shell adapted to be mounted for rotation about its centroidal axis and to press a peripheral rotary surface portion thereof along an axial line of contact against a liquid-containing web material, said surface portion having alternating generally circumferentially aligned grooves and ridges; said grooves having a narrow axial dimension at the roll periphery for receiving liquid pressed from the web material while being vented to ambient atmosphere at both sides of said line but also tending to resist flow of liquid out of the groove in response to rotation of the roll; said grooves defining a continuous spiral on the periphery of said roll, said ridges presenting smooth generally cylindrical outer peripheral land areas, doctor means presenting a generally axially continuous doctor blade to said land areas for removing liquid from said land areas during rotation of the roll, and wiper means at the on-coming side of the doctor means in the direction of roll rotation, said wiper means having an axially continuous surface portion extending from close proximity to said roll peripheral surface portion gradually away from such roll surface in the direction of roll rotation for pumping liquid out of the grooves moving past the wiper means, said grooves having an axial dimension at the roll periphery of 0.005 to 0.035 inch and said land areas having axial dimensions 2 to 20 times the axial groove dimension at the roll periphery, as an average along said axial line of contact, thereby presenting a rotary surface portion with an average effective open area of not more than substantially 33⅓%.

12. In combination, a generally cylindrical press roll shell adapted to be mounted for rotation about its centroidal axis and to press a peripheral rotary surface portion thereof along an axial line of contact against a liquid-containing web material; said surface portion having alternating generally circumferentially aligned grooves and ridges; said grooves having a narrow axial dimension at the roll periphery for receiving liquid pressed from the web material being vented at both the off-running and on-coming sides of said axial line contact to facilitate receipt of liquid pressed from said web material at superatmospheric pressures and said grooves also tending to resist flow of liquid out of the groove in response to rotation of the roll; said ridges presenting smooth generally cylindrical outer peripheral land areas, generally axially continuous doctor means for removing liquid from sai land areas during rotation of the roll, and wiper mear at the on-coming side of the doctor means in the directio of roll rotation, said wiper means having an axially cor tinuous surface portion extending from close proximit to said roll peripheral surface portion gradually awa from such roll surface in the direction of roll rotatio for pumping liquid out of the grooves and partially ont the land areas moving past the wiper means.

13. In a machine for dewatering and cleaning grooved roll, a substantially axially continuous saveall el ment extending the length of the roll in close proximit to the outer periphery thereof, clamp means substantiall co-extensive with said element mounting a doctor blad for wiping land areas dry along a first axially continuou line on the roll periphery, and wiper sheet means secure to said element substantially parallel to but spaced fro said clamp means to permit the flow of water thereb tween into such saveall element, said wiper sheet extendin from a second axially continuous line at the on-comin side of said first line gradually away from said roll t said saveall whereby to effect pumping action betwee the wiper sheet and the grooved roll surface to drai water out of the grooves at the on-coming side of sai doctor blade.

14. A machine as claimed in claim 13 wherein th saveall is substantially closed against external atmospher pressure from said wiper to said doctor blade and i cludes a connection to the interior of the saveall for ge erating subatmospheric pressure therein to amplify th pumping action of said wiper.

15. In a machine for dewatering and cleaning grooved roll, a substantially axially continuous saveall el ment extending the length of the roll in close proximi to the outer periphery thereof, clamp means substantial co-extensive with said element mounting a doctor blac for wiping land areas dry along a first axially continuou line on the roll periphery, and wiper sheet means secure to said element substantially parallel to but spaced fro said clamp means to permit the flow of water thereb tween into such saveall element, said wiper sheet exten ing from a second axially continuous line at the on-con ing side of said first line gradually away from said rc to said saveall whereby to effect pumping action betwee the wiper sheet and the grooved roll surface to dra water out of the grooves at the on-coming side of sa doctor blade and pivot means mounting said saveall el ment for simultaneously moving the doctor blade ar wiper sheet in and out of functional contact with sa grooved roll periphery.

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