Sept. 30, 1941. G. RUEGENBERG 2,257,428

ALL-AROUND EXTENSIBLE PAPER

Filed Aug. 2, 1938 2 Sheets-Sheet 1

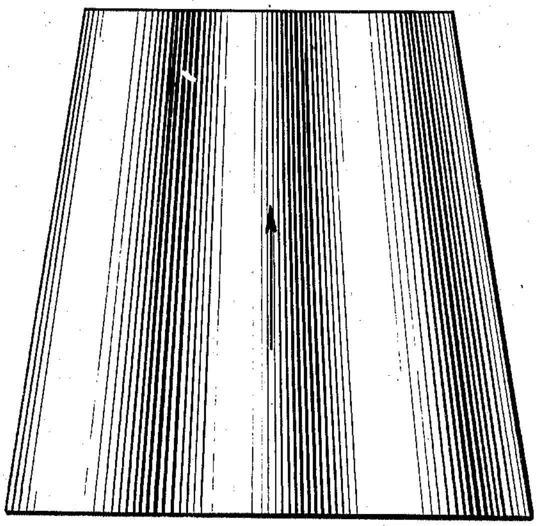

Fig. 1.

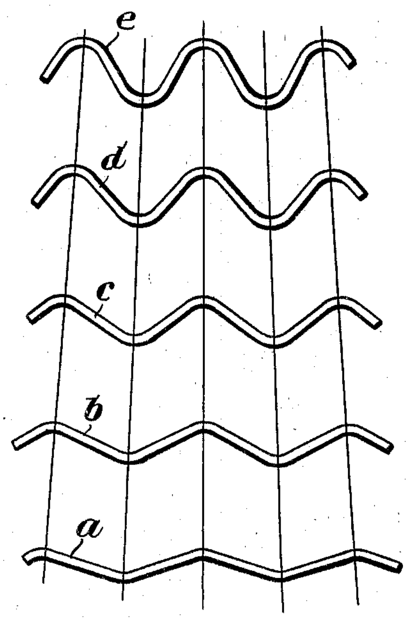

Fig. 2.

Fig. 3

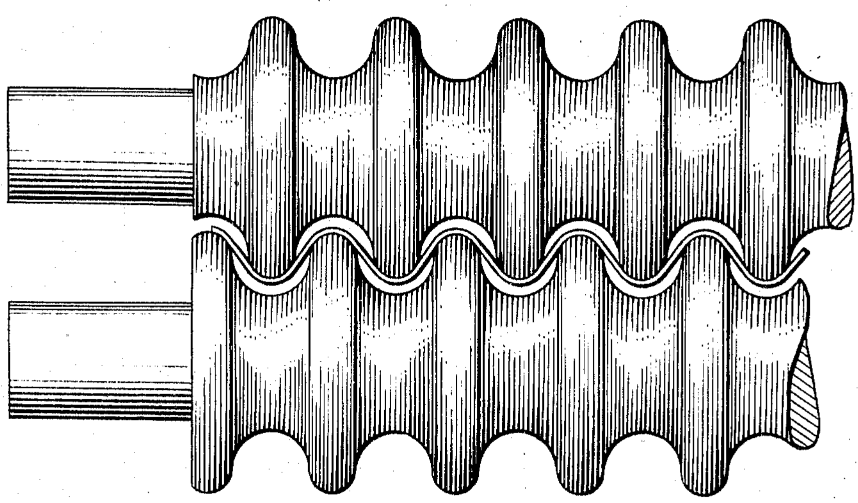

Fig. 4.

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Fig. 7.

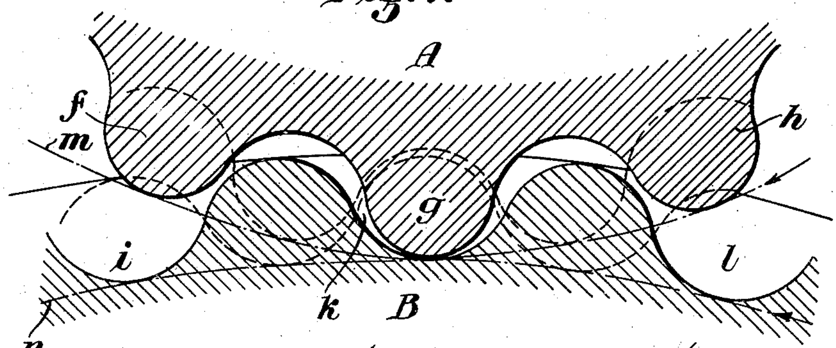


Fig. 6.

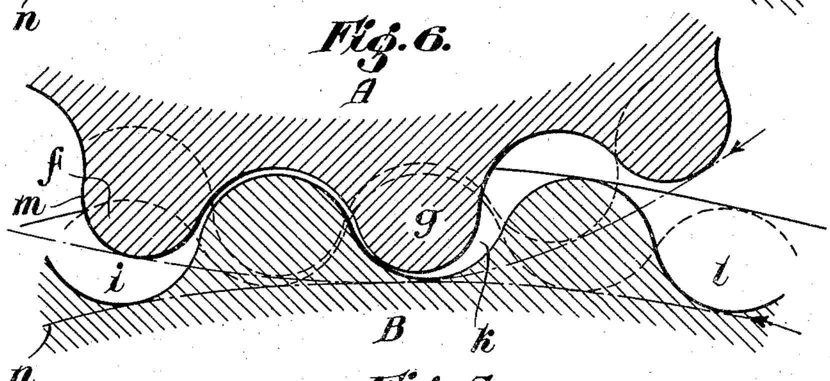


Fig. 5.

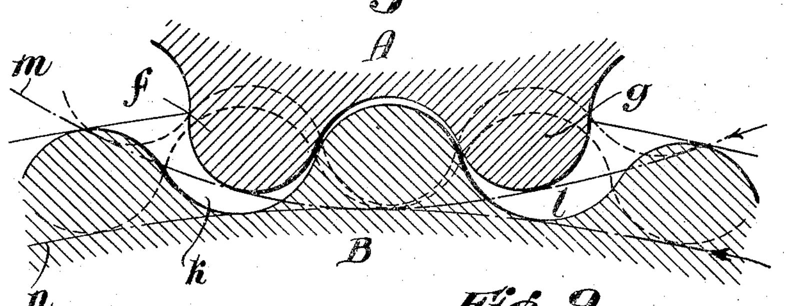


Fig. 9.

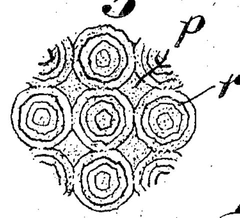
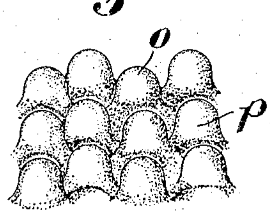


Fig. 8.



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2,257,428

ALL-AROUND EXTENSIBLE PAPER

Gottfried Ruegenberg, Dusseldorf-Oberkassel, Germany

Application August 2, 1938, Serial No. 222,729
In Germany August 4, 1937

6 Claims. (Cl. 154—55)

The object of the present invention is to provide an improved or all-around extensible paper.

Crepe paper (damp-crepe) is known to be a very extensible and elastic kind of paper. This is made on what is called the "creping cylinder" of a paper-making machine, a moist paper web being so "crowded" or crinkled on said cylinder by means of a "doctor" roll that the paper in consequence of a close formation of folds or gathers running transversely to the web or length extent thereof is extensible in the longitudinal direction. A defect of this form of creping however, consists in the fact, first, that the paper is extensible only in the longitudinal direction and, second, that the one-way crinkled formation thereof affords or opposes only a slight resistance to tensional stress in the longitudinal direction or web of the paper. This second defect prevents in particular the mechanical further treatment of such paper, as for instance its making into paper bags.

Processes generally utilisable for the production of paper which is elastic both longitudinally and transversely have not hitherto been known.

According to the present invention, paper obtains or is given the desired all-around extensibility and elasticity by being made into small folds or fold groupings at many points which are distributed over the surface of the paper in any desired arrangement and density and which are not parallel to each other. These small folds concentrated into "fold nests" distributed in the desired number and density over the surface can be of any nature or form (shape) desired, but in preferred particular will be in the form of ray lines, rings, stars, criss-crosses or other shapings disposed over the area of the web. The measure of the extensibility of the paper is determined by the number and density of these collections of folds, this extensibility, by virtue of a symmetrical arrangement of the fold nestings, being made uniform or equal in all directions. The fact that the paper is heaped (gathered) up at many places in the surface individually into short small folds which as such are not connected with each other and run or extend in all directions, imparts to the paper, with great local all-around extensibility and elasticity, a considerable resistance to deformation from tensional stresses in any direction. In the making of this paper having an all-around extensibility, the invention contemplates and makes provision for a sufficient paper surface at the individual places for the formation of the "fold nests," and for the same to be uniformly distributed. To this end, the continuous paper web is first bunched (gathered) up transversely (i. e. by a transverse action) to the running direction in corrugated (wave) form, so as to be contracted with a grooving or ribbing in said running or the longitudinal direction, and then is bunched up also in the longitudinal direction (i. e. by a longitudinal contracting action) between cylinders rolling over or contact with each other, the surfaces of which cylinders are provided with suitable complementary elevations and depressions. The elevations and depressions which effect the bunching up in the longitudinal direction of the paper web at the same time fulfill the purpose of uniformly distributing the gatherings or contractions of the paper surface in the transverse and longitudinal directions and to so fix or constitute said surface that on further treatment of the paper web the local heaping up of the paper surface is maintained.

Owing to the fact that the aforenamed cylinders are heated and the paper web before being introduced between the pair of cylinders is moistened, the shrinking effect is greater and the form (texture) of the paper surface, provided with said elevations and depressions produced in the stated way becomes more resistant.

The paper material gathered (shrunk) up by or in the elevated (raised) portions is in a further working step made into small folds. This is effected, according to the fineness and arrangement of the folds to be attained, between one or more pairs of cylinders having flat or suitably engraved surfaces.

In order that in this working step the elevations of the paper surface shall not be squeezed backward to the direction of running, whereby the heaping of material would be partly counteracted, it is advisable for the cylinder coming into contact with the more sharply stamped (raised) or embossed side of the paper web to be given a certain lead (advance) with respect to the opposite (counter) cylinder in the surface movement, so that the raised places of the paper web drawn therebetween will be evened before the closest engagement or full bite (press) of the cylinders.

Referring to the stated first action on the paper, the heaping up of the paper web transversely (i. e. by transverse action) to its longitudinal direction so as to give it a longitudinal grooving takes place between a series of driven pairs of rollers, the surfaces of which are made into corrugated form in their longitudinal section. Each pair of said rollers engages in such a manner that a wave crest of the one roller comes opposite a wave depression of the other roller. The depth of engagement of the first of these pairs is so small that the paper web introduced therebetween is brought without excessive friction into a slight corrugated form which runs in the longitudinal direction.

The corrugations so first formed in the web are deepened between the successive pairs of rollers, the engagement of which with a correspondingly smaller wave division each time becomes deeper with a decreasing distance between the corrugations. In this way, the paper is gathered into furrow form towards the centre without considerable frictional or tensional stressing. The pairs of cylinders which thus effect the contraction of this longitudinally corrugated paper web, differ by special kinematic conditions fundamentally from the normal conditions of embossing calenders. The normal arrangement or structure of embossing cylinders is such that the elevations of one cylinder fit as exactly as possible into the depressions of the other or counter cylinder, taking into consideration the thickness of the material to be embossed, and such that the surfaces of the two cylinders have a like mean speed of rotation, that is, that the theoretic rolling circles for the movement of the cylinder with respect to each other lie in the centre between maximum and minimum diameters of the engraved cylinders. A stamping of a web of material between such cylinders is possible only by stretching the fibrous structure of the material, which with a comparatively large depth of the cylinder engraving must lead to the disruption of the surface of the material, while a contraction of the superficial extent is hardly to be attained thereby.

In the present process, on the contrary, the arrangement and shape of the cylinders is such that the paper web is continuously drawn and rolled pointwise into the depressions of the counter cylinder by the elevations of the other cylinder, which are preferably arranged in staggered sequence. This unrestricted drawing and rolling inwardly is attained by the surface of the one cylinder having depressions correspondingly broadened in cross-section being given an accelerated movement of rotation as compared with the surface of the counter cylinder.

A favorable rolling over condition is attained for example by an arrangement in which the deepest parts of the circumference of the one cylinder and the highest parts of the circumference of the counter cylinder, coincide with the theoretical rolling circles of the cylinder system.

Owing to the formation of the elevations in the web of the paper taking place not by stamping at the expense of a fibrous extension or distortion, but by the drawing together of the paper surface without stress, there results between these elevations an accumulation of paper in the form of star-shaped small folds which impart to the paper web, even in this raised embossed condition, great extensibility in all directions.

The annexed drawings illustrate diagrammatically in the several views the steps of the process.

Referring to said drawings, Figures 1, 2 and 3 show a section of a paper web in process of treatment according to the invention. Figure 1 is an elevation of the paper web and in Figure 2 are shown five different cross-sections *a*, *b*, *c*, *d*, *e* taken at equal distances from each other through said web to show the progressive stages of transverse gathering. This is done by means of a suitable number of pairs of rollers in engagement with each other, the surfaces of which are of corrugated form in longitudinal section as shown by Figure 4. The spacing of the corrugations and the depth of engagement of these pairs of rollers, which successively follow each other at a certain distance, are different. The flat paper web is introduced between the first pair of rollers, having the largest spacing of corrugations and the least depth of depressions or engagement and attains therefrom a slightly waved surface somewhat as represented at *a* in Figure 2. The corrugations so initiated are gradually deepened between the following successive pairs of rollers with suitably narrowing spacing and deepening engagement such that the paper web after leaving the first pair of rollers is gathered up towards its centre. This progressive treatment will be understood from the sequential cross-sectional illustrations (*b*, *e*, *d*, and *e*) through the web of Figure 1. After reaching the desired extent of gathering in, approximately as shown by *e* in Figure 2, the corrugation of the paper web can be subdivided (or increased) without injurious tensional or frictional stresses stepwise up to any desired fineness. Thus, Figure 3 shows in cross-section through the paper web, a single stage subdivision of the form of corrugation of cross-section *e* of Figure 2.

The paper web longitudinally corrugated in this way to a suitable subdivision and depth is next gathered up also in its longitudinal direction between two cylinders rolling upon each other and having their surfaces provided with special complementary elevations and depressions, which at the same time gather or heap up the paper in both longitudinal and transverse directions so as to be uniformly distributed about the central top points of the lumps, buttons, nibs or cones stamped in this way out of the paper web.

The elevations so made in the paper are arranged in staggered relation with respect to each other so that the lumps lie in rows which are disposed at a certain angle to the gatherings. In this way, apart from the possibility of attaining a particularly dense arrangement of the raised parts, an increased elasticity of the paper web and also a greater resistance to tensional stresses is attained. This staggered arrangement is employed in the method of carrying out the process described below.

Figures 5, 6, and 7 show on an enlarged scale a fragmentary portion of the engaging pair of cylinders A—B, the same being illustrated in cross-section and in three different positions of engagement, *f*, *g*, and *h* being elevations of the surface of the one cylinder, which elevations in this case are made of spherical or globular form. These elevations roll in depressions *i*, *k*, and *l* of the other or counter cylinder, which depressions are broadened out in the cross-section of the cylinder, that is, in the direction of the movement of rotation. The relative rotational movement is indicated by the lines *m* and *n* which represent the circles described by the cylinders, which with a mutual toothed wheel drive coincide with the like circles of the toothed wheels. Owing to the fact that the protuberant surface of the cylinder B is external of its rolling circle *n*, whereas the surface of the cylinder A is on the other hand located within its rolling circle *m*, the revolving movement of the surface of B is considerably accelerated with respect to the surface of A, so that the deepest points (depressions) of the counter cylinder B have the same or a greater speed than the highest (projected) points of the primary cylinder A. The depressions of the cylinder B must be widened in the same ratio with this acceleration with respect to the corresponding elevations of A, in the direction of rotational movement. The ideal surface conformation of the cylinders in this sense is attainable by running the already engraved (formed) cylinder A in the not yet engraved (completely formed) cylinder B, thereby fixing the ratios of their diameters and rolling circles in the above-mentioned sense, e. g., by running or working an engraved cylinder A of a hard material into an unengraved cylinder B consisting of softer material (much as pressed material), or by corrosion or etching of the counter cylinder B on the running or working in with the finished cylinder A. In the case of an embodiment of the cylinder A with spherical or globular shaped elevations, as in this instance, then the cross-sectional (contour) lines of the depressions of the counter cylinder B would run somewhat in cycloidal form.

The paper surface provided with tip-shaped elevations or nibs and corresponding depressions (in the opposite side) after leaving this pair of cylinders can now be treated between one or more pairs of cylinders in such manner that the paper surface heaped up at the raised places is formed into small folds, the arrangement of which is determined by the nature of the surface engraving of these cylinders.

In order that with this process of smoothing, the said elevations of the paper web shall not be depressed unequally backward to the direction of the web running, it is advisable for the surface of the one cylinder of the pair to be given a certain lead or advance with respect to the other of said pair.

Figures 8 and 9 show by way of example the appearance of the paper obtained by the described treatment.

Figure 8 illustrates the appearance after leaving the second cylinder (embossing) group. Here the paper is provided with elevations or nibs *o* from the tips of which proceed ray-like folds *p*.

Figure 9 illustrates the paper after leaving the last cylinder (press) group. Here, the elevations are more or less collapsed or flattened, so that in addition to the aforenamed folds *p* running in radiating form, ring folds *r* have been formed. Naturally the number, form and arrangement of the folds can be varied according to the profiling of the cylinders and according to the intended purpose or use of the paper.

I claim:

1. An all-around extensible or elastic paper, comprising a web or sheet of paper material having a surface gathered inwardly both transversely and longitudinally into heaped up accumulations or concentrations of small folds around semi-spherical raised portions formed at numerous points distributed uniformly over the area of said surface, the said heaped up accumulations being in the form of nests in which the folds are disposed in the main part radially with reference to the centers of said raised portion, and the same being produced by drawing the web or sheet inwardly within its mean or general plane first in the one or the other of the transverse and longitudinal directions and then in the other of said directions with numerous foldings upon itself grouped predominantly in radial relation around the center points at which the heaped up places of fold accumulation are intended to occur, the heaped up portions being pressed flatwise to the web or sheet with an over-folding at right angles thereto.

2. An all-around extensible or elastic paper, comprising a web or sheet of paper material having a surface formed by a gathering of the web or sheet inwardly both transversely and longitudinally into a series of heaped up accumulations or concentrations of small folds around center points raised upwardly in the form of semi-spherical elevations from said surface at numerous places distributed uniformly and closely over the area of the same and said elevations being flattened downward upon the surface, the folds of the material in said heaped up or elevational portions being partly radiational from the center points thereof into the surrounding portions of depression or valley therebetween and partly circular or ring-like in encirclement of said center points.

3. An all-around extensible or elastic paper according to claim 2, wherein the heaped up fold accumulations or semi-spherical elevations of the surface are so arranged in staggered relation to each other upon the web or sheet that the portions of depression lying therebetween are disposed cross-wise at different angles to the longitudinal axis of the web or sheet.

4. An all-around extensible or elastic paper, comprising a web or sheet of paper material having an underlying form of corrugation in one direction of its extent over the entire surface area thereof and having a contraction or the equivalency of corrugation in the other direction of its extent, with a series of raised globularly-shaped portions distributed uniformly at closely spaced points over the full surface area of the same, the said globularly-shaped raised portions having multitudinous small folds or accumulations of the material around the center points or tops thereof, and the center points of the raised portions at each side of the web or sheet being substantially uniformly offset from a general medial plane of the web or sheet.

5. An all-around extensible or elastic paper according to claim 4, wherein the raised globularly-shaped portions of the surface are arranged in staggered relation to each other upon the web or sheet so that the portions of depression lying therebetween are disposed cross-wise at different angles to the longitudinal axis of the web or sheet.

6. An all-around extensible or elastic paper according to claim 4, wherein the globularly-shaped raised portions are pressed flatwise to the web or sheet with an over-folding at right angles thereto.

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