Sept. 18, 1973 W. G. MIHELICH 3,759,785

HIGH STRENGTH NEWSPRINT

Filed Oct. 6, 1971 3 Sheets-Sheet 1

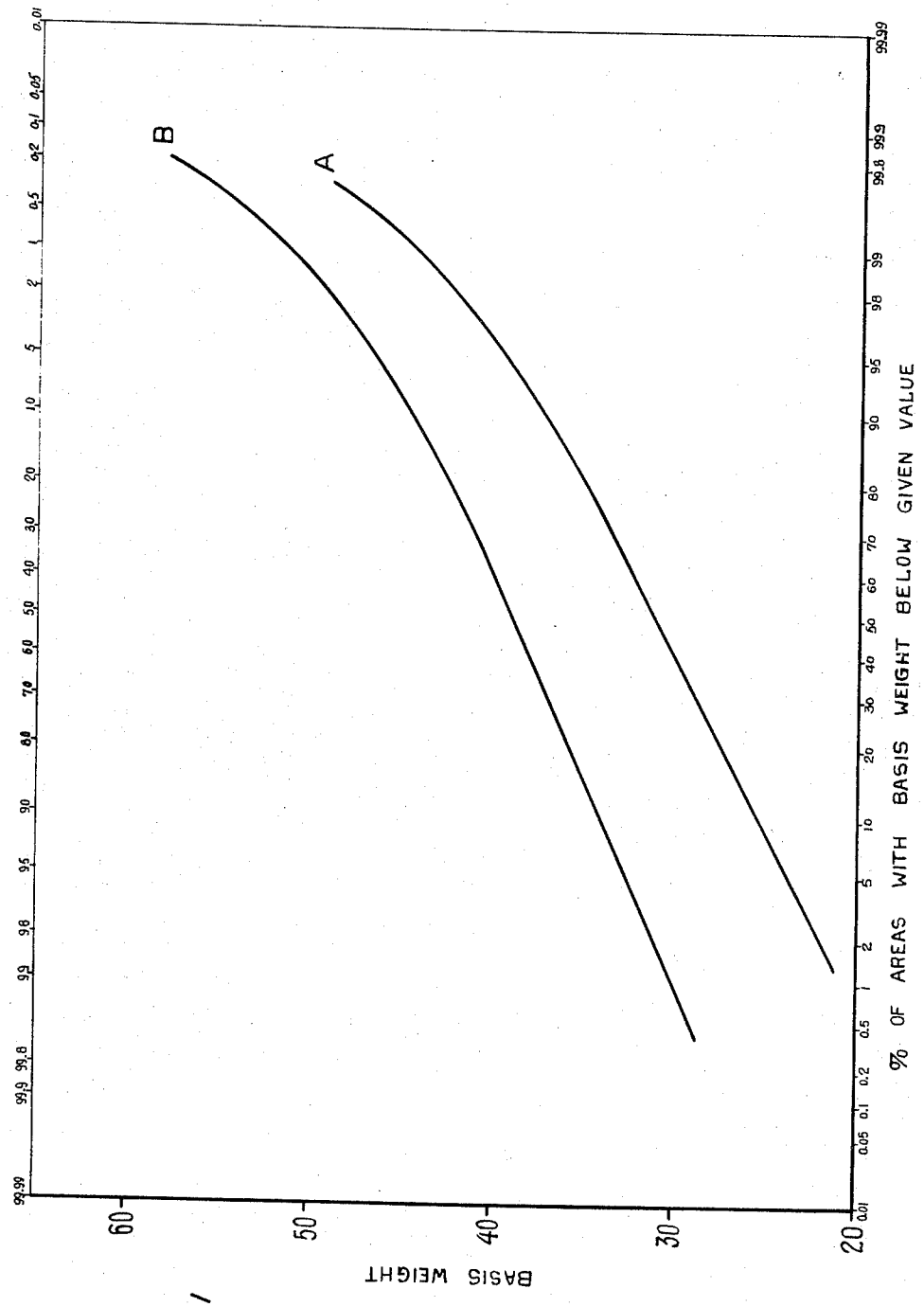


FIG. 1

HIGH STRENGTH NEWSPRINT

Filed Oct. 6, 1971 3 Sheets-Sheet 2

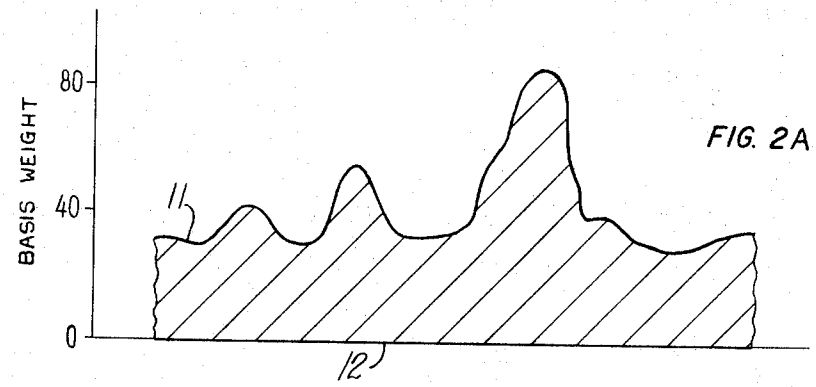


FIG. 2A

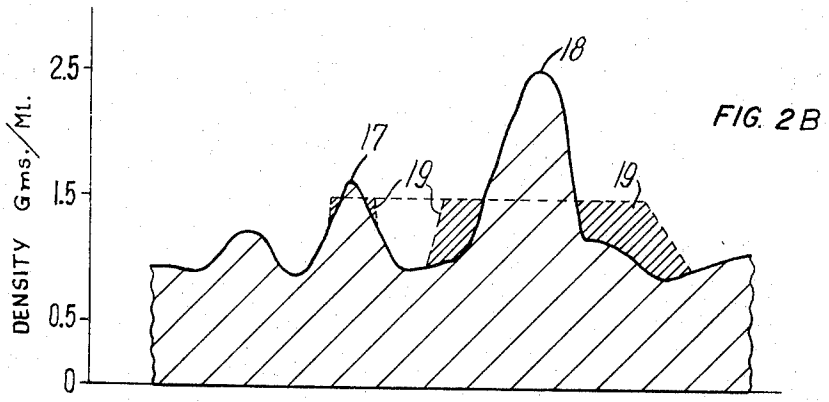
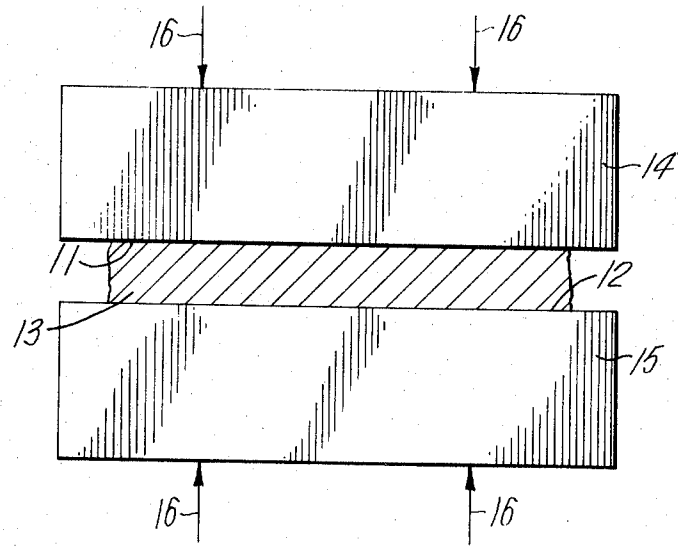


FIG. 2B

FIG. 3



Sept. 18, 1973 W. G. MIHELICH 3,759,785

HIGH STRENGTH NEWSPRINT

Filed Oct. 6, 1971 3 Sheets-Sheet 3

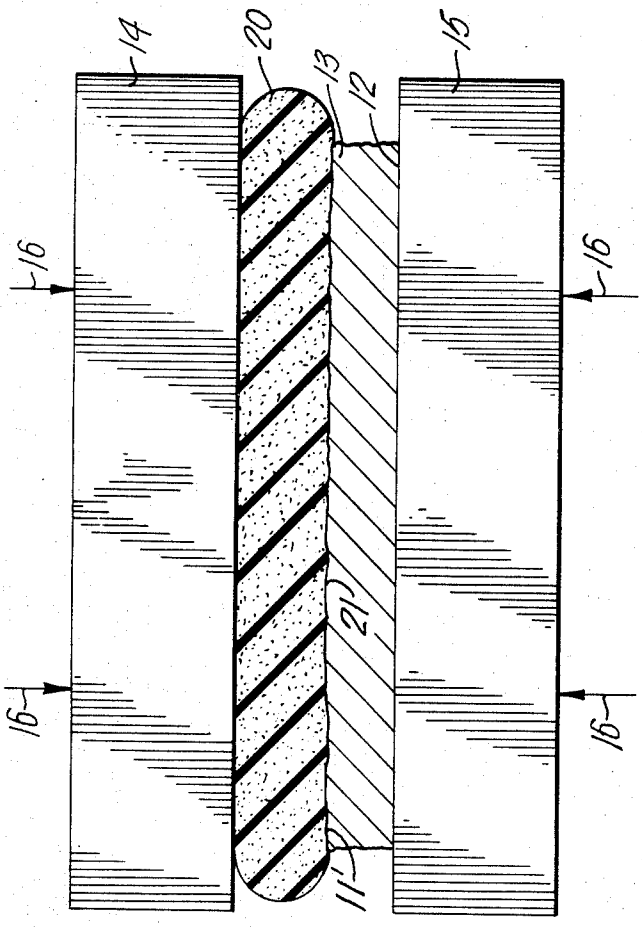


FIG. 4

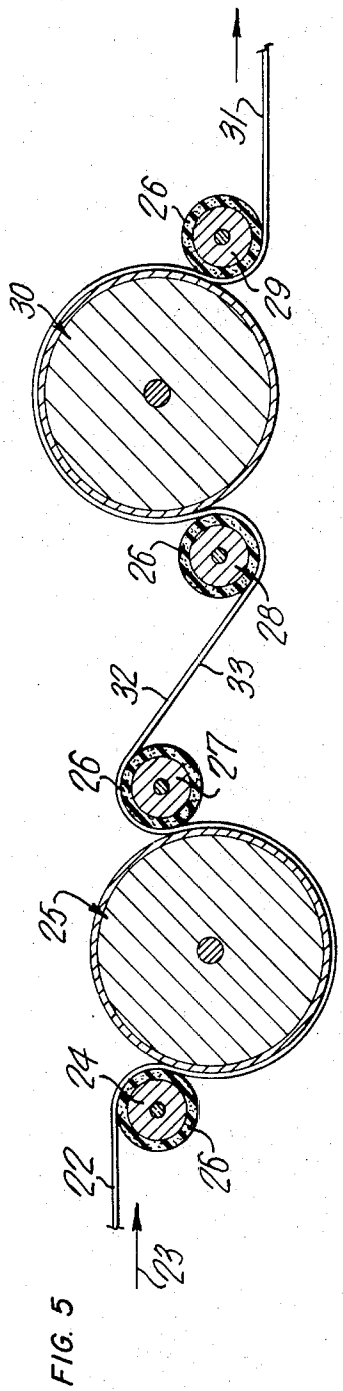


FIG. 5

United States Patent Office 3,759,785 Patented Sept. 18, 1973

3,759,785

HIGH STRENGTH NEWSPRINT

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Continuation-in-part of application Ser. No. 860,022, Sept. 22, 1969. This application Oct. 6, 1971, Ser. No. 186,963

Claims priority, application Canada, Sept. 22, 1969, 62,706

Int. Cl. D21f *11/00;* D21h *5/12*

U.S. Cl. 162—142 11 Claims

ABSTRACT OF THE DISCLOSURE

High strength newsprint is made by calendering a newsprint paper web between a smooth hard metallic surface and a firm resilient surface so that the thickness of the paper under the applied pressure varies from point-to-point in approximate proportion to the corresponding point-to-point basis weight of the paper. The calendering is effected so that smoothing pressure is applied by passing the web through at least two resilient nips, each nip comprising a hard roll and an opposing resilient roll, so that each side of said web contacts a hard roll at least once. The newsprint paper may have at least 25% of superground wood.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 860,022, filed Sept. 22, 1969, and abandoned.

BACKGROUND OF THE INVENTION

This invention relates to the manufacture of newsprint paper.

DESCRIPTION OF THE PRIOR ART

The newsprint manufacturing process involves flowing a dilute water suspension of wood pulp fibers on to a travelling, open meshed, fine wire screen (or between two such screens) through which the bulk of the water drains. Further water is usually removed by using a vacuum to draw it from the layer of fibers formed on the screen. The layer of fibers (then a wet, weak piece of paper) is passed through the nips formed by paired opposed rolls to squeeze out more water and is then passed over rotating, heated cylinders to remove, by evaporation, most of the remaining water content to yield a dry sheet of paper usually containing 5% to 15% moisture. At this point in the process newsprint paper typically has a weight, called the basis weight, of about 32 pounds per 3,000 square feet of area: it will have a thickness (caliper) of about 0.0055 to 0.0060 inch.

The paper at this stage has surfaces too rough to give a well-printed newspaper, by the commonly used process. Also, due to its soft, bulky structure (high caliper) paper rolls made from it would be of low weight (relative to diameter), soft and easily damaged in handling or transit.

These shortcomings are presently remedied by the step of calendering in which the paper is passed through successive nips formed between rotating, heavy iron rolls stacked upon one another with their axes parallel and in a common vertical plane. In this commonly used calender stack, the weight of each roll is supported by the one below. The paper passes through the nips from top to bottom of the stack and is subjected to step-wise increases of pressure due to the increase in the number of rolls weighing down upon each successive nip. In its passage through this series of nips the paper is progressively reduced in thickness and its surfaces made smoother by compression and a moderate frictional ironing effect.

After the calendering process, newsprint will be typically about 0.0031 to 0.0033 inch thick and will have a surface smooth enough to give good reproduction in the printing process. It will also have the density required to make a hard, sound roll of paper which can adequately resist the stresses of handling and shipping.

It is an essential property of newsprint that it should run through printing presses with a minimum number of breaks of the paper web. The average tensile strength of newsprint is several times more than the normal tensile loadings imposed upon it by the printing presses. In consequence, paper breaks in printing presses are infrequent and may typically occur with a frequency of once for every 50 to 500 miles of paper printed. Even at these low frequency levels, paper breaks are a cause of troublesome delays and the resulting "down time" of the machinery adds significant costs to the printing of newspapers.

It is now established that most press breaks result from the presence in the web, specially at or near the edge of the web, or flaws or weak spots. These flaws are most commonly associated with the presence of shives in the sheet. Shives are small bundles of wood fibers which are not separated from one another in the pulp making process, and remained as small wood slivers. They may vary in size from innocuous aggregations of two or three fibers up to clusters of a hundred or more fibers. They may range up to half an inch long and have widths and thicknesses up to, or over 0.02 in.

As more fully described below, the applicant has found that shives have very little, or no, effect upon the strength of uncalendered newsprint and that their weakening effect in calendered newsprint arises almost wholly as a direct consequence of the present conventional mode of calendering between hard, iron rolls. The applicant has also found that conventional calendering results in the development of numerous weak spots in the paper in non-shive bearing areas where small, chance aggregations of fibers give spots of high basis weight which are crushed in calendering. The present invention provides a method for effecting the changes now sought by the conventional calendering process while substantially reducing the loss of strength caused by conventional calendering.

The technical literature on calendering newsprint deals largely with mechanical variables related to smoothness and caliper changes in the paper. It has been recognized that the conventional newsprint calendering process reduces the strength of shive bearing areas. There has been no known prior recognition that this process results in serious strength loss in those small non-shive bearing areas where, by chance distribution of fibers within the web, basis weights are substantially higher than average. The applicant has discovered that such areas, when conventionally calendered form within the sheet a multitude of weak spots which substantially weaken the sheet and the applicant has provided a process by which the weakening of such high weight spots, and of shive bearing areas, is much reduced.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method by which newsprint paper, as produced after the dryer section of the paper machine, may be reduced in thickness, or calendered, to the lesser caliper wanted in the final product. The invention makes it possible to increase the surface smoothness of the paper simultaneously with its reduction in caliper and to give, for any degree of reduction in caliper, a smoother surface than possible for the like degree of reduction by conventional calendering. The invention provides the further and distinguishing feature of reduced caliper and increased smoothness with a much re-

duced loss of strength, as compared to the loss caused by conventional calendering.

In the manufacture of newsprint using the conventional calendering process, it is necessary to use a fiber furnish which will provide sufficient initial strength that there will remain, after the strength damaging action of conventional calendering, sufficient residual strength to permit the paper to be printed with no more than an acceptable level of press breaks. In general, the measures used to provide this strength all involves higher costs. Thus, for instance, increased strength may be had by increasing the proportion of chemical pulp and reducing the proportion of groundwood used. Depending on the type of chemical pulp involved, it may cost 1.5 to over 3 times the cost of ground-wood and thus any increase in its proportion substantially increases the cost of the newsprint. In another alternative, the groundwood content can be increased in strength by increasing the energy used to grind it. Several hundred kilowatt hours extra may be required per ton of pulp to give a substantial strength increase. This represents a substantial cost increase and, since grinder motor capacities are always limited, reduces the amount of groundwood which can be produced. Since the method of the invention substantially reduces the strength loss on calendering, finished paper of equivalent strength to that made with conventional calendering can be made from paper designed to have a lower strength in the pre-calendered condition with consequent savings in cost of chemical pulp and/or grinding energy.

The conventional calendering process is a continuous one in which the paper is pressed between metal surfaces in the nips formed between opposed parallel, rotating rolls. Its ancestor, a batch process, obtained very similar results by applying pressure to a stack made up of sheets of uncalendered paper between each of which was placed a metal plate having two smooth surfaces. This batch form can serve to illustrate the cause of the paper strength loss caused by conventional calendering and to clearly show both how the present method of calendering differs from it and why the present method provides reduced loss of strength.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further illustrated by reference to the accompanying drawings, in which:

FIG. 1 is a graph showing the distribution of areas of differing basis weight in a sheet of newsprint paper;

FIG. 2*a* is a cross-section on an exaggerated scale of a typical sheet of uncalendered newsprint paper;

FIG. 2*b* is a cross-section on the same scale as FIG. 2*a* of the same sheet of newsprint paper after conventional calendering;

FIG. 3 is a schematic cross-section on an exaggerated scale representing the calendering effect of pressing a newsprint sheet between the flat surfaces of opposed metal plates;

FIG. 4 is a similar view of FIG. 3 showing the pressing of a newsprint sheet between a flat metal surface and a flat resilient surface, being a batch embodiment of the present invention; and

FIG. 5 is a schematic vertical cross-section through an apparatus suitable for the continuous operation of the process of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, the curve marked A gives the frequency of occurrence of various basis weights within a sample of commercial calendered newsprint. The individual "samples" on which basis weights were determined were randomly selected areas of approximately one ten-thousandth ($\frac{1}{10,000th}$) of a square inch. Such samples are too small for the conventional method of measuring basis weight by direct weighing and measurement of surface area. Basis weights were determined by X-raying the paper, measuring the optical density of small areas of the X-ray film and converting the density values to basis weights by appropriate calibration procedures. FIG. 1, curve A, shows that, while the average basis weight of the paper is about the normal 32 pounds per ream of 3,000 square feet, this figure is the result of averaging the basis weights of very large numbers of small areas having a wide range of basis weights. Curve A shows that 40% are below 30 pounds while 5% are above 39 pounds.

In FIG. 2*a* shown a simulated cross section of a piece of uncalendered newsprint in which the spacing between the upper surface **11** and the lower surface **12** of the paper is in proportion to the basis weight as shown by the scale at the left. In effect, FIG. 2*a* is a simulation of part of the data from which curve A of FIG. 1 was obtained.

FIG. 3 shows, as **13**, the paper segment of FIG. 2 as held under pressure, indicated by the arrows **16** between the smooth surfaced, metal plates **14** and **15** in the course of being calendered by the batch form of the conventional calendering process as previously described. It is to be particularly noted that the segment **13** has now been so compressed as to make its upper surface **11** and lower surface **12** plane and parallel.

FIG. 3 can equally serve to represent conditions in the continuous form of the conventional calendering process: here **14** and **15** would represent parts of adjacent metal rolls and the paper **13** would be in the condition in which it is found at the narrowest part of the nip between the rolls. Again, the two surfaces of the paper are parallel. The compression of the paper as illustarted in FIG. 3 results in the development, in the sheet under pressure of density differences since the thickness is uniform while the substance per unit area varies as per FIG. 2*a*. These density differences are represented in FIG. 2*b* in which the height of the section at any point represents the density at that point.

Particular attention is drawn to the peaks in FIG. 2*b* marked **17** and **18**. Theoretically, in pressing these will have attained maximum densities of 1.63 and 2.52 gms./ml. respectively. These densities are greater than the ultimate density of the solid material of which newsprint is made and therefore cannot be reached in calendering. Instead, part of the volume of these peaks (indicated by the horizontal hatching) must flow laterally to occupy space as indicated by the dashed lines **19** embracing the displaced volumes shown by diagonal hatching.

The forces required to compress and laterally displace the material under high weight peaks, such as **18**, crush and cut the fibers stacked there to form the weight peak. Additionally, the lateral flow of mass also results in fiber breakage. In sum, high weight, small areas of paper, which should be stronger because they contain more material, are actually weaker because of damage caused by the conventional calendering method. In general, the higher the basis weight of a small, localized area, the lower will be the strength of that area. It is conventional doctrine that higher basis weight paper will be stronger than that of lower basis weight. This, despite the foregoing is still true with respect to averaged strength over larger areas of paper. However, within the larger areas, small areas of higher than average basis weight will have lower strength than those of average basis weight in the case of the papers with both higher and lower average basis weights.

The same paper, for which the basis weight distribution of random small areas is given by curve A of FIG. 1, was tested for tensile strength. The 15 mm. wide strips used in the tensile test were matched with the X-ray films previously made and the exact locations of the tensile breaks in the strips were noted on the corresponding X-ray films. The average basis weight of the paper along a strip 0.3 mm. wide and centered on the break lines was measured by film densitometry. The distribution of basis weights so found is given by line B of FIG. 1. It will be noted that while 50% of the area of the paper

had a basis weight below 31 pounds (curve A), only 2% of the area of the zones through which tensile failure occurred were as low. Also, while 50% of the paper through which tensile failure lines ran had a basis weight over 39.5 pounds, less than 5% of each of the strips tested for strength was that heavy. It is thus obvious that the lines of tensile failure "selected" sections of high basis weight. The apparent anomaly is due to the increased calender damage done to higher basis weight areas by the conventional calendering process, as described.

Shives in paper represent small areas in which the normal basis weight of the paper is supplemented by the basis weight contributions of the shives. They are, therefore, areas of high basis weight and are subject to the weakening action of calendering as described. It will thus be obvious that the weakening of shive-bearing areas by conventional calendering is only a particular case of the general case of conventional calendering damage to small areas of high basis weight which the applicant has discovered.

The newsprint calendering method of the invention achieves the desired reduction of paper caliper and the desired increase in surface smoothness while very substantially reducing the number, and the weakness, of the weak spots in the paper relative to conventional calendering.

The principle of the present method is represented in FIG. 4 showing its application as a batch method in analogy to the conventional process as represented in FIG. 3. As in FIG. 3, **14** and **15** represent smooth surfaced metal plates to which pressure is applied as indicated by the arrows **16**. Below the upper plate **14** is placed a firm, resilient sheet **20** which may be made, for instance, of a fairly hard rubber composition. The paper being calendered is represented by **13** and its two surfaces are represented by **11'** and **12**.

An important feature of the present method of calendering newsprint is the interposition of a firm resilient material between the paper being calendered and one of the hard surfaces through which pressure is applied to the paper to effect the calendering. One important consequence of interposing this resilent layer is indicated by the profile of the paper surface **11'** as indicated in FIG. 4.

Since the surface of the layer **20** is resilient, small areas of high basis weight in the paper can now indent into the layer **20** and the upper surface **11'** of the paper is no longer forced into a single plane as is the surface **11** with conventional calendering. By the present process, the thickness of the paper from point-to-point under the calendering pressure can vary in some relationship with the corresponding point-to-point variation in basis weight. Thus a high basis weight area can indent a substantial distance into the resilient layer **20** as shown at **21** of FIG. 4. Whereas in conventional calendering very high pressures are brought to bear to force high basis weight areas to a common caliper with the rest of the paper with resulting crushing and loss of strength as described, the applicant's process limits the extra pressure placed on such areas by permitting them to indent the resilient surface. In consequence there is a very substantial reduction in the number of damaged areas when the applicant's process is substituted for the conventional one. With fewer damaged areas, average paper strength is higher and more uniform from area to area within the paper.

The comparative effects of conventional calendering and of calendering by the present process were clearly shown in a test in which a lot of paper was made from a normal newsprint furnish of groundwood and sulphite pulps; a second lot of paper was made from the same pulp blend to which a small proportion of shives had been added to develop added small areas of high basis weight in the second lot of paper. The two lots were divided: part of each was tested for tensile strength; part of each was calendered by the conventional method to 0.0032 inches thickness then tested for tensile strength; another part of each was calendered to like thickness by the applicant's method and was then tested for tensile strength. The resulting data are given in Table I.

These tensile tests, and others referred to in this application were done according to TAPPI Standard tensile test for paper T404–ts 66.

TABLE I

	Without added shives			With added shives		
Mode of calendaring	None	Conventional	Invention	None	Conventional	Invention
Average tensile, kgs./15 mm.	3.14	2.57	3.05	3.05	2.25	2.78
Standard deviation	.25	.34	.18	.18	.57	.33
Average minus 3 times standard deviation	2.39	1.23	2.24	2.60	0.54	1.79

It will be seen that the addition of shives has had only a minor effect upon the strength of the uncalendered paper. Calendering by the conventional process has caused a loss of about 18% in the average strength of the paper without added shives and a loss of 26% in that with added shives. In contrast, calendering by the applicant's method caused corresponding losses of only 3% and 9%, respectively.

Many miles of newsprint ordinarily run through a printing press between each paper break. It is therefore obvious that its average strength, even with conventional calendering, is more than adequate to support the stresses imposed upon it. Only the rare, weakest parts of newsprint are likely to cause a break. The standard deviation of tensile tests provide a masure for roughly estimating the frequency with which various levels of strength may be expected. Statistically tensile tests of average minus three times standard deviation may be expected about twice in every thousand tests. The last row of Table I gives such values for uncalendered paper, conventionally calendered paper, and paper calendered by the applicant's process both with and without added shives. It will be noted that standard deviations are higher for conventional calendering than for the applicant's calendering process and as a result these important, infrequent test values are at a very much higher strength level for newsprint paper calendered by the present process than for paper calendered in the conventional way. Conversely, if some specific, low, tensile strength value is required before a newsprint web will break in the printing press, such values will occur with much reduced frequency in paper calendered by the applicant's method as compared to paper calendered by the conventional method.

Referring to FIG. 4, it will be seen that the paper surface **12** is being pressed into conformity with the smooth, plane surface of the metal plate **15**. This action substantially increases the smoothness of the paper surface **12** and fits it for faithful reproduction of printing. The surface **11'** contacts the smooth but resilient surface of the layer **20** and is not made as smooth as the surface **12**. The applicant therefore finds it desirable, in order to get good printing surfaces on both sides of the paper, to repeat the calendering process with the paper face **11'** in contact with the surface of the plate **15** in the second instance. This double calendering produces good, and equal smoothness on both sides of the paper.

The applicant has described the calendering process of the invention in terms of its application as a batch process to more clearly set forth its principles, benefits and causes of the improved results given by it. Commercial application requires that the process be adapted to continuous operation. FIG. 5 is a schematic cross-section of an apparatus which may be used to apply the process of the invention to the calendering of the newsprint. In FIG. 5 the number **22** represents uncalendered paper moving in the direction indicated by the arrow **23** into the nip formed between the roll **24** and the roll **25** about which it is wrapped. Roll **24** has a journaled metal core bearing a resilient rubber or plastic cover **26**. Means, not shown, are provided for pressing the roll **24** against the paper in the nip which is supported by roll **25**. Means are provided by which the pressure between the rolls **24** and **25** may be adjusted to effect, in combination with the like action of the other rolls shown, the degree of caliper reduction required. The rolls **27**, **28** and **29** have the same structure and functions as the roll **24**. The roll **25** has a hard metal shell having a smooth, outer cylindrical surface which smooths and polishes the surface of the paper pressed against it. Means may be provided by which the roll **25** may be heated to thereby heat the paper, increase its plasticity and render it more responsive to the calendering action. Such heating means may be located either within or outside the cylinder **25**, or both. After passing through the pressure nip formed between the rolls **25** and **27**, the paper continues through nips formed between rolls **28** and **30** and **29** and **30** to complete the calendering process. Roll **30** is of the same general nature as roll **25**. The calendered paper **31** continues to a reel-up mechanism not shown. It will be noted that the applicant's calendering process thus involves two separated but similar calendering steps. In the first step, one surface of the paper is calendered in contact with the smooth hard surface of the roll **25**. In the second step, the opposite surface of the paper is calendered in contact with the smooth hard surface of the roll **30**.

Means are provided for driving rolls **25** and **30** while rolls **24**, **27**, **28** and **29** are usually driven by rolls **25** and **30** by frictional forces transmitted through the paper. Apparatus suitable for performing the process is described in U.S. Patents 3,365,774 (Kusters) and 3,124,504 (Mahoney et al.).

While the apparatus described by Mahoney et al. can be used for the performance of the present process, it should be noted that there is no teaching of the applicant's process by Mahoney et al. It is a primary purpose of the method of the present invention to effect a substantial reduction in the caliper of the newsprint while simultaneously increasing surface smoothness. The caliper (thickness) reductions to be obtained by the applicant's process ranges from 25% to 50% of the thickness of the uncalendered paper. Mahoney et al. provide a method and apparatus specifically designed to smooth, gloss and coalesce the paper surface "without substantially affecting the bulk or thickness of the web" (U.S. Pat. 3,124,504, col. 1, lines 58 and 59) and this emphasis on little or no change in paper thickness is repeated at numerous places in their disclosure. Furthermore, in setting out the advantages of their method and apparatus over other calendering means, Mahoney et al. cite, as a disadvantage of these, that they "produce an end product the thickness or bulk of which is altered considerably as a result thereof" (col. 1, lines 52 and 53). Thus, their process does not teach substantial caliper reduction, which is an object of the present invention. Furthermore, the effects of smoothing and glossing sought by Mahoney et al. are the result of a differential velocity of paper and hard polished roll through the pressure nip, a characteristic of nips formed between rolls of different hardness. The paper surface is dragged over and smoothed by the metal surface and this relative slippage is essential to the production of smoothing. The applicant's process is, as described with respect to FIG. 4, used without differential velocities between the paper and the metal surfaces. Such conditions will not give the glossing and polishing which are the objectives of the invention of Mahoney et al.

Due to the deformation of the resilient roll cover **26** in its passage through the pressure nip, its surface velocity changes from point-to-point through the nip relative to the constant surface speed of the roll **25**. Since the paper adheres more to the cover **26** than to the polished surface of the roll **25**, the differential velocity of the cover **26** results in the paper sliding slightly on the polished surface **25**. In combination with the pressure exerted between the rolls **24** and **25**, this sliding effects an "ironing" action which is very efficient in smoothing that surface of the paper in contact with the surface of roll **25**. After passing the roll **27**, the paper will be smoother on the side **32** than on the side **33**. To eliminate this difference the paper is recalendered through the nips formed by rolls **28** and **30**, and **29** and **30** whereby the surface **33** benefits in turn from the described ironing process and the surfaces **32** and **33** become of substantially equal smoothness.

The newsprint calendering process of the invention may be applied to uncalendered newsprint of moisture content up to 12 to 15%. The metallic surface forming one element of the calendering nips is preferably so heated as to give paper temperatures in the nips in the range from 100 to 200° F. Actual temperature of the metal rolls to give such paper temperatures will depend upon such factors of specific equipment units as operating speed, mode of heating and duration of contact of the paper web with the heated surface. Suitable pressures for calendering will lie in the range of 100 to 1,000 pounds per lineal inch of nip width. The covering **26** of the rolls **24**, **27**, **28** and **29** may be of hard rubber or other elastomer with a preferred hardness in the range of 0 to 25 as measured by the Pusey and Jones ⅛" ball method with a preferred range from 2 to 7.

These parameters of temperature, roll hardness and nip pressure, paper moisture and speed are the usual variables of any paper calendering process and the proper combination of them to achieve a desired degree of calendering will be within the range of adjustments available on the paper making machine and calender, and within the competence of paper machine operators. A desired degree of calendering would involve a substantial reduction of paper thickness. Ordinarily this would be from an initial thickness of 0.005 inch to 0.0065 inch down to 0.003 to 0.0038 inch.

The process for making newsprint, which is the subject of this application may be applied to papers made of any of the known blends of fibers used for making newsprint. The applicant has found that in common with all newsprint papers is the fact that the strength losses produced by conventional calendering are a consequence of the application of excessive pressures upon localized areas of high basis weight and that such areas exist in newsprints made from all types of fiber furnishes and that such areas are not necessarily the result of the presence of shives, but may be due to random excesses of normal fibers in small areas. The blends used for making newsprint may, for example, be made of stone or refiner groundwood made from suitable softwood or hardwood species, in combination with varying proportions of chemical pulps (or without them) such as semibleached kraft, high or normal yield sulphite pulps, or others.

Independent of the particular combination of fiber types used in making newsprint, the wet forming processes used invariably result in the formation of numerous small areas of basis weight substantially above average basis weight. Newsprint paper is normally made at a basis weight of 32 pounds per 3,000 square feet. This weight per unit area is roughly equivalent to that given by three of the wood fibers used in making the pulps from which the paper is made. Actually, in the groundwood, which is the principal

complement of newsprint, most of these fibers have been broken into fragments and a typical section through the thickness of the paper will consist of many more than three fibrous elements. However, there are many fibers and fiber fragments of the full cross sectional thickness of the original wood fiber and many of these will cross and be superimposed at many locations within the paper. Given that the final arrangement of fibers in the paper is largely a matter of chance, there will be many small areas in which the number of fibers through the thickness of the paper is other than the average of three. It may be less or it may be four, five, six, or more, with reduced likelihood of occurrence being associated with the increased number of superimposed fibers.

Since each superimposed fiber is equivalent to about 10 pounds in basis weight, six of them would represent a very small area having a basis weight of about 60 pounds or nearly twice the average basis weight.

Examples of newsprint to which the invention is specially applicable are those containing supergroundwood, as will now be explained.

Newsprints are generally made with mixtures of "stone" groundwood pulps and chemical pulps. The relatively inexpensive "stone" groundwood pulps are made by forcing whole logs of wood against a revolving, abrasive grindstone, while the chemical pulps require expensive chemical treatment of the wood and yields are much lower in the latter case. For the sake of economy, newsprint producers have, for many years, been trying to develop methods which result in the production of newsprint with a minimum content of chemical pulp.

More recently, a process for making groundwork by disc-refining wood chips instead of forcing whole logs of wood against a revolving grindstone has been developed. This refiner-groundwood pulp, when produced under known optimum operating conditions, is of higher strength than the stone-produced pulp and drains well on the web-forming section of a paper-making machine even in the absence of chemical pulp. Because of its superior strength qualities, this pulp is often called "supergroundwood." It has been found to have sufficient wet-web strength to run on a paper machine with acceptably few breaks, and, is, therefore, starting to find more and more applications as a replacement of all or part of the "stone" groundwood component used in newsprint pulp furnishes. This topic is well covered in Pulp and Paper Magazine of Canada, vol. 64, No. 7, T–299 (July 1963), "Supergroundwood: Its Manufacture from Chips and Use as Sole Newsprint Furnish," L. R. Beath and M. T. Neill.

However, this "supergroundwood" pulp was also found to have a higher specific volume than the "stone" groundwood pulp ("Science and Technology of Mechanical Pulp Manufacture," N. G. Gavelin, Lockwood Publishing Co. (1966), p. 213). Furthermore, any reduction in the proportion of chemical pulp content in the furnish also results in a higher paper specific volume because the chemical pulp has a lower specific volume than the groundwood pulp. The increase in specific volume due to the above reasons leads to difficulties meeting newsprint smoothness and bulk specifications and requires heavier calendering on the paper machine. See the Gavelin article.

The heavier calendering of newsprnt made from "supergroundwood" pulp to give normal newsprint thickness results in a reduction of its average strength. Furthermore, supergroundwood generally contains more long shives than ordinary "stone" groundwood as explained in "Science and Technology of Mechanical Pulp Manufacture," N. G. Gavelin, Lockwood Publishing Co. (1966), p. 212. The presence of shives, coupled with the heavier calendering introduces more "flaws" or "weak points" in the newsprint web. It has been shown by G. F. Sears, R. F. Tyler, G. W. Denzer, "Shives in Newsprint. The Role of Shives in Paper Web Breaks," Pulp and Paper Magazine of Canada, vol. 66, No. 7, T–351 (July 1965) that these flaws trigger newsprint web breaks on printing presses For these reasons it is not possible, according to normal newsprint manufacturing procedure, to take full advantage of the higher strength of supergroundwood by substantially reducing the proportion of chemical pulp.

An aspect of the present invention is, therefore, the combination of making paper with a newsprint pulp furnish of which all of the mechanical pulp content is supergroundwood pulp and calendering the paper made therefrom in a resilient nip calender as described herein. The same benefits to a lesser degree may be obtained by making paper with a newsprint pulp furnish of which about one-quarter or more by weight of the mechanical pulp content is supergroundwood, and calendering the paper made therefrom in a resilient nip-calender. Despite the reduced proportion of chemical pulp, compared with normal practice, the resulting paper still has adequate strength to run on high-speed printing presses with acceptably few breaks.

A preferred aspect of the invention, therefore, is to employ a newsprint furnish made up entirely of supergroundwood pulp. The invention also contemplates the use of a varying amounts of chemical pulp depending on the requirements of the newsprint user. In any case, the combination of the use of a proportion of not less than 25% supergroundwood pulp, based on the total mechanical pulp, in combination with resilient-nip calendering permits the amount of chemical pulp employed to be reduced below that which would have to be used to make an acceptable newsprint using a paper made from a furnish in which all the mechanical pulp is groundwood pulp and metal-nip calendering.

This aspect of the invention contemplates making supergroundwood pulp with disc refiners and auxiliary equipment, making paper with this pulp, and, after drying, calendering the dried paper in a resilient-nip calender. The presence of the supergroundwood pulp, in amounts of at least about a quarter by weight of the total mechanical pulp, allows a reduction in chemical pulp content without deterioration of the paper machine runability. The resilient-nip calendering prevents the deterioration in dry strength and generation of shive flaws which would result from heavier conventional calendering required to reduce the bulkier supergroundwood furnish to normal newsprint thickness.

The production of supergroundwood pulp is an art which is still evolving, but some preferred methods have now been established. For example, the applicant has produced excellent supergroundwood pulps by disc-refining softwood chips in one pass through Sprout Waldron single-disc refiners or through Bauer double-disc refiners. Enough dilution water is added so as to give a consistency of about 15% to 40% in the refining zone. About 80 to about 110 H.P.-days per oven-dry ton of energy is applied at the refiners, equipped with refining plates of a suitable pattern (for example D 13A001 on the Sprout and 40106 on the Bauer).

The pulp is then screened and centricleaned as usual. Although there are several possible variations to this process for the production of supergroundwood, it is not always possible to make supergroundwood with refiners unless specific conditions of equipment and operation are correctly combined to get it. For example, the disc-refining of the wood chips can be done in one, two, three or more stages and it can be done under atmospheric or pressurized conditions. Sometimes the consistencies in the second and subsequent stages can be lowered to about 5% and supergroundwood quality still maintained. This process, in any of the forms mentioned, results in supergroundwood pulps which are of superior strength and papermaking characteristics than "stone" groundwoods.

A comparison of typical properties of supergroundwood, stone groundwood and sulphite pulps made with northern softwoods is given in Table II.

TABLE II

	Super ground-wood	Stone ground-wood	News-grade sulphite
Canadian standard freeness	100	100	680
Apparent specific volume, c.c./A.D. gm.	2.75	2.45	1.70
T.A.P.P.I. burst factor	18	14	55
T.A.P.P.I. tear factor	80	45	90

A specific example of the conditions and equipment required to produce supergroundwood according to one preferred method is given below:

Wood species: Spruce-balsam fir mixture
Chip quality: As for newsgrade sulphite production
Type of refiner: Sprout, Waldron 42–1 with 2000 H.P. motor
Plate pattern: D 13 A 001/Ni-hard
Rate of chip feed: 21 oven-dry tons per day
Rate of addition of dilution water to chips: 13 U.S.G.P.M.
Temperature of dilution water: 40 to 80° F.
Average refiner motor load: 2000 H.P.
Average specific energy consumption: 95 H.P.-days per ton

As mentioned previously, supergroundwood is also of higher specific volume and generally contains more long shives than "stone" groundwood. With heavier conventional calendering of the newsprint made with supergroundwood to obtain normal newsprint calipers, the average dry strength of the newsprint is reduced and more weak shive-flaws are introduced. The invention overcomes this problem by replacing the conventional calendering with resilient-nip calendering.

Essentially what is required is that the newsprint web leaving the drying section of the paper machine be passed through at least two resilient nips, each nip fromed between a smooth, non-resilient, heated metal roll and an opposing roll covered with a resilient material such that each side of the newsprint web contacts a metal roll at least once. These resilient-nip calenders are available in several different assemblies and are sometimes called Gloss Calenders or Burnishers or Thermoplanishers. Suitable machines are described in U.S. Patents 3,124,504, 3,190,-212 and 3,230,867. Although these machines are generally used to impart very high gloss finishes to papers and boards, the applicant has found that they can be operated, according to the invention, to produce normal newsprint finishes. For example, the applicant has used the Beloit "Burnisher" to calender newsprint in this way. One set of operating conditions using this equipment was:

Basis weight of newsprint: 32.05 lb./ream (24 x 36 x 500)
Paper moisture entering first nip: 16.6% o.d.
Speed of paper through calenders: 1350 f.p.m.
Total number of resilient nips: 4
Nip pressure at each nip: 350 p.l.i.
Resilient roll covering plastometer, P & J units: 3
Smooth non-resilient roll surface temperature: 320° F.
Paper moisture after calendering: 10.2% o.d.

Other combinations of paper moisture content, metal roll surface temperatures and lineal nip pressures may be chosen to produce the caliper and smoothness of newsprint desired, without losing the dry strength of the supergroundwood and without the generation of numerous shive flaws.

The surprising difference between the average strength properties of supergroundwood when calendered in the conventional manner and when calendered in a resilient-nip calender is shown in the following tables.

TABLE III

	Conventional calender	Resilient-nip calender
Basis weight, A.D. lb./ream (24 x 36 x 500)	34.7	31.8
Apparent specific volume, c.c./A.D. gm.	1.51	1.51
T.A.P.P.I. burst factor	10.4	20.6
T.A.P.P.I. tear factor	32.7	52.6
Breaking length, km.	1.97	3.60
Stretch, percent	1.18	2.35

Table IV shows the effects of conventional and resilient-nip calendering on the tensile strengths of supergroundwood strips having at least one shive lying at right angles to the direction of stressing.

Visual observation of the strips used to obtain the above results showed that normal calendering caused cutting of the fibers lying directly above and below the shives. This cutting locally destroyed the fiber network of the sheet along the length of the shive creating, in effect, a small slit in the paper. This was confirmed by the much greater number of strips which broke at the shives wtih conventional calendering than with resilient-nip calendering.

TABLE IV

	Conventional calendered					Resilient-nip calendered				
	Basis wt.	Caliper, in.	Shive length, mm.	Tensile, kg./15 mm.	Did or did not break at shive	Basis wt.	Caliper, in.	Shive length, mm.	Tensile, kg./15 mm.	Did or did not break at shive
Strip number:										
1	32.9	.00333	9	1.38	Yes	33.4	.00330	9	2.61	No.
2	32.5	.00333	7	0.92	Yes	32.9	.00327	8	2.85	No.
3	32.0	.00323	9	1.52	Yes	33.2	.00323	7	2.80	No.
4	32.3	.00320	12	0.72	Yes	32.6	.00330	8	2.60	No.
5	32.6	.00333	11	0.38	Yes	33.5	.00327	13	2.80	No.
6	32.2	.00330	14	0.20	Yes	32.6	.00330	15	2.60	No.
7	32.9	.00333	11	0.90	Yes	32.9	.00330	11	2.69	No.
8	33.4	.00340	8	0.82	Yes	33.6	.00337	8	2.70	No.
9	32.9	.00340	10	0.62	Yes	33.0	.00330	8	2.45	No.
10	33.3	.00340	7	1.40	Yes	33.0	.00337	10	2.32	Yes.
11	33.5	.00327	10	0.95	Yes	33.2	.00343	11	2.21	No.
12	32.6	.00330	7	0.98	Yes	32.6	.00343	10	2.80	No.
13	32.3	.00333	13	1.00	Yes	32.9	.00337	8	2.60	No.
14	32.3	.00313	9	0.79	Yes	33.0	.00330	8	2.86	No.
Average	32.7	.00331	9.78	0.90		33.0	.00332	9.56	2.63	

I claim:

1. A process for producing newsprint which comprises preparing a newsprint pulp furnish of fibers, making a wet paper web of said furnish, drying said web, calendering dried web to reduce its thickness by from 25% to 50% and to increase its surface smoothness while causing minimal strength loss by pressing the dried web between two opposed surfaces one of which surfaces is smooth and made of a hard metallic material and the second of said surfaces is made of a firm resilient material such that the thickness of the paper between said opposed surfaces under the applied pressure varies from point-to-point in approximate proportion to the corresponding point-to-point basis weights of the paper, removing said paper from between said opposed surfaces and re-pressing it between two opposed surfaces one of which surfaces is smooth and

made of a hard metallic material and the second of said surfaces is made of a firm resilient material such that the thickness of the paper between said opposed surfaces under the applied pressure varies from point-to-point in approximate proportion to the corresponding point-to-point basis weights of the paper, said re-pressing being performed so that the surface of the paper which was in contact with the metallic surface during the first pressing is in contact with the resilient surface during said re-pressing.

2. A process as defined in claim **1**, in which the smooth surfaces made of a hard metallic material are the surfaces of cylindrical rolls, the surfaces made of firm resilient material are the surfaces of cylindrical rolls, the said rolls cooperating in pairs of unlike surfaces to form between said pairs rolling pressure nips, and calendering said web by passing it through said rolling pressure nips.

3. A process as defined in claim **2**, in which the cylindrical rolls having hard metallic surfaces are heated to increase paper temperature and thereby increase its plasticity and ease of calendering.

4. A process for producing newsprint which comprises, preparing a newsprint pulp furnish of fibers of which at least about one-quarter by weight of the mechanical pulp content is of supergroundwood pulp fibers, making a paper web from said furnish, drying said web, and then, calendering opposite sides of the web through calendering nips formed from mutually-reversed resilient and hard calendering rolls.

5. A process as defined in claim **4**, in which the newsprint pulp furnish is entirely of supergroundwood pulp fibers.

6. A process, as defined in claim **4**, in which said hard rolls are formed of a metal, and said resilient roll is formed by a roll covered by a resilient material.

7. Newsprint produced by the method defined in claim **5**.

8. The method of producing a newsprint web with a minimum chemical pulp content comprising the steps of:

(a) preparing a newsprint furnish containing a blend of pulp fibers including supergroundwood to the extent of a least 25% by weight of the total mechanical pulp content of said blend of pulp fibers in which the supergroundwood has a normal shive content;

(b) forming a continuous wet web from said furnish by dewatering an aqueous suspension of the blended furnish and wet pressing the web on paper making apparatus;

(c) drying the wet web in dryer apparatus and attaining normal, controlled moisture content; and

(d) calendering the dried web with resilient calendering means by progressively calendering opposite sides of the continuous web through calendering nips formed from mutually-reversed resilient and hard calendering rolls so that each side of said web is contacted by a hard roll at least once and controlling the soft-calendering lineal pressure and substantially preventing the shives from severing local fibers surrounding the shives for producing an acceptable newsprint with improved burst and tear factors and minimizing shive flaws.

9. Newsprint produced by the method as claimed in claim **8**.

10. The method according to the step set forth in claim **8** in which said newsprint furnish is prepared so that the blend contains supergroundwood to the extent of 100% by weight of the total mechanical pulp content.

11. Newsprint produced by the method as set forth in claim **10**.

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162—150, 206