March 11, 1958 C. VILLORESI 2,826,239

ELASTIC PACKING PAPER AND METHOD OF MAKING SAME

Filed July 5, 1955 4 Sheets-Sheet 1

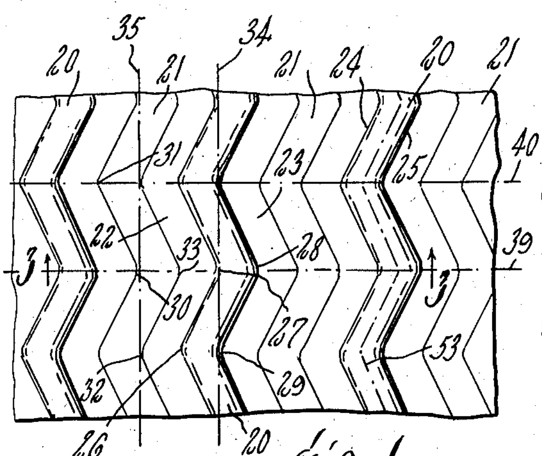

Fig. 1.

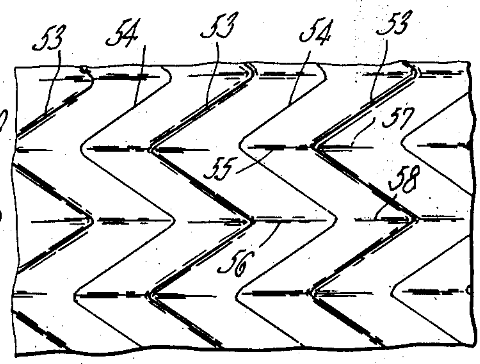

Fig. 2.

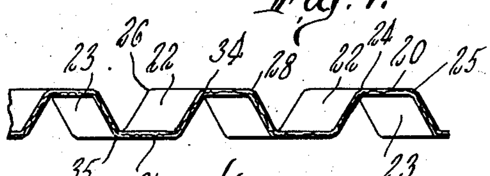

Fig. 3.

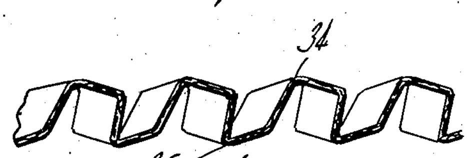

Fig. 4.

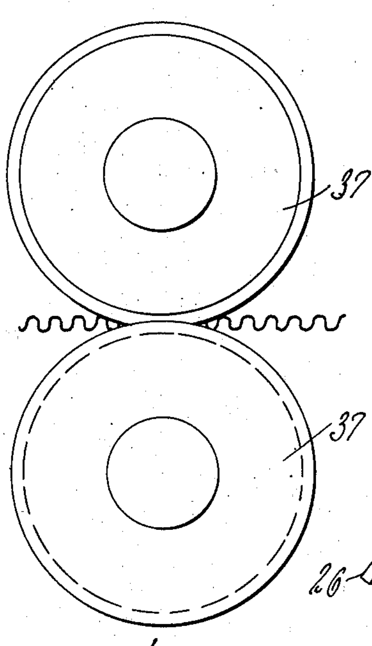

Fig. 5.

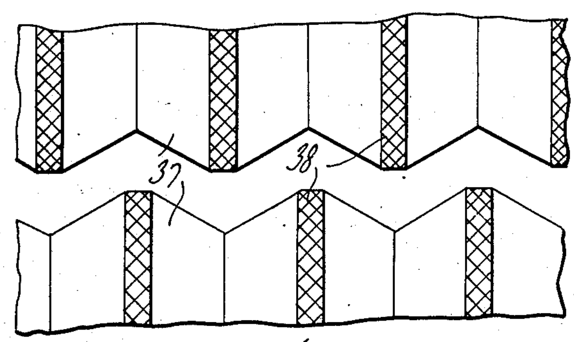

Fig. 6.

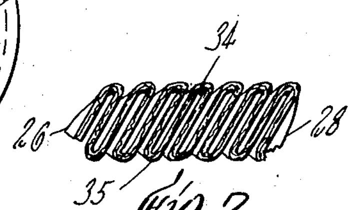

Fig. 7.

Inventor
Camillo Villoresi
Arthur D. Thomson
Atty.

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ELASTIC PACKING PAPER AND METHOD OF MAKING SAME

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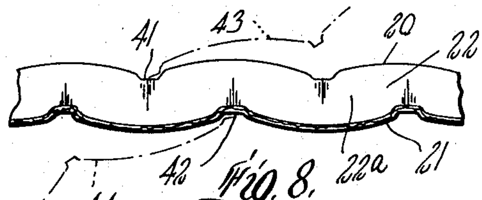

Fig. 8.

Fig. 9.

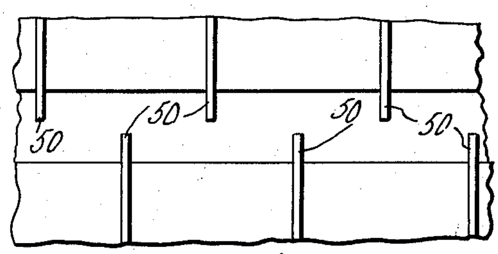

Fig. 10.

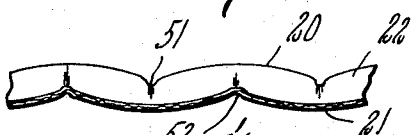

Fig. 11.

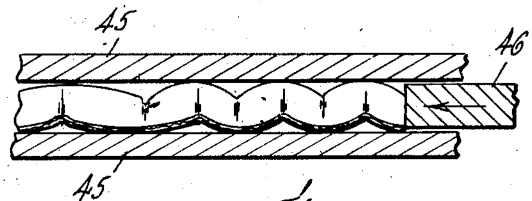

Fig. 12.

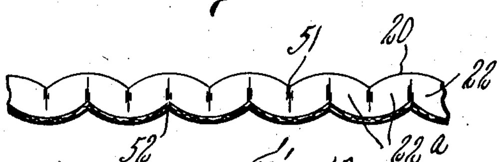

Fig. 13.

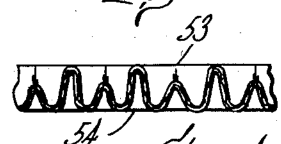

Fig. 14.

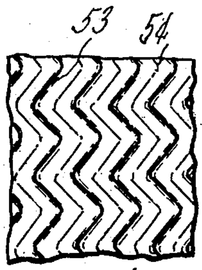

Fig. 15.

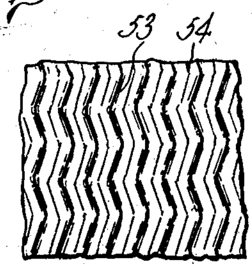

Fig. 16.

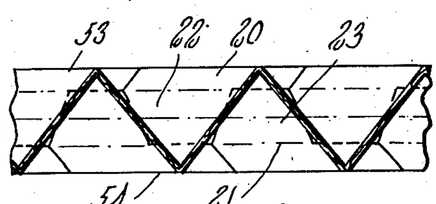

Fig. 18.

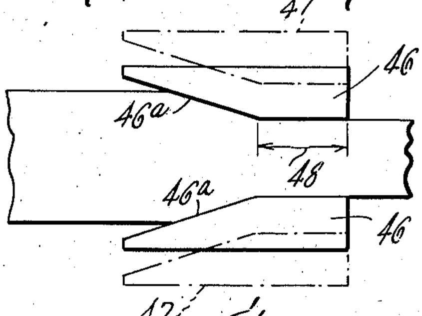

Fig. 17.

Inventor
Camillo Villoresi
Arthur D. Thomson
Atty.

ELASTIC PACKING PAPER AND METHOD OF MAKING SAME

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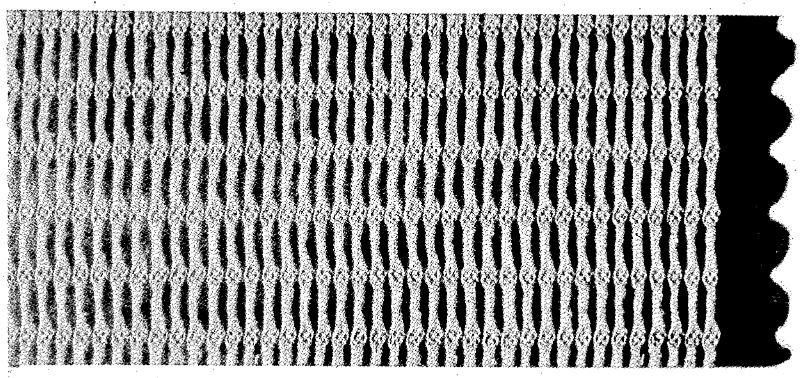

Fig. 19

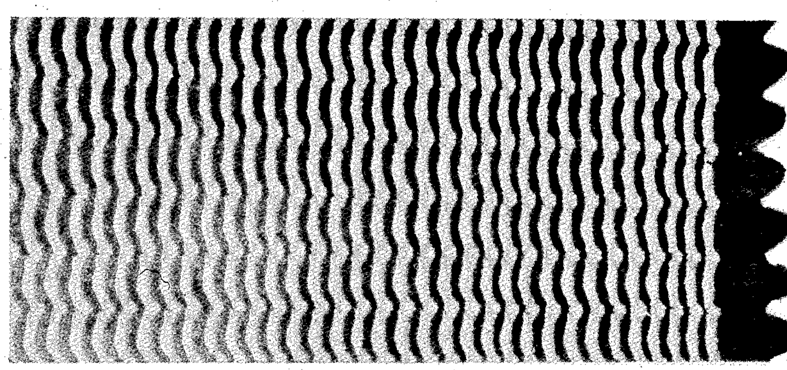

Fig. 20

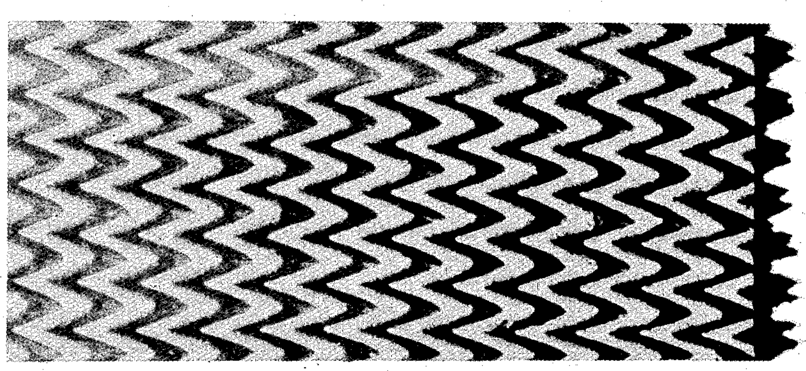

Fig. 21

Inventor
Camillo Villoresi

By Arthur D. Thomson
Attorney

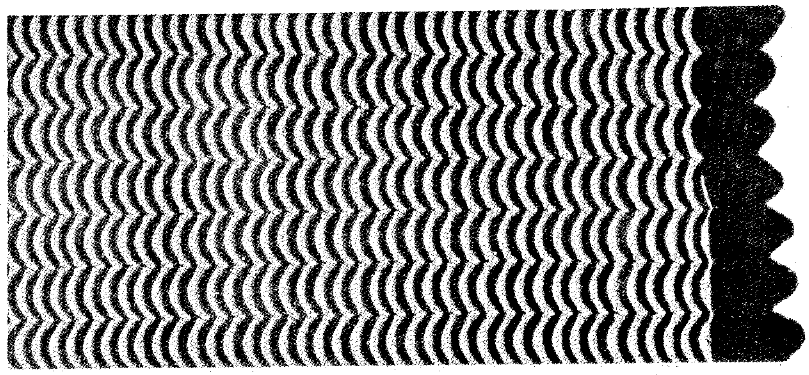

Fig. 22

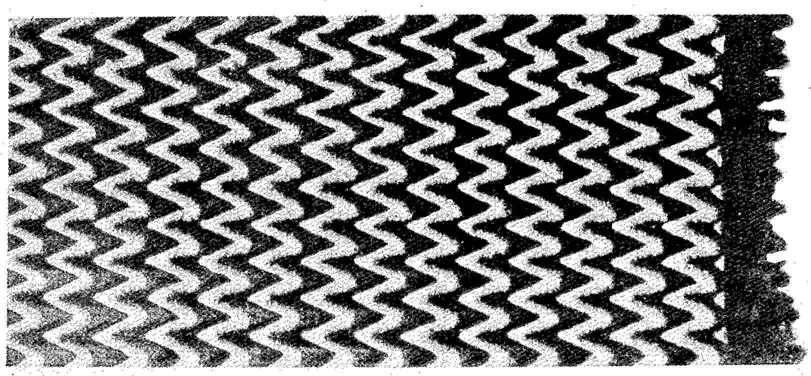

Fig. 23

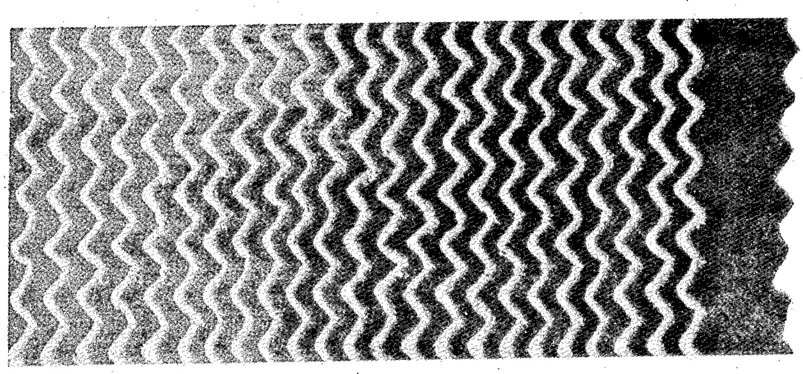

Fig. 24

Inventor
Camillo Villoresi

By Arthur D. Thomson

Attorney

United States Patent Office

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Patented Mar. 11, 1958

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ELASTIC PACKING PAPER AND METHOD OF MAKING SAME

Camillo Villoresi, Milan, Italy, assignor to Societa per Azioni Fabbriche Fiammiferi ed Affini, Milan, Italy, a corporation of Italy

Application July 5, 1955, Serial No. 520,083

Claims priority, application Italy July 12, 1954

15 Claims. (Cl. 154—33.05)

This invention relates in general to the production of formed crush-resistant paper suitable for protective and decorative purposes, and pertains more particularly to improvements in the type of paper described in my copending United States patent application Serial No. 470,469, filed November 22, 1954.

The products here described are all derived from a basic type of product described in the aforesaid copending application. In its basic "rigid" form the paper there described has regular zigzag rows of undulations running transversely across the sheet. These undulations are produced by running the paper between a pair of impressing rolls which are heated to a relatively high temperature and maintaining the paper in contact with one of the rolls during a considerable part of its travel. The rolls have meshing chevron-shaped teeth which impart the zigzag configuration to the undulations. The undulations are approximately trapezoidal in cross-section, that is, the peaks and valleys are somewhat flattened.

For the sake of clarity the direction perpendicular to the rows of undulations, ordinarily the direction of run of the paper through the impressing rolls, will be consistently referred to as the longitudinal direction of the sheet, and the mean direction of the rows as the transverse direction of the sheet. In the basic form of the paper, the rows of undulations are so spaced and proportioned that the paper remains straight along the transverse median lines of the peaks and valleys of the rows. These lines form natural fold lines about which the paper can be subsequently pleated, by a process described in the aforesaid copending application, with the result that the rows of undulations are brought closer together in the longitudinal direction.

Paper which is described as "elastic in the longitudinal direction" can be stretched longitudinally and tends to spring back to its unstretched condition when released. Likewise, paper which is described as "elastic in the transverse direction" can be stretched transversely and tends to spring back when released. "Longitudinal flexibility" implies that the paper can be bent readily, that is, without permanent deformation, about an axis transverse to the sheet (or parallel to the general direction of the rows of corrugations). Similarly, "transverse flexibility" implies that the paper can be bent readily about an axis disposed in the longitudinal direction of the sheet.

In the basic form, referred to herein as the "basic rigid" form, the paper is highly resistant to crushing and is relatively inflexible in both the longitudinal and transverse direction. The pleated form of the paper, referred to herein as the "basic elastic" form, is rigid in the transverse direction, but highly flexible and extendible in the longitudinal direction, and has a somewhat greater crush resistance than the rigid form. The elastic form of paper may be described as "tight," "normal," "stretched," or "loose," depending on the closeness of successive pleats. The rigid form is useful for such purposes as liners for flat walled boxes, and a padding or protective wrapper for flat articles. The elastic form is useful for packaging articles of cylindrical or somewhat irregular shape as it can be both bent and stretched in the longitudinal direction without seriously impairing its crush-resistant properties. For packaging articles of highly irregular shape, or articles having a double curvature, however, it has been found desirable to impart a certain amount of transverse flexibility, or elasticity, or both, to paper of the type just described.

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One of the objects of this invention is to provide a packing paper, of either of the general types described in the aforesaid copending application, with the desired degree of flexibility or elasticity, or both, in the transverse direction. Another object is to produce a packing paper which is highly crush-resistant and higly flexible and elastic in both the transverse and longitudinal directions so that for practical purposes it can be stretched in any direction to fit an object of double curved or highly irregular shape.

In producing one of the new types of paper described in this application, the basic elastic form of the product is crushed along alternating longitudinal lines on the top and bottom of the paper. These lines run through alternate vertices of the zigzags. The paper thus produced is moderately flexible in the transverse direction and will be referred to herein as type I.

A second new form of paper is produced by subjecting a sheet of type I to pressure in the transverse direction while substantially confining it in the direction perpendicular to the general plane of the sheet. This process, referred to as "cross-pressing," causes the paper to bend into transverse ripples and brings the vertices of the zigzags somewhat closer together in the transverse direction. Although the transverse force applied is substantial, papers of type I, especially when made from a tight elastic type, will yield only to a moderate degree. The resulting product has a moderate amount of elasticity and flexibility in the transverse direction, and is useful for wrapping articles of fairly large double curvature, such as automobile fenders, and for uses where only a moderate degree of elasticity in the transverse direction is required. This type of paper will be referred to herein as type II.

A third product is obtained by scoring the elastic form of paper rather sharply along longitudinal lines running through alternate vertices of the zigzags on the top and bottom of the sheet, and then cross-pressing the sheet. The scored paper will yield to a substantial extent in the transverse direction, and a very high degree of elasticity in the transverse direction can thus be obtained. The paper becomes bent rather sharply along the score lines and appears somewhat bowed in between. This process can be performed on paper which has been longitudinally pleated to any desired degree of tightness, and the resulting product is highly elastic and flexible both in longitudinal and transverse directions, so that it is, in effect, flexible and elastic in all directions. This form of paper is also more resistant to crushing than either the "rigid" or the "elastic" form, or any of the other new forms here described. This type will be referred to herein as type IIIA. Because of the large amount of original stock required for manufacturing this type of paper, its cost per unit area is relatively high. It can be shipped and stored in relatively small space, however, and subsequently stretched to the weight per unit area desired for a particular use.

Another type of paper can be produced by directly cross-pressing paper of an elastic type which is rather loose, for example, in which the pleats are spaced about 5 mm. peak to peak. In this case the scoring step is omitted. As the result of this process the original straight fold lines tend to disappear and the zigzag undulations form into what appear to resemble zigzag pleats, with vertices which are more acute, and spaced closer together transversely, than those of the original undulations. This product, which will be referred to herein as type IIIB is flexible and elastic in both longitudinal and transverse directions. Although not as flexible and elastic, or as crush-resistant as type IIIA, the type IIIB paper is satisfactory for many uses where extreme flexibility and elasticity are not required and its weight per square foot is considerably less than that of type IIIA. It is therefore cheaper to produce than type IIIA, as less original stock is required to produce the same footage, and its lower weight is an advantage, particularly as a wrapping for articles for shipment by air. Type IIIB is also superior to type IIIA from the standpoint of shock transmission, because of its lower density. Paper of type IIIB can be further modified by pressing in the longitudinal direction to bring the pleats closer together in that direction and impart a somewhat higher degree of longitudinal elasticity, while retaining its transverse flexibility and elasticity. This product will be referred to as type IIIC.

Another product, which will be referred to as type IV, is obtained by directly cross-pressing the basic rigid type of paper, the scoring step being omitted. As in type IIIB, the straight transverse fold lines tend to disappear in cross-pressing, and the zigzag undulations assume more nearly the form of zigzag pleats, with the vertices more acute and closer together transversely than those of the basic rigid product. Paper of type IV is inextensible and only slightly flexible in the longitudinal direction, and is transversely flexible and elastic to a degree which depends to some extent on the degree of cross-pressing. Its use as a wrapper is restricted to packaging flat articles, or articles of fairly large radius of curvature. Its weight per unit area, and consequently its cost, is lower than that of the other cross-pressed products.

The processes and products to which this invention relates are described herein with particular reference to paper. It has been found, however, that many other flexible sheet materials, including, for example, plastic sheets, such as cellophane, metal foils laminated to paper, and fabrics, can be manipulated and formed in the same manner to produce products of similar characteristics. It will accordingly be understood that paper is referred to, in this description, merely as a typical example of the sheet material from which these products are manufactured and that the word "paper" as used in the following description and in the appended claims, is intended to include equivalent flexible sheet materials capable of being processed in the manner here described. All the products here described have a pleasing decorative appearance as well as the physical characteristics which make them useful as protective wrappers. Many of the products may also have acoustical, insulating or other properties, and are thus useful for purposes other than packaging.

In the drawings illustrating preferred embodiments of the invention:

Fig. 1 is a plan view, somewhat enlarged as compared to the product in its usual commercial form, and somewhat idealized, of a piece of the basic rigid type of paper;

Fig. 2 is a plan view, also somewhat enlarged, of a piece of paper of type IV;

Fig. 3 is a cross-section taken along line 3—3 of Fig. 1;

Fig. 4 is a cross-section, along the same line as Fig. 3, of a piece of the basic elastic type of paper, somewhat loosely pleated;

Fig. 5 is a schematic side view of a pair of rolls for making paper of types I and II;

Fig. 6 is an enlarged fragmentary view of the surfaces of the rolls of Fig. 5;

Fig. 7 is a cross-section similar to Fig. 4 of the very tight basic elastic form of paper;

Fig. 8 is a transverse cross-section of a piece of paper of type I;

Fig. 9 is a transverse cross-section of a piece of paper of type II;

Fig. 10 is an enlarged fragmentary view of a pair of rolls used to score paper for making type IIIA;

Fig. 11 is a transverse cross-section of a piece of paper which has been scored in preparation for making type IIIA;

Fig. 12 is a schematic transverse view of a cross-pressing device, showing the effect of cross-pressing on the paper of Fig. 11;

Fig. 13 is a transverse section of a finished piece of paper of type IIIA;

Fig. 14 is a transverse cross-section of a piece of paper of type IIIB;

Fig. 15 is a plan view of a piece of paper of type IIIB;

Fig. 16 is a plan view of a piece of paper of type IIIC;

Fig. 17 is a schematic plan view of a device for performing the cross-pressing operation;

Fig. 18 is a somewhat idealized transverse cross-section of a piece of paper of type IV, and

Figs. 19–24 are photolithographs of actual samples of paper of types I, II, IV, IIIA, IIIB, and IIIC, respectively.

For clear understanding of the reactions which occur in the paper, in the manufacture of the new elastic types here described, certain characteristics of the basic rigid form must be kept in mind. The direction of from right to left, as the paper is illustrated here, will be referred to as the "forward" direction of the paper, corresponding ordinarily to the direction of run through the impressing rolls which impart the zigzag undulations to the sheet. As shown in Figs. 1 and 3, the transverse undulations are approximately trapezoidal in form, with substantially flat peak strips **20** and valley strips **21**, connected by substantially straight forward wall strips **22** and rear wall strips **23**. The peak strips have forward edges **24** and rear edges **25** which may be considered as lines for purposes of explanation, but which, in the actual product, are rounded off to some extent, the radius of curvature depending on such factors as the shape and mesh of the impressing teeth and the thickness of the stock from which the paper is made. The peak strips have outer vertices **26**, and inner vertices **27**, along their forward edges, and outer vertices **28** and inner vertices **29** along their rear edges. The vertices are here shown as relatively sharp. On the actual paper these vertices may be more rounded, although they are usually reasonably well defined, particularly the inner vertices. The valley strips **21** similarly have inner vertices **30** and outer vertices **31** along their forward edges, and inner and outer vertices **32** and **33**, along their rear edges respectively. The regions of vertices **26**, **29**, **31**, and **32** will be referred to as the "forward" vertices of the rows as a whole, and the regions of vertices **27**, **28**, **30** and **33**, as the "rear" vertices of the rows.

It will be noted that the paper is substantially straight along lines **34**, which pass through the inner vertices **27** and **29** of the peak strips, and also along lines **35** which pass through the inner vertices **30** and **32** of the valley strips. These lines correspond to natural fold lines along which the paper is pleated in converting the basic rigid type to the basic elastic type, lines **34** being referred to as the top fold lines and lines **35** as the bottom fold lines. As shown in Figs. 4 and 7, in the basic elastic paper, the pleats as a whole have a slight backward tilt, when the elastic paper is produced by means of a knurled braking roll bearing on the upper surface of the paper as it leaves the impressing stage, in the manner described in my aforesaid co-pending application.

For producing paper of type I, paper of the basic elastic type is subjected to a "crushing" process which produces grooves, or furrows, of substantial width, along longitudinal lines running through alternate vertices of the zigzags. This can be done in a number of ways. For production of type I in a continuous manner, the paper may be run through a pair of crushing rolls having the configuration here illustrated in Figs. 5 and 6, as described in the machine described in a co-pending application by Pietro Molla, Serial No. 519,781, filed July 5, 1955. These rolls are made up of circumferential ribs **37** with flattened, knurled rims **38** which form the furrows on the top and bottom surfaces of the paper. Because of the initial tilt of the pleats of the elastic paper, it is preferable to crush the upper surface of the paper along lines **39** (Fig. 1) which run through the rear vertices of the rows, and the under surface along lines **40** which run through the forward vertices of the rows. The basic elastic paper naturally tends to yield more readily, when bent upward, along the inner vertices **27** which face slightly upward, rather than along the inner vertices **29** which face downward. This natural tendency can be used to best advantage by placing the top furrows at the rear vertices so that a crushing effect is produced on the upper part of the front walls **22** in the region of vertices **27**. The reverse is true with respect to the bottom surfaces of the paper, on which vertices **33** are the points at which the paper will yield most readily to downward bending. The crushing devices are heated, preferably to a temperature in the neighborhood of 100° C.

As shown in Figs. 8 and 19, a finished piece of paper of type I has staggered top and bottom furrows **41** and **42**. The paper, when bent upward, will tend to collapse along furrows **41**, as indicated by the dotted line **43**. When bent downward, the paper tends to collapse along furrows **42**. The furrows may be considered as regions of transverse flexibility. Between the furrows. the extreme upper and lower surfaces may appear more or less bowed. This formation is shown greatly exaggerated in the shadow **49** at the right of the photolithograph Fig. 19.

In making paper of type I, the transverse width of the sheet remains substantially unchanged, and the resulting product is flexible, but not elastic, in the transverse direction. The longitudinal flexibility and elasticity remain the same as in the basic elastic sheet.

Paper of type I can be made from basic elastic paper of various degrees of tightness, that shown in Fig. 19 being made from the tight elastic type illustrated in Fig. 7. It is frequently convenient to make paper of type II from tight basic elastic paper, and subsequently stretch the sheet to obtain the desired weight per unit area.

In the manufacture of paper of type II, elastic paper which has first been crushed along longitudinal lines in the manner of type I is subjected to a "cross-pressing" process. Essentially this process consists of applying transverse pressure to the sheet while it is restrained in the vertical direction so that the sheet as a whole cannot buckle to escape the pressure. The restraining members may be heated in any suitable manner, or the cross-pressing may be performed while the paper retains some residual heat from its passage through the impressing rolls. On many types of paper, the cross-pressing process can be satisfactorily performed cold. Suitable apparatus for performing this step may consist basically, as shown in Fig. 12, of a pair of restraining members **45** with parallel surfaces spaced apart by a distance equal to, or slightly greater than, the overall height of the sheet, and a transversely movable plate **46** which engages the edge of the sheet. In Fig. 17, such a device is schematically illustrated in plan. A pair of plates **46** are mounted to reciprocate toward and away from each other and to engage both longitudinal edges of the sheet. Alternatively, one plate may be fixed and the other movable. The plates have sloping lead-in edges **46a**. These plates are shown in the extreme inward position. When the plates are moved out to the position indicated by dotted lines **47**, the sheet is advanced by a distance **48**, bringing a partially cross-pressed section of the sheet between the straight sides of the plates. One of the restraining members **45** may be moved out of engagement with the sheet while the latter is advanced. The cross-pressing process may be advantageously performed in a continuous manner by a mechanism described in the aforesaid co-pending Molla application.

In cross-pressing, the paper bends transversely along the furrows **41** and **42**, and the surfaces between the furrows become more bowed. The vertices of the zigzags are brought closer together, with a resulting decrease in the transverse width of the sheet, and the overall height of the sheet is slightly increased. The longitudinal characteristics of the paper remain substantially unchanged. As shown in Figs. 9 and 20, finished paper of type II has a rather pronounced transverse rippled effect. Paper of type I will yield only to a limited degree in cross-pressing. Consequently the maximum degree of cross-pressing, and correspondingly the degree of transverse elasticity, which can be obtained in paper of type II, as measured by the reduction in transverse width of the sheet is about 20%. The transverse elasticity and flexibility of paper of type II, although appreciable, is considerably less than its longitudinal flexibility and elasticity.

In manufacturing paper of type IIIA, basic elastic paper is first scored rather sharply on the top and bottom surfaces along lines passing through alternate vertices of the zigzags. As in making paper of type I, it is preferable to score the upper surface along lines corresponding to lines **39** of Fig. 1, and the under surface along lines corresponding to lines **40** of Fig. 1. The scoring operation may be performed by any device suitable for impressing score lines on paper, but may be advantageously carried out in a continuous manner by running the paper through a pair of finned rolls, as described in the aforesaid Molla application. A fragment of the surfaces of these rolls is here illustrated in Fig. 10, it being understood that the fins **50** are appropriately spaced to correspond to the spacing of alternate vertices of the zigzags on the basic elastic paper. The scoring devices need not be heated. After the scoring step, the paper has grooves **51** and **52** crossing the tops and bottoms of the peak and valley strips, respectively. The paper is then cross-pressed. As shown in Fig. 13, after cross-pressing the paper is bent alternately upward and downward along score lines **51** and **52**, respectively, and these lines have also been brought closer together in the transverse direction. Between the scored lines the peaks and valleys are distinctly bowed in the vertical direction. As shown in Fig. 22, the relatively straight top fold lines corresponding to lines **34** have virtually disappeared, and the peak strips **20** have been folded rather sharply along lines which are pronouncedly scalloped in plan. The vertices **26** which lie midway between the score lines nest within vertices **29** of the adjacent pleats, as in the tight elastic product illustrated in Fig. 7. The product illustrated in Fig. 22 was made from the tight elastic form of paper.

Paper of type IIIA can be cross-pressed to about 30 to 35% reduction in transverse width, producing a corresponding amount of transverse elasticity. This paper is about as flexible transversely as longitudinally, that is it can be bent on a very small radius in either direction. As in types I and II, the paper appears to bend, in the transverse direction, mainly along the scored lines, and these lines may be considered as region of transverse flexibility. As this paper can be stretched in two mutually perpendicular directions, it is, in effect, extensible in all directions. It will be noted, in Figs. 8, 9 and 13, that in paper of types I, II and IIIA, all of which display some vertical displacement of the walls **22**, the mid points **22a** of each section of the side wall strips **22** remain in the same horizontal plane. These points may be considered as centers of rotation of the wall sections.

Type IIIB is made by directly cross-pressing a rather loose form of the basic elastic type of paper, for example, paper of the general type shown in Fig. 4. More specifically, paper in which the fold lines **34** are spaced about 5 mm. apart can be successfully cross-pressed without any preparatory scoring or crushing step. As shown in Figs. 14, 15 and 23, the fold lines **34** have disappeared altogether in the cross-pressing, and the peak strips appear to have become folded along transverse zigzag lines **53**, which lie midway between edge lines **24** and **25** on the basic rigid paper, as indicated in Fig. 1. The vertices of the zigzags are more acute and are closer together in the transverse directions. The effect of cross-pressing in the manufacture of type IIIB may be better understood by reference to the somewhat idealized longitudinal section shown in Fig. 18. In this illustration the originally flat peak strips **20** and valley strips **21** here shown in dotted line, have been folded along lines **53** and **54** to form triangular ridges with side walls practically continuous with walls **22** and **23**. These triangular ridges may in actuality be somewhat rounded off at the top, as in the photolithographic of the sample in Fig. 23. The cross-pressing appears to produce a substantially vertical creasing, or weakening of the paper along all the vertices of the zigzags, so that the wall sections to either side of a vertex will move readily toward and away from each other, thus imparting transverse extensibility to the sheet, and the paper may be bent transversely in the regions of the vertices. All the vertices on paper of type IIIB may be considered regions of transverse flexibility.

Paper of type IIIB is about equally extensible and flexible in both longitudinal and transverse directions, and thus can be used for most of the same purposes as paper of type IIIA, although it is, of course, not as elastic in the longitudinal direction as type IIIA which has been made from the tight basic elastic type. If greater longitudinal elasticity is desired, paper of type IIIB can be longitudinally compressed, by a process similar to that used in making the tight basic elastic type from loose or normal basic elastic paper. Paper of type IIIB, when thus treated becomes type IIIC, illustrated in Figs. 16 and 24. The transverse flexibility of type IIIC is about the same as that of type IIIB but its transverse extensibility may be somewhat reduced due to the fact that the vertices of the zigzags may become less acute and move somewhat further apart transversely during the further longitudinal pressing.

Type IV is made by directly cross-pressing the basic rigid type of paper without any preparatory scoring or crushing step. As the result of cross-pressing the peak and valley strips **20** and **21** become folded along triangular ridges along lines **53** and **54**, much as in type IIIB. The edges **24** and **25** tend to disappear and pronounced rear outside fold lines **55** and **56** and inside fold lines **57** and **58** are formed. These lines run respectively from each line **53** forward to the adjacent line **54** at the forward vertices and rearward to the adjacent line **54**, at the rear vertices of the rows. These fold lines may be considered regions of transverse flexibility. It will be noted that the vertices of each row, as a whole, overlap the vertices of the next.

The basic rigid type of paper can be cross-pressed to about 50% its original width. Paper of type IV is about as flexible as types IIIA, B and C in the transverse direction and is transversely extensible in varying degrees, depending on the degree of cross-pressing. It is only slightly flexible and practically inextensible in the longitudinal direction.

All of the new products here described are at least as crush resistant as the basic types of paper from which they are formed and certain of the new products, notably type IIIA and type IV become more crush resistant as the result of the cross-pressing process. It is understood that references to various degrees of flexibility or rigidity are used in a relative sense in comparing one "type" to another as these characteristics may vary in papers of the same "type" made of different original stock.

Figs. 19–24, as reduced for printing by the Patent Office, show typical commercial products in approximately full size. It should be noted that these figures are reproduced, from photographs of samples made of double, laminated sheets of straw paper. The peak lines and vertices may therefore appear more rounded than they would be on sheets of single thickness or thinner stock. The bottom surface of the paper in each case looks the same as the top surface.

What is claimed is:

1. A sheet of formed paper having upper and lower surfaces, said surfaces being impressed with parallel transverse zigzag rows of undulations, each row having a median transverse fold line along which the paper is pleated and two sets of vertices lying alternately to either side of the fold line, each surface having furrows of appreciable width traversing one set of vertices of each row in a direction along the sheet substantially perpendicular to the rows.

2. A sheet of formed paper having upper and lower surfaces, said surfaces being impressed with parallel transverse zigzag rows of undulations, each row having a median transverse fold line along which the paper is pleated and two sets of vertices lying alternately to either side of the fold line, each surface having furrows of appreciable width traversing one set of vertices of each row in a direction along the sheet substantially perpendicular to the rows, and each row having, between the furrows, transversely extensible regions bowed in a direction substantially perpendicular to the sheet.

3. A sheet of formed paper having upper and lower surfaces, said surfaces being impressed with parallel transverse zigzag rows of undulations, each row having a median transverse fold line along which the paper is pleated and two sets of vertices lying alternately to either side of the fold line, each surface having relatively sharp score lines traversing one set of vertices of each row in a direction along the sheet substantially perpendicular to the rows, and each row having between the score lines, transversely extensible regions bowed in a direction substantially perpendicular to the sheet.

4. A sheet of formed paper having transverse rows of pleats each comprising two side walls connected together along zigzag fold lines and movable toward and away from each other in a longitudinal direction along the sheet generally perpendicular to the rows, the fold lines having alternating vertices, and each side wall being foldable on itself along longitudinal lines running through the vertices, the sheet being flexible and extensible in both the transverse and the longitudinal direction.

5. A sheet of formed paper having upper and lower surfaces, each surface having transverse rows of substantially V-shaped reliefs, each row comprising two side walls relatively rigidly connected together along zigzag peak lines having alternating vertices, and each wall having fold lines running in a longitudinal direction along the sheet generally perpendicular to the rows and disposed to pass through said vertices, each wall being foldable on itself along said fold lines, whereby the sheet is transversely flexible and extensible, the sheet being relatively rigid and inextensible in the longitudinal direction.

6. A formed sheet of paper as described in claim 5, the fold lines of each row overlapping the fold lines of the next in the longitudinal direction.

7. The method of imparting transverse flexibility to a sheet of paper of the general type having upper and lower surfaces initially impressed with transverse zigzag rows of reliefs having alternating vertices, which comprises weakening the paper on both surfaces along lines lying along the sheet in a direction perpendicular to the rows and running through vertices of each row.

8. The method of imparting transverse elasticity to a

sheet of paper, of the general type having upper and lower surfaces initially impressed with transverse zigzag rows of reliefs having alternating vertices, which comprises compressing the sheet in its transverse direction while restraining the sheet against movement in the direction perpendicular to the sheet.

9. The method of making a sheet of formed paper which comprises the following steps: impressing into a flat sheet, having top and bottom surfaces, spaced parallel zigzag rows of undulations having two sets of vertices disposed alternately to either side of relatively straight top and bottom fold lines, pleating the sheet along said fold lines, and impressing relatively wide furrows along the top and bottom surfaces of the sheet, in a direction generally perpendicular to th rows, in such a manner that the furrows on each surface of the sheet pass through one set of vertices of the undulations and are disposed in staggered relationship with respect to the furrows on the other surface.

10. The method as described in claim 9, the furrows being impressed by means of hot impressing members.

11. The method as described in claim 12, which includes the further step of confining the sheet in the direction perpendicular to the sheet, after impressing the furrows therein, and compressing the sheet, while so confined, in the direction of the rows.

12. The method as described in claim 10, which includes the further step of compressing the sheet in the direction generally perpendicular to the rows, after it has been compressed in the direction of the rows.

13. The method of making a sheet of formed paper which comprises the following steps: impressing into a flat sheet, having top and bottom surfaces, spaced parallel zigzag rows of undulations having vertices disposed alternately to either side of relatively straight top and bottom fold lines, pleating the sheet along said fold lines, scoring the sheet along lines which are perpendicular to the general direction of the rows and pass in staggered relationship through alternate vertices of each row on the top and bottom surfaces of the sheet, and subsequently confining the sheet in the direction perpendicular to the sheet and compressing the sheet, while so confined, in the direction of the rows.

14. The method of making a sheet of formed paper which comprises the following steps: impressing into a flat sheet, having top and bottom surfaces, spaced parallel zigzag rows of undulations having vertices disposed alternately to either side of relatively straight top and bottom fold lines, pleating the sheet along said fold lines, confining the sheet in the direction perpendicular to the sheet and compressing the sheet, while so confined, in the direction of the rows.

15. The method of making a sheet of formed paper which comprises the following steps: impressing into a flat sheet, having top and bottom surfaces, spaced parallel zigzag rows of undulations, confining the impressed sheet in the direction perpendicular to the sheet, and compressing the sheet, while so confined, in the direction of the rows.

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