Nov. 24, 1953 J. E. LILIENFELD 2,659,956

FABRIC, METHOD OF MAKING SAME AND ITS USES

Filed Dec. 15, 1948 3 Sheets-Sheet 1

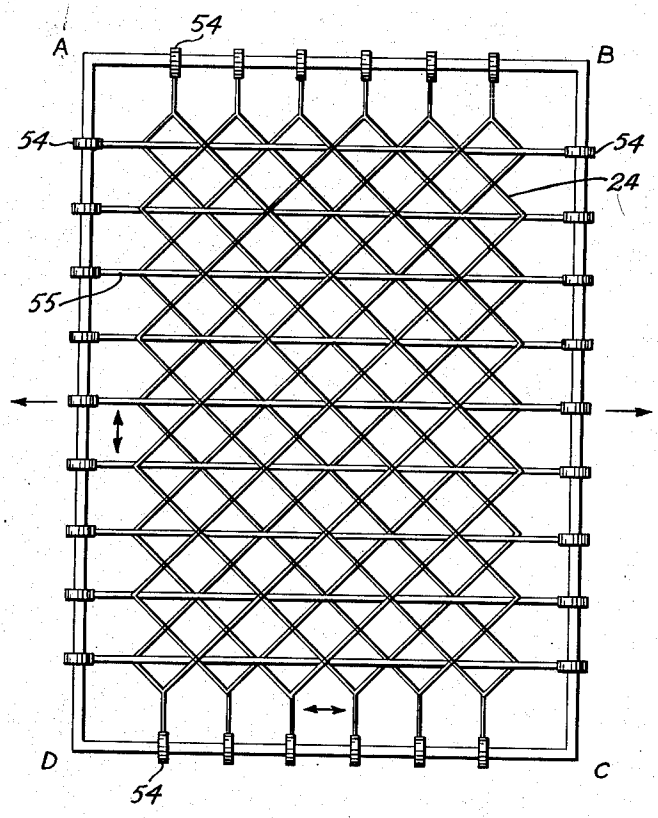


FIG. 1.

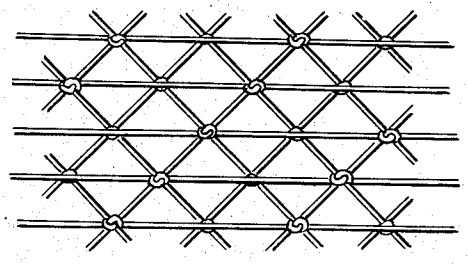


FIG. 6

INVENTOR.
JULIUS E. LILIENFELD

BY
Irving Seidman
ATTORNEY.

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FABRIC, METHOD OF MAKING SAME AND ITS USES

Filed Dec. 15, 1948 3 Sheets-Sheet 2

FIG. 2.

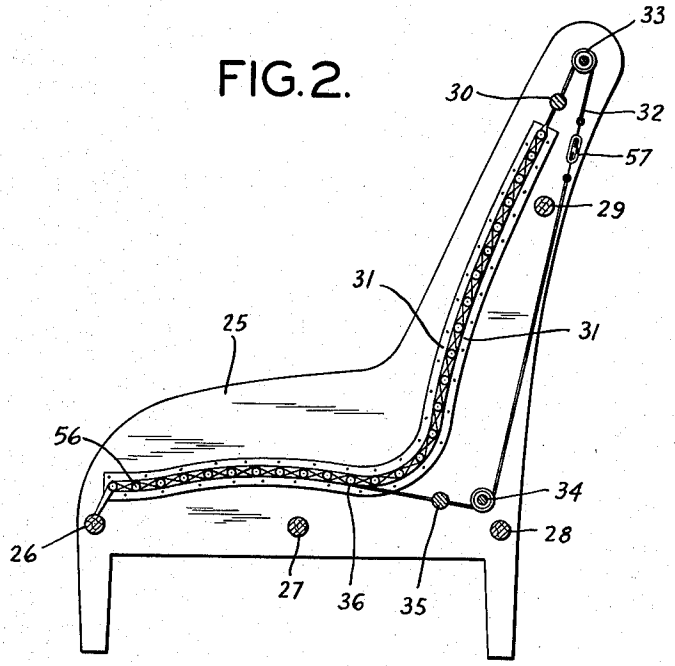


FIG. 3.

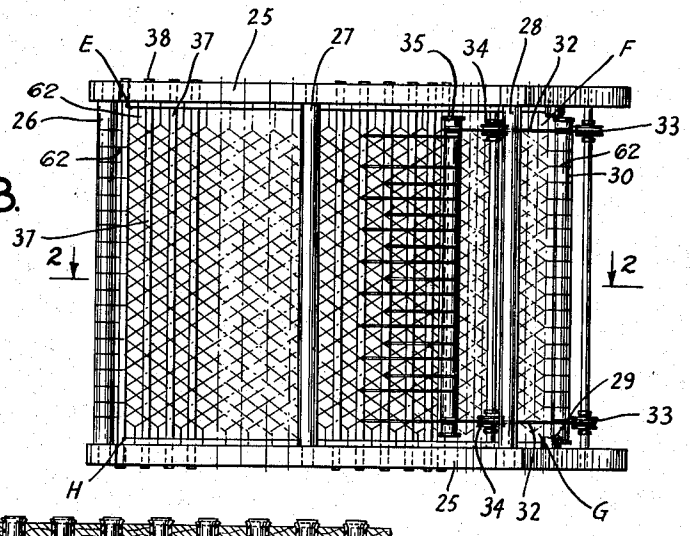
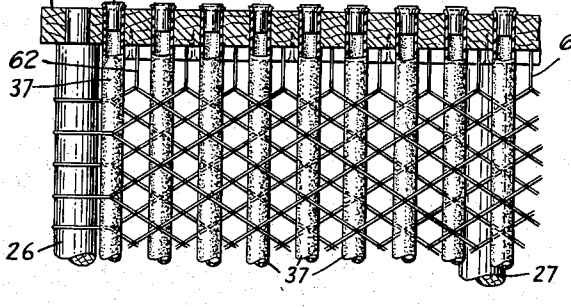


FIG. 4.



INVENTOR.
JULIUS E. LILIENFELD

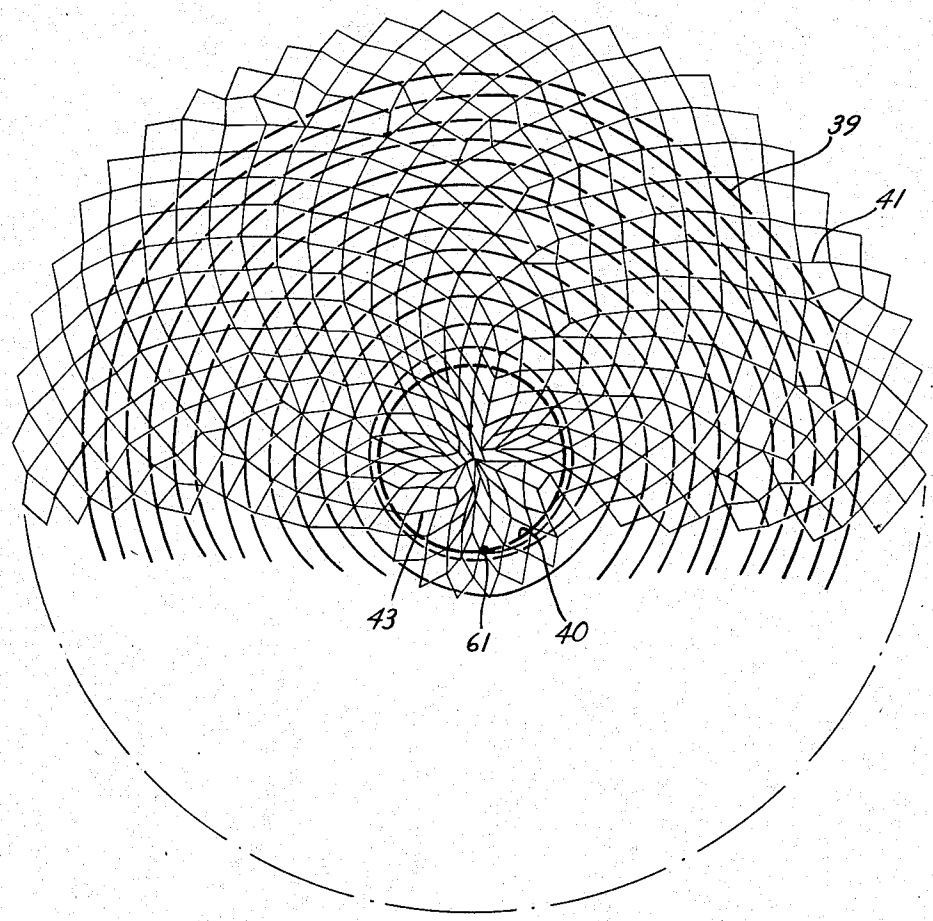
BY Irving Seidman

ATTORNEY.

FABRIC, METHOD OF MAKING SAME AND ITS USES

Filed Dec. 15, 1948 3 Sheets-Sheet 3

FIG. 5.



INVENTOR.
JULIUS E. LILIENFELD
BY
Irving Seidman
ATTORNEY.

Patented Nov. 24, 1953

2,659,956

UNITED STATES PATENT OFFICE

2,659,956

FABRIC, METHOD OF MAKING SAME, AND ITS USES

Julius E. Lilienfeld, St. Thomas, V. I.

Application December 15, 1948, Serial No. 65,484

6 Claims. (Cl. 28—78)

1

The subject matter of the present invention is a novel fabric which may be variously used and applied as an elastic support; and more specifically it may be used to support the human body by upholstering furniture with it. It may also be used for form-giving support of parts of the human body.

A fabric that may be used to so support weight has to fulfill two conditions; firstly, it has to be apt to distort when weighted; and secondly, while so responding over the full range of the intended loads, its distortions have to be fully reversible. By "reversible" is meant that a definite distortion will always correspond to a definite load; and also will change practically simultaneously with the change of the load, regardless of whether that change is an increase or a decrease of the initial one.

The first condition is satisfied, to some degree, by known fabrics made of substantially inextensible yarns. Any woven fabric will show its maximum distortion when a force attacks it diagonally. Knitted or netted fabrics exhibit this property to a higher degree. In all of the knitted aforesaid cases, the distortion is due to the fact that the threads run in a sort of three dimensional zig-zag, being for instance, coiled when the fabric is knitted. The distortion then is due to a partial straightening out of the zig-zag and, as this is indefinite, the response to a definite field of forces is indefinite as well.

If the fabric is made of an extensible yarn, however, its behavior is even more unpredictable. Elastic distortion superimposes itself over the aforesaid non-elastic one, and any one of the set of possible responses may happen under the identical load. In the language of physics, this is due to the fact that the non-elastic component of the distortion is not caused by the transformation of a definite quantity of energy. Thus, it is the very nature of all known fabrics that they will not reproduce a definite shape when attacked by a given set of forces.

The present invention avoids the indicated difficulty by using, in the construction of the fabric, both substantially inextensible and elastically extensible filaments like threads, yarns, twines, wires, with the purpose to control the geometrical displacement of the former by the expansion of the latter. This purpose is achieved by a design of the fabric essentially comprising two members: the non-elastic retiform base and the elastic form controlling filaments intersecting the pattern of said base.

By retiform base, I mean a base consisting or

2

made up of two sets of substantially inextensible filaments, the filaments of the one set running along a pattern intersecting the pattern of the other set A net 24 is a good example of such structure. Obviously, by stating that the elastic filament intersects the pattern of such base I mean so say that it substantially intersects both systems of the inelastic filaments of the base.

Fig. 1 represents a retiform base fabric, and more specifically a pattern of two systems of substantially inextensible filaments intersecting each other and elastic filaments interlaced therethrough.

Suppose that a net is stretched out, with an adequately small measure of slack, within a rectangular frame, as shown in Fig. 1, so that its suspensions on frame ABCD glide freely along the frame (e. g. by inserting rings or pulleys 54 riding on the frame); and suppose elastic filaments or bands are interwoven with it as indicated by the heavier cross lines 55 and their lengths so chosen that when assembled with the frame they become "prestretched." If weighted masses are distributed over the so constructed fabric, the elastic filaments, bands or similar elastic cross members will become elongated. The points of attachment of base to frame will spread along AB and DC, while those on AD and BC will condense along these lines by a corresponding quantity. By contradistinction, if the points of attachment on ABCD are not movable and their location is invariable, the base will be subjected to stretching forces directed mainly along AD. If a human body lies flat lengthwise on the fabric, lines of longitudinal support, which in a somewhat slack base without the elastic bands would be curved, will shorten and the supporting, lifting action along those lines will increase. The result will be that by comparison with the case without interwoven elastic bands, the body will be lifted along the length axis of the base and simultaneously hugged by the fibres running perpendicularly to that axis. This will reduce such components of the forces exerted upon the body as may tend to make for a painful condition in the sacroiliac region.

Fig. 2 represents a vertical cross-sectional view of a chair showing fabric like that shown in Fig. 1 stretched upon the framework of the chair.

Fig. 3 is a top view of the chair shown in Fig. 2.

Fig. 4 is an enlarged fragmentary view showing the means of holding the elastic elements which represent the elastic filaments.

Fig. 5 is a plan view of a form-giving breast

covering made up of a retiform base which is netted like a purse net and of an extensible filament which is spirally inserted, e. g., interlaced in said base.

Fig. 6 is a plan view of a piece of fabric showing substantially inextensible filaments intersecting each other with non-slip intersections to form a diamond-like pattern and with elastic filaments crossing said pattern diagonally.

The chair shown in Fig. 2 is designed to follow the same principle and with similar beneficial results and its economical and simple construction is indicated in Figs. 2, 3 and 4. Two properly and identically shaped boards **25** are held firmly parallel by crossbars **26, 27, 28** and **29** at a distance apart to comfortably hold the human body. A pattern of one inch holes **56** has been drilled through both boards **25** before they were assembled, as indicated by a series of successive circles shown on Fig. 2. The pattern follows the conventional lines of seat and back of a chair. A quadrangular base EFGH netted of about a one and one-half inch mesh is firmly attached to the sides **25** by its long borders EF and HG so as to follow said pattern. As means of said attachment for base EFGH, are used strips of wood or metal **31** which are drilled so that the holes coincides with those of the aforesaid pattern. The base fabric is secured to said attachment by providing its borders EF and GH with random threads **62** which are passed between the strips **31** and sides **25** by screwing or nailing such strips to the inside of sides **25**. The border FH is firmly tied to crossbar **26**. The border FG is tied to a freely swinging rod **30**, hung by two parallel wires or twines **32** over two pulleys **33** held in position above it and attached to the sides **25** or to one of the crossbars. Said wires or twines **32** run over the lower pulleys **34** and are attached to another freely swinging rod **35**, which in turn, is connected with a crossrow of meshes **36** of that part of the net which forms the seat, said crossrow being selected according to the required performance of the chair under load. Said performance is controlled by turnbuckles **57** inserted in the wires **32**. The role of the elastic cross bands is in the present instance taken over by soft rubber tubes **37** whose outside diameter is the same as the diameter of the holes drilled in the sides **25** and strips **31**. The tubes may be replaced by solid soft rubber rods. And again they may be reinforced by slipping into them helices of spring wire or spring band. Such reinforcement of rubber tubes is well known. The important advantage of tubes or rods above thinner filaments or bands is that the fabric becomes, so to speak, three dimensional and additional elastic give is provided when the reticular base stretches and compresses said tubes interwoven with the base. In some applications however, rubber tubes may be omitted altogether and helical spring wire or band may be used. This would save rubber; however, it would have obvious drawbacks. Such tubes or their equivalents may incidentally also be used in the diagrammatically presented case of Fig. 1, and in other cases. When assembling the chair, first one end of the rubber tubes **37** is passed through the holes in one of the sides **25** and in the adjacent strip **31** and conical stoppers **38** are forced into that end with the result that the tubes will not slide out of the holes even if pulled by strong forces. Next, the other end of the tubes **37** is passed diagonally, in an interweaving manner, in and out through the meshes of the corresponding

crossrow, then longitudinally pulled through the corresponding holes of the other side **25**, and finally stoppers **38** are forced into that end too so that said tubes remain in a prestressed condition. The assembly is completed by pulling taut the wires or twines **32** which run over the pulleys **33** and **34**. When a body seats itself, and the rubber tubes are deflected downward, the part of the base net forming the seat shortens and its pull transfers itself over the lower pulleys **34** to the upper pulleys **33** and hence to the back of the chair and so lifts up the back. The latter pull in turn expands the length dimension of the seat, thus lifting the cross row of meshes **36** by which action part of the load of the seated body is counteracted with the result that a perfectly elastic reaction may be obtained with smaller rubber cross section than without the pulley arrangement; and also the seat shapes itself more effectively for comfort.

There are other fundamentally inherent features which warrant an exceptionally pleasant performance of said fabric. Due to the large number of crossings between the elastic and non-elastic threads, all elastic oscillations are so strongly damped as to become aperiodic. Also, when the fabric is loaded, a pressure is exerted between the inelastic base filaments and the elastic filaments crossing them. As a consequence each intersection of one of the former with one of the latter will remain at the same point of either one, partly because the elastic filament distorts, so as to oppose the sliding along it of the crossing non-elastic one, and partly because of frictions. If the base is a net with non-sliding knots, this makes each mesh to become, so to speak, an isolated cell inasmuch as each elastic cross-piece becomes firmly anchored to its mesh, so that if the elastic filament is cut in a percentage of the meshes, no vital disruption occurs. Also in other ways the action of the fabric is more to be compared to the action of as many individual springs as the number of meshes it contains, than like anything else. A good idea of the action is given if the ends of the elastic filaments are not anchored at all, e. g. if the elastic cross-members in Fig. 1 are disconnected from the frame. Still, a fair measure of control is enacted by the elastic filaments. The device performs with much less discomfort than an ordinary hammock even if the net itself is disconnected from the long sides of the frame and instead "rimmed" with a twine, thus becoming practically a hammock.

The fact that each mesh may be considered as self-supporting lends to the fabric the further advantage of possessing a large measure of safety, which feature may be enhanced by actually tying the elastic filaments to each mesh crossed. If the elastic filaments are damaged in a few places, no breakdown occurs and the device continues to perform in much the same manner as before, provided the damage is restricted to a relatively small number of defects.

If, however, the base of the fabric is not knotted with non-slip knots as indicated, e. g., if it is knitted, anything may happen and "runs" of trouble may develop analogous to those in a knitted stocking. This recommends the "fabric" of the non-slip knotted kind for use in many cases, instead of the conventional springs, etc. for instance, for support of automobile bodies upon the chassis. Other possible applications obviously are not hard to indicate.

It is to be understood from the preceding para-

graph, that while the language speaking of a "fabric" made up of "threads" or "yarns" is conveniently retained, in some practical cases heavy rubber tubes, wires, rods or helices may be made part of the design instead of the elastic cross-threads; and perhaps wire cables or steel rods may take over the role of a non-expansible yarn. Thus a heavy substructure may result for the support of large loads like automobile bodies, instead of what conventionally is meant by "fabric."

It is also to be noted that on the one hand not only knotted nets have been designated as retiform "base." While such nets, with non-sliding or stopped knots, as occasion demands, correspond to the conventional meaning of "retiform," obviously when a construction be made in which instead of knotting, a cementing or welding were applied to the threads at their crossing, the so produced fabric would behave like a net with "stopped" knots and therefore would be appropriately called "retiform." On the other hand the fabric does not have to be necessarily "knotted" to make it possible to obtain, to some extent, similar effects as with the knotted base, by combining it in the aforesaid manner with an elastic filament. With the knotted base, however, the pattern of the fabric is strictly defined for any given set of forces. This is true with non-sliding knots to a certain extent if the knots slide with significant friction.

The preceding part of this specification aims at clearly conveying the notion of the novel "fabrics." The applications mentioned heretofore were to demonstrate the properties of various such fabrics. The specific use, however, of one of such fabrics with which the present specification is to deal, is its application to the already indicated elastically supporting breast covering.

The breast presents a more differentiated problem than that of support only, inasmuch as it also calls for adequate shaping. For this purpose the breast may be considered as an incompressible plastic mass. The mas of an individual breast is not strictly constant as it somewhat varies from day to day. This, however, does not affect the design to be presented here; and no reference to it will be made henceforth.

Fig. 5 is a plan view of a breast covering showing elastic filaments interlaced with a retiform base fabric.

The retiform base is, in the case of a breast covering, designed as a circular disk, such as is shown in Fig. 5. One way to produce such a disk is to have it netted of one continuous run of yarn after the manner of purse nets. The net resulting from such netting is shown in Fig. 5. The thread runs in a zig-zag spiral from the center or from the periphery of a circle of about two inches in diameter about that center and is joined, e. g. knotted at all points of intersection of said continuous spiral zig-zag. Such a disk presents to the eye, roughly, a structure made up of two sets of intersecting curves, the curves of one set being oppositely curved to the curves of the second set, the curves of either set extending in the direction from center to perimeter. Due to said structure the net may be produced by means different from the conventional netting, to wit, the thread may be laid out in the

pattern of the said two sets of curves and cemented or welded at the intersection of the threads. Synthetic thread such as nylon or vinyon lend themselves to such technique.

Fig. 6 is a plan view of a piece of fabric showing the inelastic filaments of the base mutually knotted at their points of intersections with non-slip knots which are well known in the art, the straight parallelly running elastic filaments being strung through said base and interconnected with it in any way by using such elastic filaments as a warp, interweaving, etc.

Although the invention is described in detail and therefore certain specific terms and language therein is used, it is to be understood that the present disclosure is illustrative, rather than restrictive, and that changes and modifications may be resorted to without departing from the spirit or the scope of the claims appended hereto.

I claim:

1. An integrated fabric, in its undisturbed condition lying flat in a plane, and consisting of a retiform non-slipping base pattern of substantially inextensible filaments, and an elastic pattern of mutually non-intersecting elastic filaments crossing the pattern of said inextensible filaments.

2. A fabric according to claim 1, wherein the elastic filaments are in the form of a pattern of straight parallel lines.

3. A fabric according to claim 1, wherein the elastic filaments are interwoven with said base pattern.

4. A fabric according to claim 3, wherein the base pattern is provided with substantially non-slipping knots.

5. A fabric according to claim 4, wherein the elastic filaments are joined to the base pattern at the knots thereof.

6. A member comprising the fabric as claimed in claim 1, and a border element edging the fabric to which both patterns are anchored.

JULIUS E. LILIENFELD.

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