Aug. 22, 1967 C. L. WOSABA II 3,337,388

SELECTIVE NAPPING OF EMBOSSED PAPER TOWELING AND ARTICLE PRODUCED THEREBY

Filed Aug. 7, 1964 4 Sheets-Sheet 1

Fig. 2

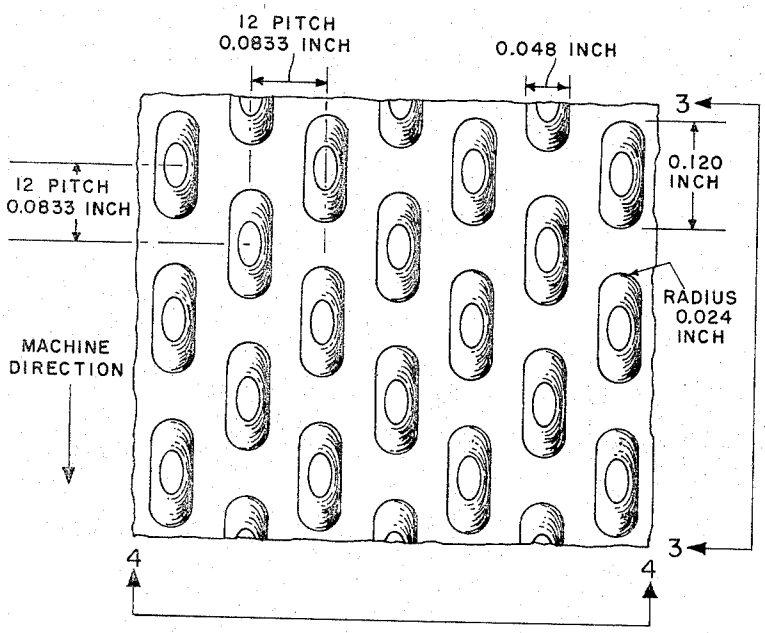


Fig. 3

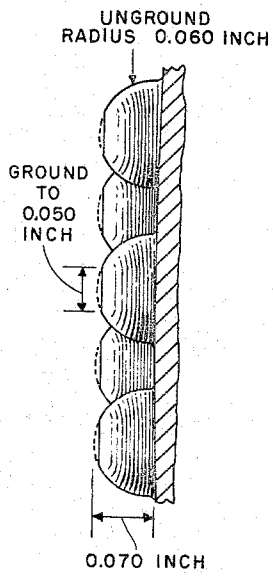
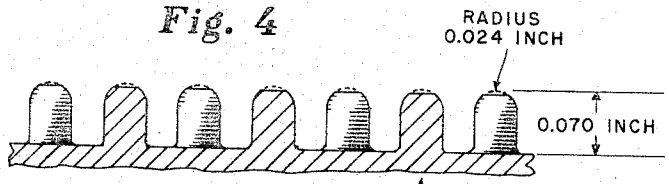


Fig. 4



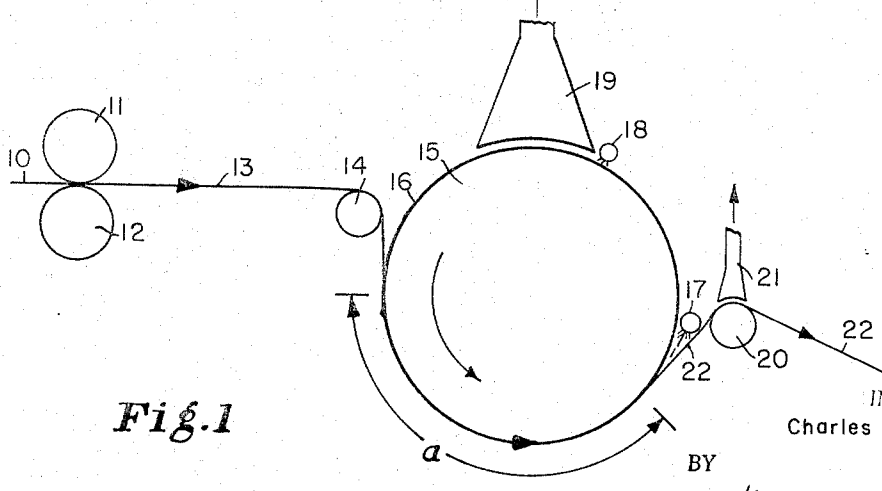


Fig.1

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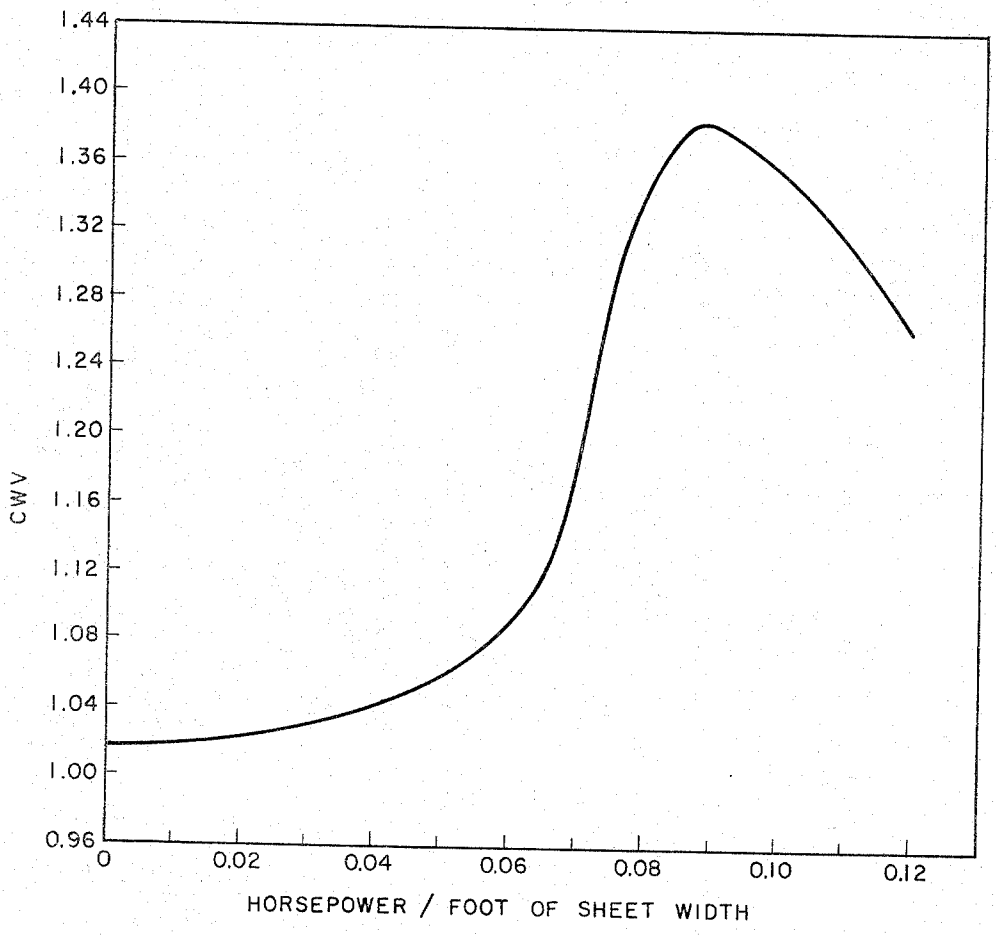
Fig. 5



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Aug. 22, 1967 C. L. WOSABA II 3,337,388
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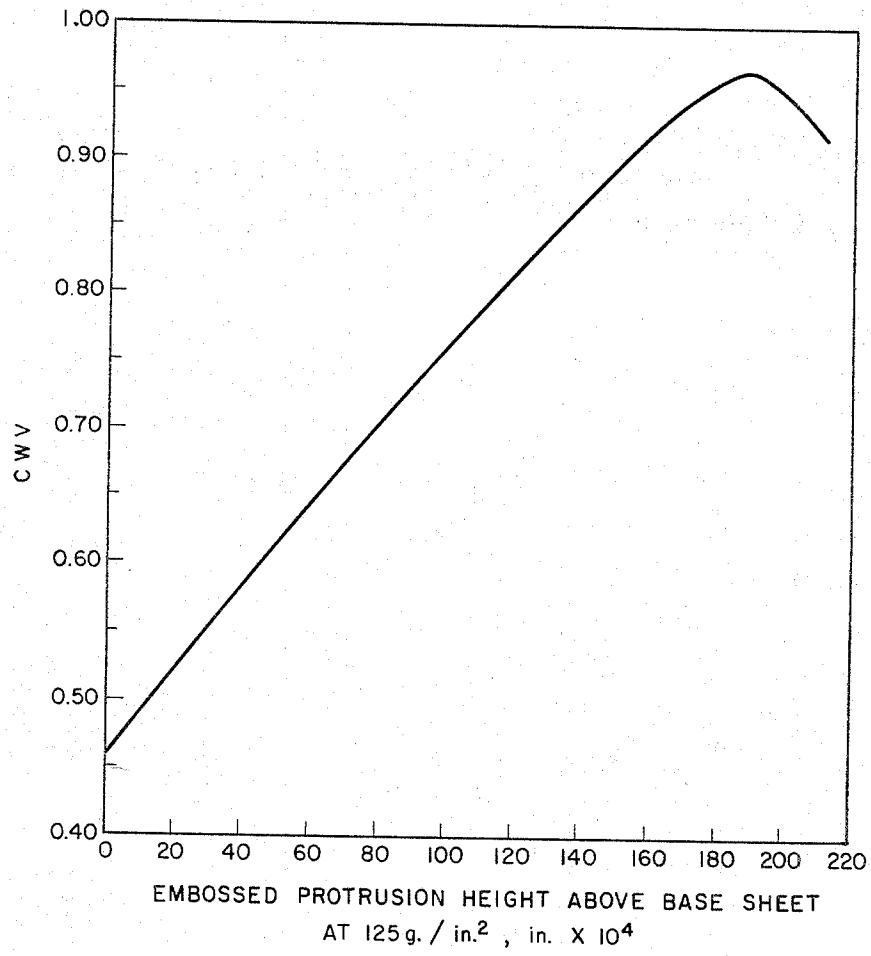
Fig. 6



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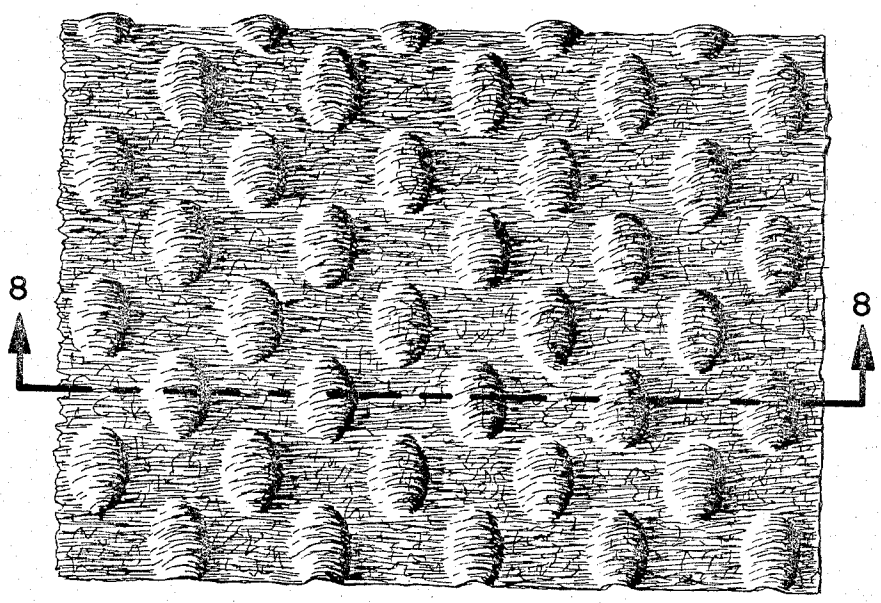

Fig. 7

Fig. 8

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United States Patent Office 3,337,388 Patented Aug. 22, 1967

3,337,388

SELECTIVE NAPPING OF EMBOSSED PAPER TOWELING AND ARTICLE PRODUCED THEREBY

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Filed Aug. 7, 1964, Ser. No. 388,172
8 Claims. (Cl. 161—63)

The present invention relates to a process for embossing a creped paper sheet and mechanically treating the distal surfaces of its embossed protuberances for the purpose of improving its softness, bulkiness and sponginess. More particularly, the invention is concerned with a method of embossing and tufting without perforating the distal surfaces of embossed protuberances of a creped paper sheet, referred to hereinafter in the present specification and claims as toweling paper, and the soft, bulky and spongy paper product resulting therefrom.

Specifically, the present invention provides for a process wherein toweling paper is subjected to a combination of embossing together with tufting, or raising the fibers, on the distal surfaces of the embossed protuberances by the action of a perforated metal abrasive, whereby a greatly improved sponginess, together with enhanced softness and bulkiness is engendered in the resultant toweling paper product.

It is known that the surfaces of paper have been abraded heretofore for the purpose of improving their softness. U.S. 439,405 issued to Gustav L. Jaeger on Oct. 28, 1890, for example, discloses the abrasive treatment of blotting paper surfaces with sand-paper, emery wheels and wire brushes to impart softness to the surfaces of paper sheets.

Applicant is further aware of the several and various embossing processes available in the prior art and also of U.S. 2,218,674 issued to Lewis B. Eaton on Oct. 22, 1940, wherein a technique of embossing followed by abrading away the embossed indentations with an abrasive wheel is disclosed as the method of perforating parchment paper for use in tea and coffee bags. In the present invention, tufting of the embossed protuberances is achieved without forming perforations.

In investigating the possibility of creating a soft, bulky and spongy paper, problems were encountered, both in the development of raised fiber tufting on the paper surfaces and in the development of embossing patterns which enhanced the soft spongy qualities of the finished product. For example, it was found that the prior art means of abrading sheet surfaces, emery wheels, wire brushes, sand-paper, etc., permitted only very slow linear sheet speeds in the present tufting treatment. Problems were also encountered in tufting the distal surfaces of the embossed protuberances without tearing the toweling paper sheets or perforating the embossed protuberances, contrary to the effect desired by applicant.

Applicant has unexpectedly discovered, however, that a highly desirable toweling paper sheet results from a process wherein the unsupported distal surfaces of a repeating embossed pattern consisting of about 16 to about 150 protuberances per square inch, raised to a height of about 0.010 inch to about 0.030 inch above the surface of the original toweling paper sheet and constituting about 10% to about 60% of the sheet surface, are tufted with a perforated metal abrasive, i.e. a thin sheet of metal provided with abrasive projections on one side thereof, formed by punching apertures in the thin sheet of metal. It is, therefore, an object of this invention to provide a process for the manufacture of a soft, bulky and spongy paper sheet for use as toweling paper and the like.

It is a further object of this invention to provide a process for the manufacture of a soft, bulky and spongy toweling paper wherein the raised surfaces of embossed protuberances are tufted with a perforated metal abrasive.

It is still another object of this invention to provide a soft, bulky and spongy toweling paper characterized by a pattern of embossed protuberances having tufts of fibers raised on their distal surfaces by the tufting action of a perforated metal abrasive.

With these general objects in view, and such others as may hereinafter appear, the present invention consists of the process for improving the softness, bulkiness and sponginess of toweling paper and the toweling paper produced thereby, as hereinafter described and particularly claimed at the end of this specification.

In the drawings which illustrate a preferred embodiment of the invention, FIGURE 1 is a schematic drawing of the side elevation of equipment for carrying out a preferred embodiment of the present process.

FIGURE 2 is an enlarged partial plan view of the surface of an embossing roll, illustrating a particularly preferred spacing and size of embossing protuberances suitable for use in the equipment shown in FIGURE 1.

FIGURE 3 is a side elevation of FIGURE 2 taken along the line 3—3, which in combination with FIGURE 4, a machine direction elevation of FIGURE 2, further illustrates the shape and spacing of particularly preferable embossing protuberances suitable for use in the practice of the invention.

FIGURE 5 is a graph illustrating the relationship of the sponginess of embossed toweling paper [in terms of compressive work value (CWV) numbers as hereinafter defined] with tufting action (in terms of horsepower per foot of sheet width) applied to the distal surfaces of embossed protuberances on the toweling paper. The graph of FIGURE 5 represents test results from toweling paper products resulting from carrying out the process of Example I with the exception that the tufting action (horsepower per foot of sheet width) was varied to develop the graph.

FIGURE 6 is a graph illustrating the relationship of the sponginess of embossed toweling paper (in terms of CWV as hereinafter defined) with the height of the raised protuberances of the embossed sheet above the surface of the original toweling paper measured under a compressive load of 125 grams per square inch. The data represented by the graph in FIGURE 6 was developed by embossing protuberances of various heights on the toweling paper of Example I, using the embossing roll surface illustrated in FIGURES 2, 3 and 4, at different pressures.

FIGURE 7 is an enlarged partial plan view of an embossed and tufted toweling paper sheet resulting from carrying out the present process with the embossing roll illustrated in FIGURES 2, 3 and 4.

FIGURE 8 is a cross section of the embossed and tufted toweling paper sheet illustrated in FIGURE 7 taken along line 8—8 which illustrates the shape of the embossed protuberances created by the particularly preferred embossing roll and illustrates the fibrous tufts standing on the distal surfaces of the embossed protuberances.

The CWV numbers, referred to herein, define the compressive deformation characteristics (sponginess as part of a total impression of softness to a person who handles the paper) of a paper sheet compressively loaded on its opposing surfaces. The significance of the CWV number is better understood by the realization that it represents the total work expended in compressing the surfaces of a single paper sheet inwardly toward each other with a gradually increasing load to an ultimate unit load of 125 grams per square inch.

In accomplishing the foregoing compression test, the apparent thickness of the paper sheet is decreased, and work is done. This work, or expended energy, is similar

to the work done by a person who pinches the surfaces of a sheet of paper between his thumb and forefinger to gain an impression of its softness. Applicant has found that CWV numbers correlate well with the softness impression obtained by a person who handles a paper sheet.

An Instron tester (Model No. TM, Serial No. 261) was used to measure the CWV numbers by placing a single sheet of the paper to be tested between compression plates having an area of four square inches. The sample was then loaded on its opposing surfaces by forcing the compression plates together at a rate of 0.02 inch of compression deformation per minute until the loading per square inch reached 125 grams.

The Instron tester is equipped with a recording unit which integrates the compression movement of the compression plates in contact with the sheet surfaces of the instantaneous loading to give the total work in inch-grams required to reach the 125 grams per square inch loading at which the test is concluded. This work, expressed as inch-grams and obtainable from the graphical plot made by the Instrom tester recorder, is the CWV number referred to herein. The heights of embossed protuberances disclosed herein are measured from the surface of the original toweling paper with the test toweling paper sheet subjected to a loading of 125 grams per square inch on its opposing surfaces as taken from the loading plot made on the Instron tester.

In general, the process of the present invention comprises the steps of (1) passing a continuous toweling paper sheet between embossing rolls to form a raised pattern of embossed protuberances on the surface of the toweling paper sheet and (2) contacting the embossed toweling paper sheet with a perforated metal abrasive, in such a manner that the distal surfaces of the embossed protuberances on the surface of the embossed toweling paper sheet are subjected to tufting action by the small raised points constituting the effective surface of the perforated metal abrasive.

Referring now to FIGURE 1 of the drawings, a toweling paper sheet **10** is shown passing through the nip formed by a rubber-covered roll **11** and a steel embossing roll **12**. The embossed toweling paper sheet **13** is then passed around an idler roll **14** and into contact with the surface of a rotating tufting roll **15** whose cylindrical surface **16** is covered with a perforated metal abrasive as described hereinbelow. The embossed toweling paper sheet **13** is contacted with the cylindrical surface **16** of the rotating tufting roll **15** so that the distal surfaces of the embossed protuberances on the surface of the embossed toweling paper sheet are brought into contact with the cylindrical surface **16** over a portion of the circumference of the rotating tufting roll **15** subtended by an angle of α degrees. As the embossed and tufted toweling paper sheet **22** leaves the cylindrical surface **16**, it is blown free of loose material by an air doctor **17** and passes over an idler roll **20**, placed to maintain contact between the distal surfaces of the embossed protuberances and the cylindrical surface **16** through the angle, α. The idler roll **20** is equipped with a supra-mounted dust hood **21** to remove dust from the surface of the embossed and tufted toweling paper sheet **22**. As the cylindrical surface **16** of the rotating roll **15** rotates past the point where the embossed and tufted toweling paper sheet **22** departs the roll, it is blown free of loose fibrous material by an air doctor **18**, and the loose fibrous material is removed from the roll surface by the dust hood **19**.

In carrying out the process of the present invention, applicant selects a toweling paper having a basis weight of about 15 pounds to about 40 pounds, preferably about 25 to about 35 pounds, per 3000 square feet. The toweling paper should also have a machine direction tensile of about 700 to about 3000, preferably about 900 to about 2000, grams per inch of paper width to prevent tearing during contact with the tufting roll.

The selected toweling paper is embossed with a repeating pattern consisting of about 16 to about 150, preferably about 60 to about 80, protuberances per square inch, raised to a height of about 0.010 inch to about 0.030 inch, preferably about 0.020 inch, above the surface of the original toweling paper. The embossing is conducted so that about 10% to about 60%, preferably about 15% to about 20% of the toweling paper surface is raised.

As illustrated in FIGURE 1, a preferred embodiment of the process contemplates embossing the toweling paper by passing it through the nip formed by running a steel embossing roll against a rubber-covered roll, but any method which produces the disclosed degree of embossing is satisfactory for use in the process.

One particularly preferred embodiment of a steel embossing roll for use in the present process has certain protuberance dimensions and spacing, as illustrated in FIGURES 2, 3 and 4, but other embossing means resulting in toweling papers having the above embossed protuberance specifications can be employed to obtain the benefits of the process. While any protuberances resulting in toweling papers having the above embossed protuberance specifications will achieve the benefits of the present invention, it is preferred that ones having a flattened distal end structure be used because this shape results in additional tufted area.

The steel embossing roll protuberance dimensions and spacing illustrated in FIGURES 2, 3 and 4 simulate the surface of a roll covered with 12 by 12 wires per inch, plain weave wire woven of 0.047 inch diameter wires with pre-crimped wires passing circumferentially around the roll and straight wires parallel to the axis of the roll. The protruding surfaces of the embossed protuberances, the wire cross-over points, are ground to create flat surfaces, preferably having a dimension of about 0.050 inch in the machine direction.

After the selected toweling paper has been embossed, fibrous tufts are formed on distal surfaces of the embossed protuberances by contact with a rotating tufting roll covered with perforated metal abrasive as more fully described below. Applicant has found it preferable to contact the rotating tufting roll through an arc subtended by an angle, α, as illustrated in FIGURE 1 of about 80 degrees to about 180 degrees, but any contact arc greater than that subtended by an angle of at least 20°, which will achieve the range of horsepower per foot of web width disclosed hereinbelow, will be found suitable. Contact arcs subtended by an arc of less than 20 degrees have not been found suitable because the concentrated tufting treatment tears the embossed toweling paper. A speed differential of about 50 to about 2000, preferably about 500 to about 1500, feet per minute between the embossed toweling paper and the surface of the rotating tufting roll has been found necessary to prevent snagging and tearing the sheet. About 0.2% to about 2% of the toweling paper basis weight, dependent upon the percentage of raised sheet surface, is removed from the distal surfaces of the embossed protuberances by the tufting treatment.

As illustrated in the graph which comprises FIGURE 5 of the attached drawings, the CWV of embossed and tufted toweling paper can be enhanced in a desirable way by maintaining a power input to the raised surfaces of the moving, embossed toweling paper of about 0.07 to about 0.10, preferably about 0.09, horsepower per foot of web width. FIGURE 6 shows that the CWV of toweling paper is increased to a peak by embossing alone and then falls off. It will be understood that different embossing patterns within the disclosed range will require the amount of work done on the sheet surface to be regulated for the achievement of an optimum CWV number. The optimum amount of work will in each case be determined by running the CWV number of the sheet to a maximum by adjusting the power input within the range specified.

In measuring the power transmitted to the distal sur-

faces of the raised protuberances on the moving, embossed toweling paper, applicant used the following formula.

$$\text{HP.} = \frac{T \times S}{33{,}000 \text{ ft.-lbs. per minute}}$$

where

T is the numerical difference in the paper tension before and after the rotating tufting roll in pounds per foot of sheet width, and

S is the sheet speed in feet per minute

Applicant has discovered that the desired horsepower per foot of embossed toweling paper sheet width holds very nearly constant within the practical ranges of sheet speed. This constancy arises from the fact that the numerical difference in paper tension, T, due to tufting treatment decreases as the paper speed increases, so that the horsepower, as defined above, to accomplish the optimum tufting remains the same per foot of sheet width.

The rotating tufting roll is covered with a perforated metal abrasive, whose pattern of raised points is such that uniform tufting is obtained when the roll rotates against a surface. A perforated metal abrasive having about 80 to about 500, preferably about 100 to about 300, pierced perforations per square inch is desirable to prevent tearing the embossed toweling paper as it passes around the tufting roll. The piercing operation forms metal points extending upwardly around the periphery of the pierced perforations in the perforated metal abrasive. Although any perforated metal abrasive having the above characteristics can be used to tuft the embossed toweling paper, a particularly suitable perforated metal abrasive is described in United States Patent No. 2,820,281, issued to Alfred W. Amsen on Jan. 21, 1958, and is commercially available under the tradename, "Dragonskin."

Practice of the above described process results in a soft, bulky and spongy toweling paper having a basis weight of about 15 pounds to about 40 pounds, preferably about 25 to about 35 pounds per 3000 square feet. The product also exhibits a repeating pattern of about 16 to about 150, preferably about 60 to about 80, embossed protuberances which constitute about 10% to about 60%, preferably about 15% to about 20% of the toweling paper surface and are raised to a height of about 0.010 inch to about 0.030 inch, preferably about 0.020 inch, above the surface of the toweling paper prior to tufting. The CWV of the product toweling paper sheet is at least 1.20, preferably about 1.40.

Having described the process and product of this invention, the following examples are intended to illustrate modes of advantageous operation, but it will be understood that those skilled in the art will immediately be aware of other advantages stemming from the herein disclosed inventive concept. It is understood, therefore, that the examples are intended to be illustrative and not limiting, and the scope of the invention is only to be construed by the scope of the appended claims.

Example I

A dry-creped toweling paper having a basis weight of 31.5 pounds per 3000 square feet and having a machine direction tensile strength of 1400 grams per inch together with a cross-machine tensile strength of 1250 grams per inch and a 25% machine direction stretch was embossed with a raised pattern by passing it through a nip formed by a steel embossing roll and a rubber-covered roll. The rubber-covered roll had a P & J ⅛" ball hardness of 123 and a diameter of 14 inches; the rubber covering was 1 inch thick. The steel embossing roll had protuberances in a pattern on its surface identical to those illustrated in FIGURES 2, 3 and 4 of the attached drawings. The 12 inch diameter steel embossing roll was pressed against the rubber-covered roll with a force of 300 pounds per linear inch.

In the foregoing manner the toweling paper sheet was embossed with a repeating pattern of 72 raised protuberances per square inch in the pattern of the embossing roll. The raised surfaces of the embossed protuberances were raised 0.018 inch above the surface of the original toweling paper and constituted 16% of the total surface area.

The embossed toweling paper was next passed over and in contact with a 16 inch diameter roll covered with a perforated metal abrasive having 128 perforations per square inch. The perforations had five triangular cutting points formed by the displaced metal around a 0.037 inch diameter hole. The height of the displaced metal cutting edges above the plane surface of the perforated metal was 0.025 inch.

The embossed toweling paper speed was 1000 feet per minute and the rotating tufting roll surface speed was 1800 feet per minute. The speed differential between the embossed toweling paper and the tufting roll surface was 800 f.p.m.

The embossed toweling paper was brought into contact with the rotating tufting roll around an arc subtended by an angle of 120 degrees so that the raised protuberances, embossed on the toweling paper, were brought into contact with the points of the perforated metal abrasive covering the rotating tufting roll to form fibrous tufts on the distal surfaces of the embossed protuberances. about 0.75% of the embossed toweling paper basis weight was abraded away.

The difference intension between the moving, embossed toweling paper sheet before contact with the rotating tufting roll and after contact with the rotating tufting roll was 2.91 pounds per foot of sheet width. Using applicant's formula for horsepower transmission stated hereinabove:

$T = 2.91$ lbs. per foot of sheet width

$S = 1000$ feet per minute

$$\text{HP.} = \frac{2.91 \times 1000}{33{,}000} = 0.088 \text{ horsepower per foot of sheet width}$$

The product toweling paper had a CWV of 1.38 inch-grams and was excellently suited for use as a kitchen towel. Embossed and tufted toweling papers prepared according to the process of Example I with the exception that they had 16 protuberances per square inch, constituting 55% of the sheet surface and raised to a height of 0.030 inch above the original toweling paper surface prior to tufting, and 150 protuberances per square inch, constituting 14% of the sheet surface and raised to a height of 0.010 inch above the original toweling paper surface prior to tufting, respectively, exhibited desirable product characteristics similar to those of the basic example product.

Having thus described the invention, what is claimed is:

1. A process for the manufacture of a soft, bulky and spongy toweling paper which comprises the steps of (1) selecting a toweling paper having a basis weight of about 15 to about 40 pounds per 3000 square feet and a machine direction tensile strength of about 700 to about 3000 grams per inch of toweling paper width, (2) embossing thereon a repeating pattern consisting of about 16 to about 150 protuberances per square inch, raised to a height of about 0.010 inch to about 0.030 inch above the surface of said toweling paper, said protuberances constituting about 10% to about 60% of the surface area of said toweling paper and (3) forming fibrous tufts on the distal surfaces of the protuberances by contacting said distal surfaces with a perforated metal abrasive, having about 80 to about 500 pierced perforations per square inch, moving at a speed differential of about 50 to about 2000 feet per minute with respect to the embossed toweling paper and maintaining a power input to the raised surfaces of the embossed toweling paper of about 0.07 to 0.10 horsepower per foot of toweling paper.

2. A process for the manufacture of a soft, bulky and spongy toweling paper with comprises the steps of (1) selecting a toweling paper having a basis weight of about 15 to about 40 pounds per 3000 square feet and a machine direction tensile strength of about 700 to about 3000 grams per inch of toweling paper width, (2) embossing thereon a repeating pattern consisting of about 16 to about 150 protuberances per square inch, raised to a height of about 0.010 inch to about 0.030 inch above the surface of said toweling paper, said protuberances constituting about 10% to about 60% of the surface area of said toweling paper and (3) forming fibrous tufts on the distal surfaces of the protuberances by maintaining a power input of about 0.07 horsepower to about 0.1 horsepower per foot of toweling paper width to the distal surfaces of said protuberances by contacting said distal surfaces, through an arc subtended by an angle of at least 20 degrees, with a rotating tufting roll the surface of which is covered with a perforated metal abrasive having about 80 to about 500 pierced perforations per square inch and the surface of which runs at a speed differential of about 50 to about 2000 feet per minute with respect to the embossed toweling paper.

3. A process for the manufacture of a soft, bulky and spongy toweling paper which comprises the steps of (1) selecting a toweling paper having a basis weight of about 25 to about 35 pounds per 3000 square feet and a machine direction tensile strength of about 900 to about 2000 grams per inch of toweling paper with, (2) embossing thereon a repeating pattern consisting of about 60 to about 80 protuberances per square inch, raised to a height of about 0.020 inch above the surface of said toweling paper, said protuberances consituting about 15% to about 20% of the surface area of said toweling paper and (3) forming fibrous tufts on the distal surfaces of the protuberances by maintaining a power input of about 0.09 horsepower per foot of toweling paper width to the distal surfaces of said protuberances by contacting said distal surfaces, through an arc subtended by an angle of about 80 degrees to about 180 degrees, with a rotating tufting roll the surface of which is covered with a perforated metal abrasive having about 100 to about 300 pierced perforations per square inch and the surface of which runs at a speed differential of about 500 to about 1500 feet per minute with respect to the embossed toweling paper.

4. A process for the manufacture of a soft, bulky and spongy toweling paper which comprises the steps of (1) selecting a toweling paper having a basis weight of about 31.5 pounds per 3000 square feet and a machine direction tensile strength of about 1400 grams per inch of toweling paper width, (2) embossing thereon a repeating pattern consisting of about 72 protuberances per square inch, raised to a height of about 0.018 inch above the surface of said toweling paper, said protuberances constituting about 16% of the surface area of said toweling paper and (3) forming fibrous tufts on the distal surfaces of the protuberances by maintaining a power input of about 0.088 horsepower per foot of toweling paper width

to the distal surfaces of said protuberances by contacting said distal surfaces, through an arc subtended by an angle of about 120 degrees, with a rotating tufting roll the surface of which is covered with a perforated metal abrasive having about 128 pierced perforations per square inch and the surface of which runs at a speed differential of about 800 feet per minute with respect to the embossed toweling paper.

5. The process described in claim 4 wherein the embossing procedure of step 2 is carried out by passing the toweling paper through the nip formed by running a rubber-covered roll against a steel roll, whose surface is engraved in the embossing pattern of a roll covered with a 12 by 12 wires per inch, plain weave wire woven of 0.047 inch diameter wires with pre-crimped wires passing circumferentially around the roll, said embossing pattern being further characterized by having the distal surfaces of the embossing protuberances ground to create flat surfaces having a dimension of about 0.050 inch in the machine direction.

6. A soft, bulky and spongy toweling paper having a basis weight of about 15 to about 40 pounds per 3000 square feet and a CWV of at least 1.2 which is further characterized by a repeating pattern constituting about 10% to about 60% of said toweling paper surface and consisting of about 16 to about 150 fibrous, tufted protuberances per square inch, raised to a height of about 0.010 inch to about 0.030 inch above the surface of the toweling paper prior to tufting.

7. A soft, bulky and spongy toweling paper having a basis weight of about 25 to about 35 pounds per 3000 square feet and a CWV of at least 1.2 which is further characterized by a repeating pattern constituting about 15% to about 20% of said toweling paper surface and consisting of about 60 to about 80 fibrous, tufted protuberances per square inch, raised to a height of about 0.020 inch above the surface of the toweling paper prior to tufting.

8. A soft, bulky and spongy toweling paper having a basis weight of about 31.5 pounds per 3000 square feet and a CWV of about 1.4 which is further characterized by a repeating pattern constituting about 16% of said toweling paper surface and consisting of about 72 fibrous, tufted protuberances per square inch, raised to a height of about 0.018 inch above the surface of the toweling paper prior to tufting.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,337,388 August 22, 1967

Charles L. Wosaba II

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, line 6, for "Procter & Gamble Company" read -- The Procter & Gamble Company --.

Signed and sealed this 15th day of October 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents