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Rowland

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[45] **Nov. 5, 1974**

[54] **FOLDING CHAIR**

[76] Inventor: **David L. Rowland,** 8 E. 62nd St., New York, N.Y. 10021

[22] Filed: **Sept. 7, 1973**

[21] Appl. No.: **395,365**

Related U.S. Application Data

[60] Continuation-in-part of Ser. No. 268,870, July 3, 1972, which is a division of Ser. No. 126,808, March 22, 1971, Pat. No. 3,720,568, Continuation-in-part of Ser. No. 268,907, July 3, 1972, which is a division of Ser. No. 126,563, March 22, 1971.

[52] **U.S. Cl.** **297/56,** 297/331

[51] **Int. Cl.** **A47c 4/42**

[58] **Field of Search**........ 297/56, 57, 313, 331–335, 297/337, 338, 445, 452–458; 160/403, 404; 5/353, 354; 156/292; 117/99; 161/57, 108, 112, 239; 267/107–111

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Primary Examiner—Bobby R. Gay
Assistant Examiner—William E. Lyddane
Attorney, Agent, or Firm—Owen, Wickersham & Erickson

[57] **ABSTRACT**

A folding chair which has a spring-resilient seat and a spring-resilient back, both of which are very thin—so thin that when the chair is folded, the *lower* surface of the seat lies within the chord across the back of the chair. Also, the spring resilience incorporates a two-way stretch action and other comfort structures.

24 Claims, 19 Drawing Figures

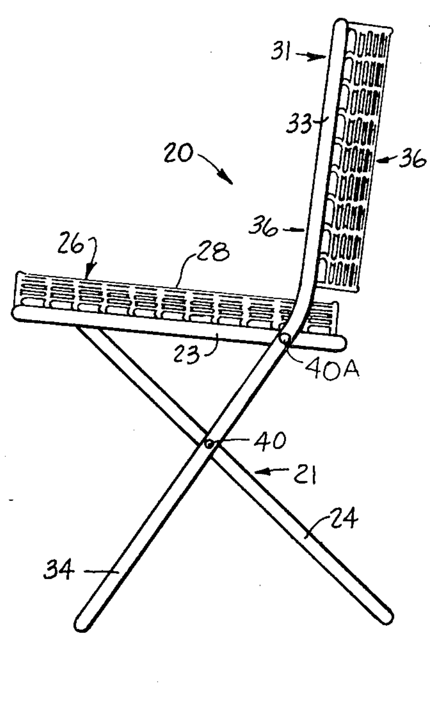


FIG. 3

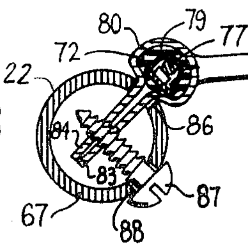


FIG. 4

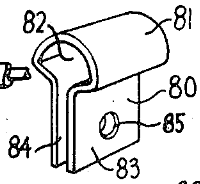


FIG. 1

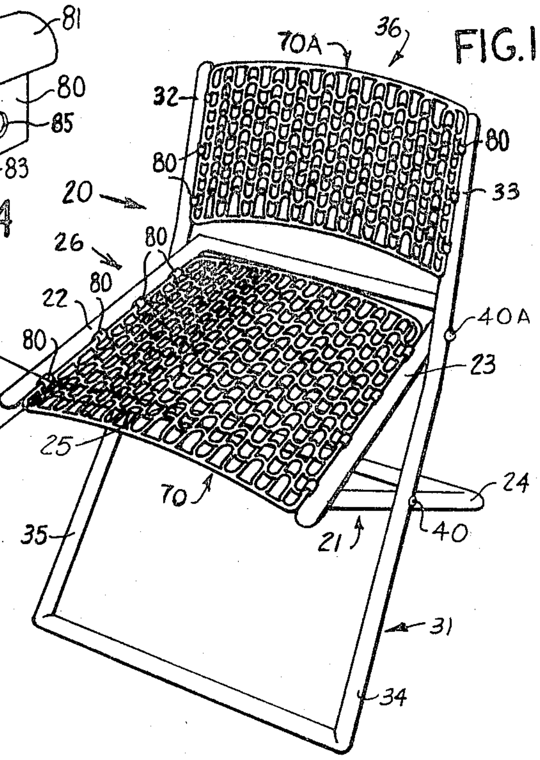


FIG. 2

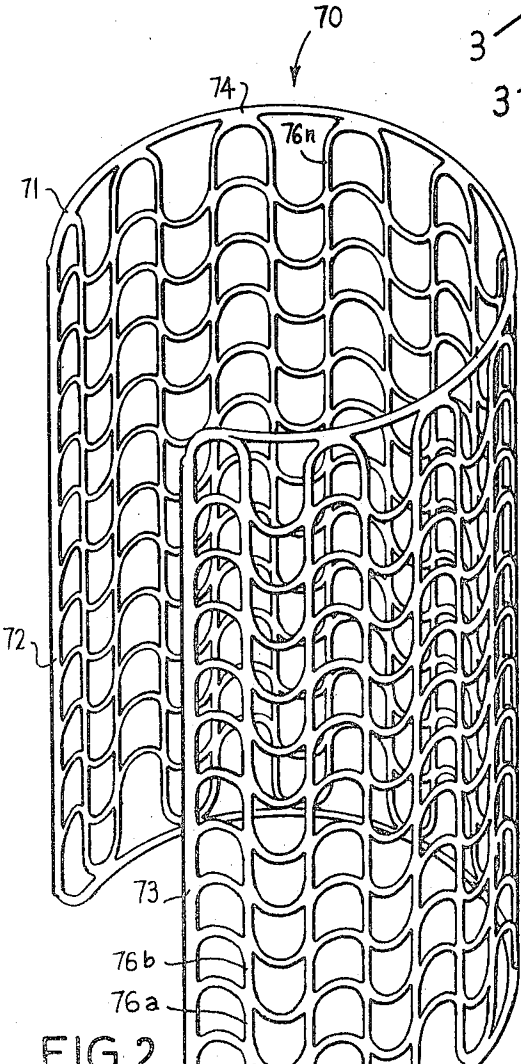


FIG. 5

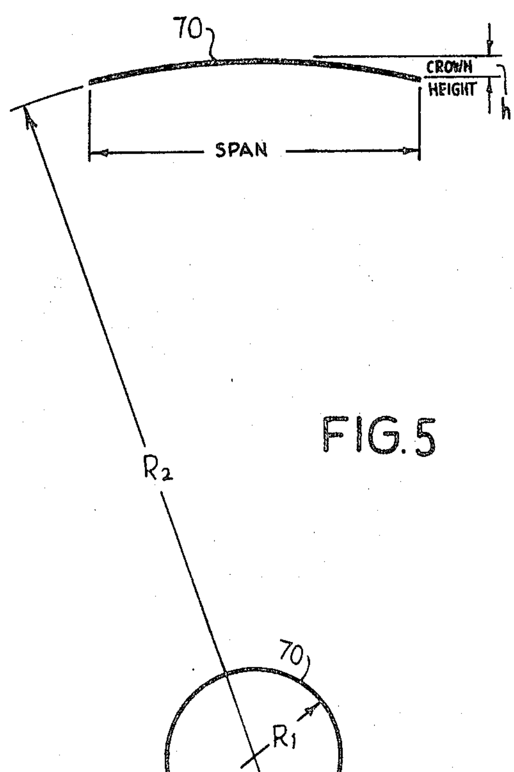


FIG. 9

FIG. 8

FIG. 6

FIG. 7

FIG. 10

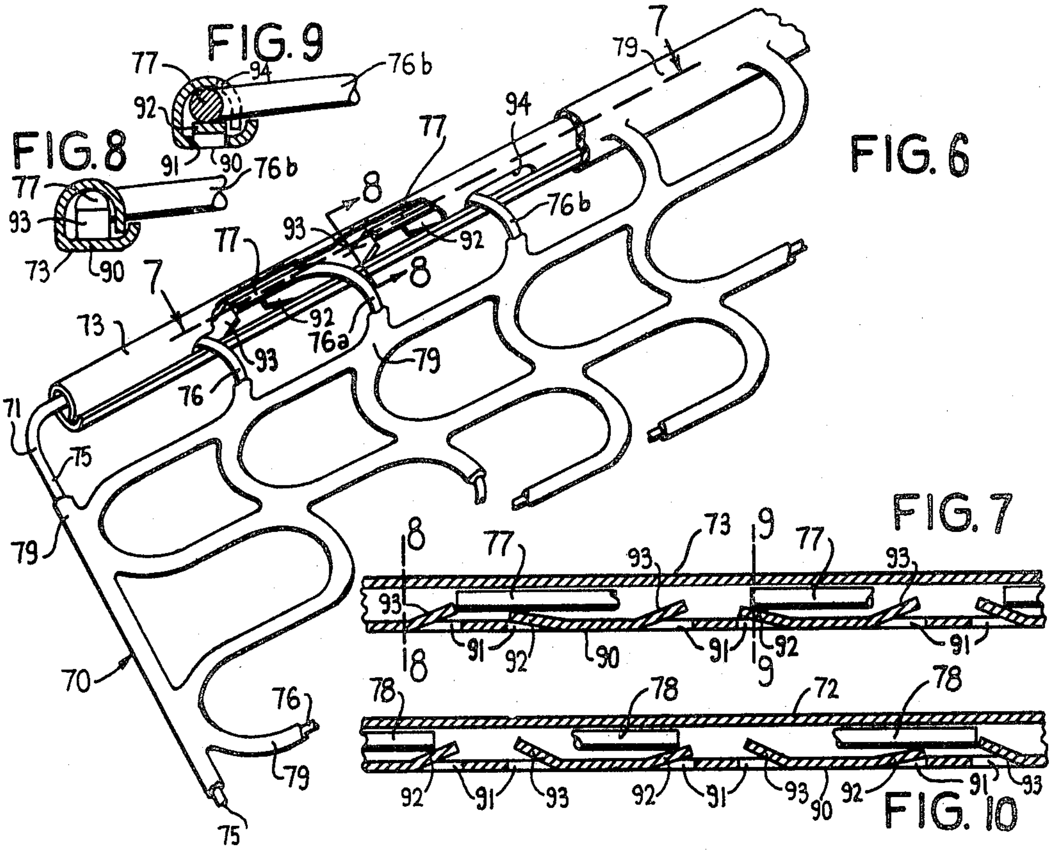


FIG. 11

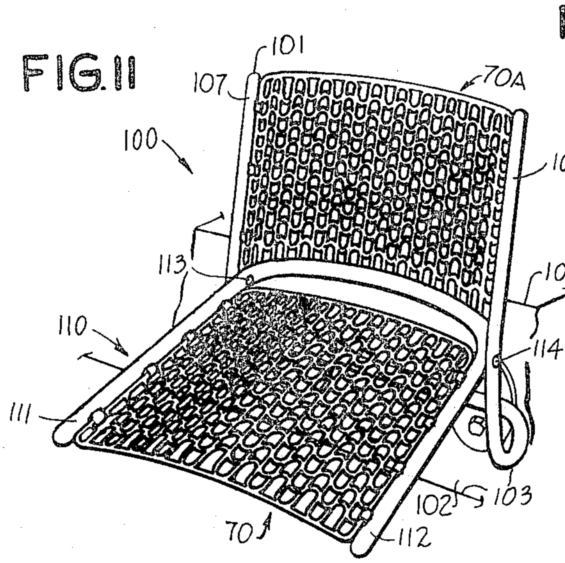
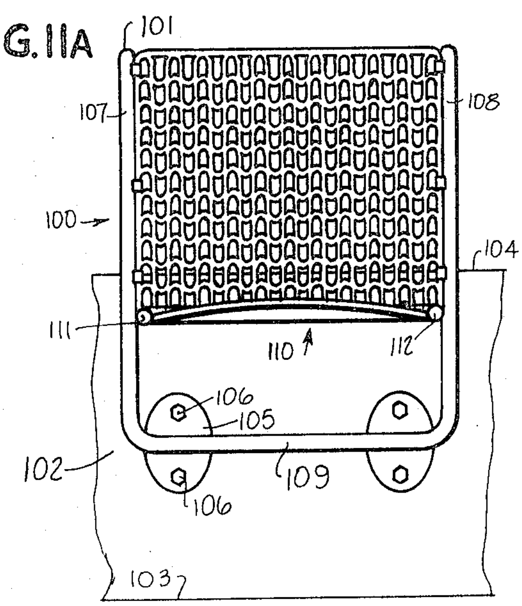


FIG. 11A



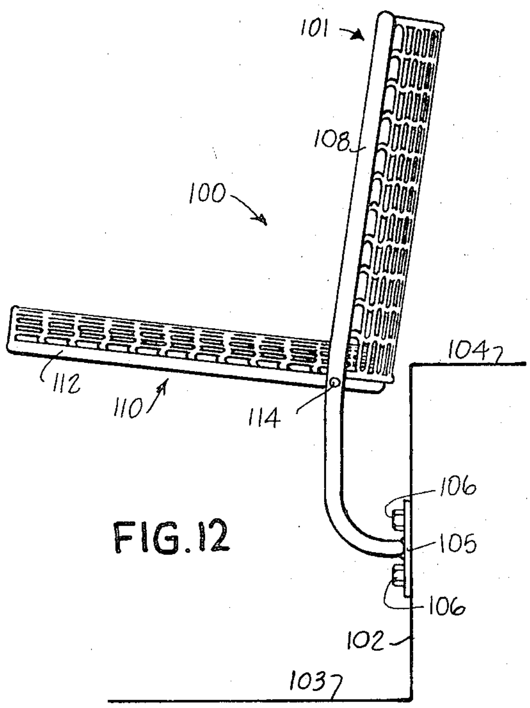


FIG. 12

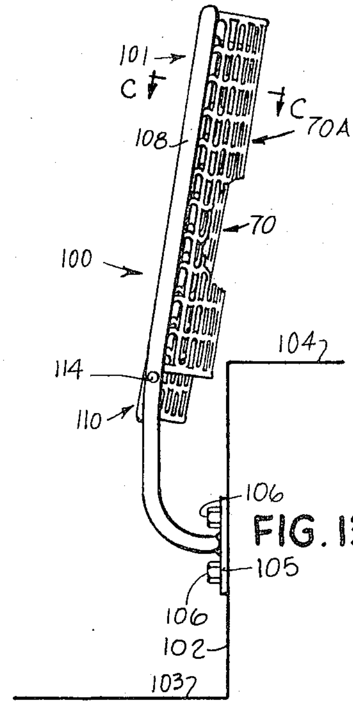


FIG. 13

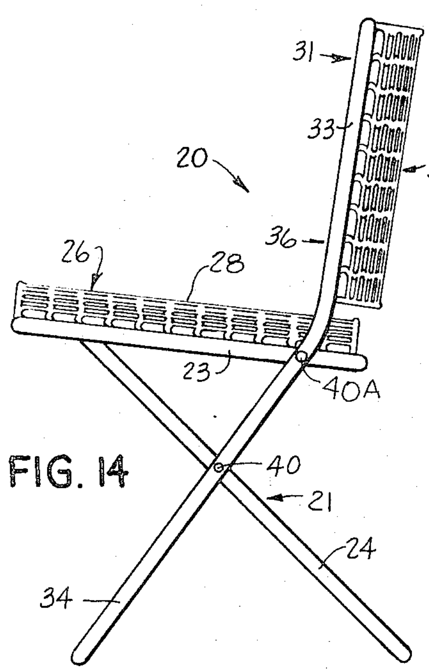


FIG. 14

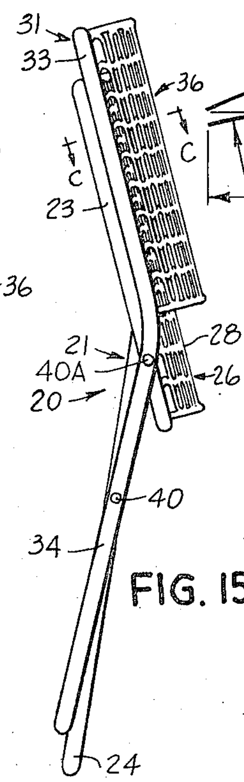


FIG. 15

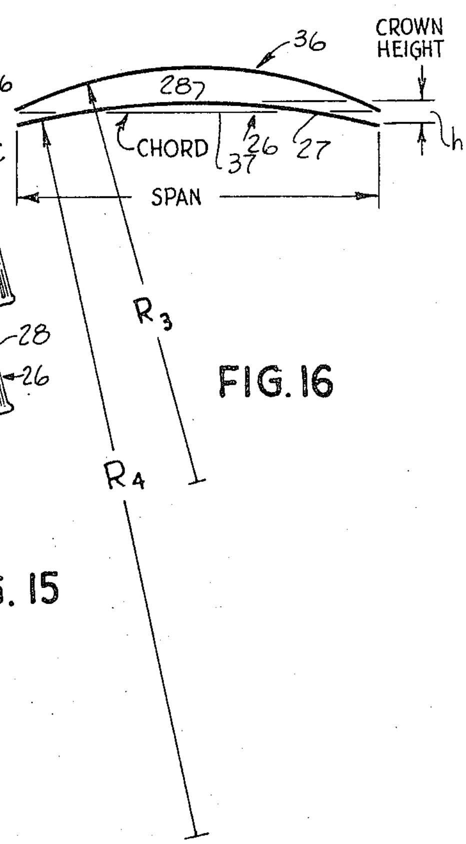


FIG. 16

FIG. 17

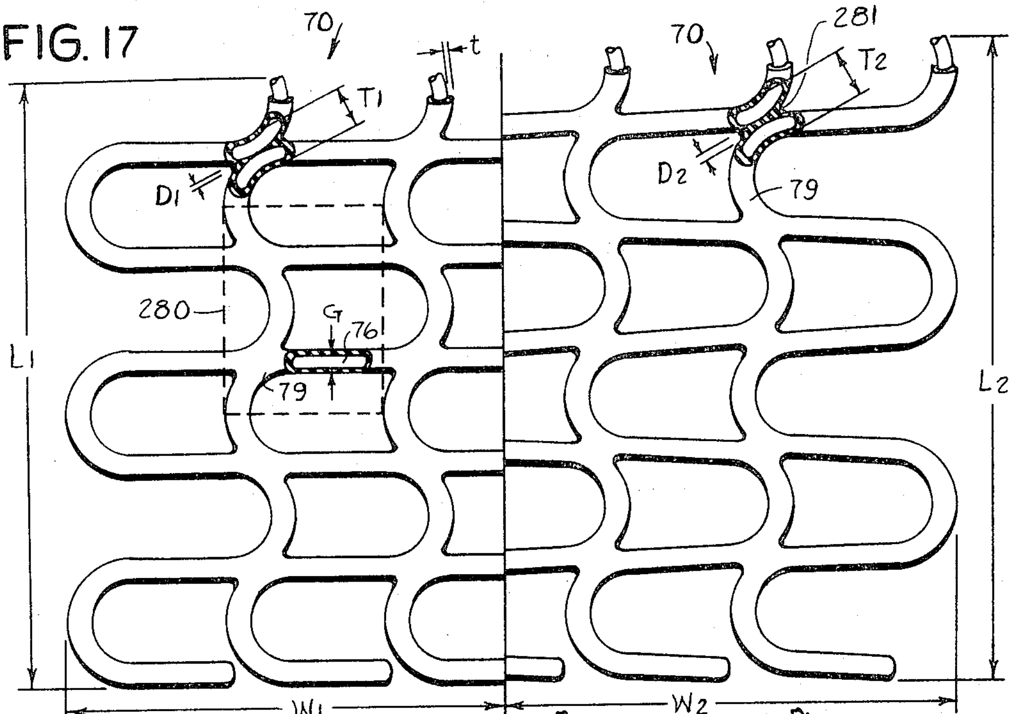
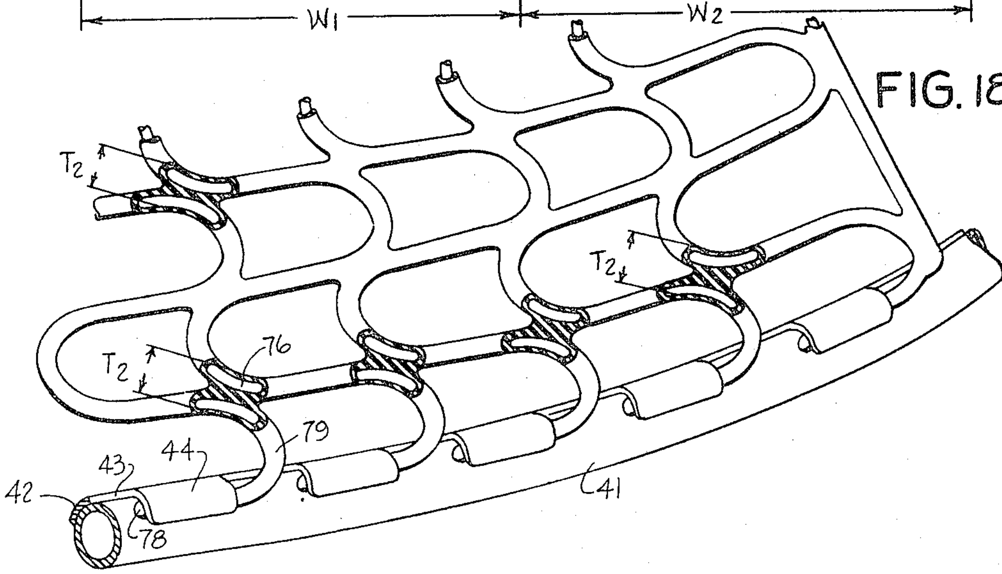

70
t
281
70
T2
T1
D1
D2
79
280
L1
G
76
79
L2
W1
W2

FIG. 18


T2
T2
76
T2
79
43
44
42
78
41

FOLDING CHAIR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of application Ser. No. 268,870, filed July 3, 1972, which was a division of application, Ser. No. 126,808, filed Mar. 22, 1971, now U.S. Pat. No. 3,720,568.

This application is also a continuation-in-part of application Ser. No. 268,907, filed July 3, 1972, which was a division of application Ser. No. 126,563, filed Mar. 22, 1971.

BACKGROUND OF THE INVENTION

This invention relates to a folding chair having a spring-resilient seat and a spring-resilient back.

Folding chairs have long been known—Tutankhamen's tomb contained one. However, few of them have been comfortable, and compactness has generally been confined to such as is gained merely by the act of folding in itself. The seats have generally been hard and when upholstery was provided, compactness has been sacrificed. In fact, comfort has been achieved largely by padding, due to misunderstandings about the nature of comfort.

The seated human body rests mainly on the ischial tuberosities, the two lower points of the pelvis. Additionally, it rests on the meaty and fatty flesh in a 1 to 2 radius therefrom. The reason why a flat, hard surface becomes uncomfortable quickly is that the load is concentrated on the small area of the ischial tuberosities, and the flesh immediately covering them is compressed with great force. Spreading this load over a larger area makes a more comfortable condition as the unit area compressive force is substantially reduced. Automatically shaping the seat surface to generally conform to the sitter helps to accomplish this. On the other hand, spreading this area over too wide a surface, such as is the case when a seat is too soft, results in engulfing the sitter too deeply and also often results in a lack of security, which comes from feeling insufficiently supported. One often sees automobiles in which the owner has gone to the trouble of installing wooden slat accessory pads to make the seat firmer.

Dr. Bengt Akerblom, eminent Swedish authority on human posture, says in his book *Standing And Sitting Posture*, published by A. B. Nordiska Bokhandeln, 1948:

> "Naturally a rather soft seat would distribute the pressure over the tuberosities better than a hollowed rigid one. They are, however, so small that there would be very little sense in having a very soft and resilient seat. On the contrary, such a seat might be expected to transfer a not inconsiderable proportion of the weight on to tissues which are not adapted for bearing it. The best consistency for the seat would therefore be such that although it gave under pressure, it only gave slightly."

Proper resilience alone is not enough, either. Independent freedom of movement of such as that found in a two-way stretchable material more appropriately conforms to the human posterior shape, which itself has compound curvature.

While certain spring and padding combinations can afford proper yieldability and firmness, practically all padding materials have the fault of being good heat insulators. In a cold room, this might be acceptable temporarily, but people usually wear clothes appropriate for temperature conditions anyway, and to sit for any length of time on a heat-insulative material becomes uncomfortable because of inhibition of dispersion of body heat in the human posterior area. To get to a cooler spot, the person squirms. Also, anyone who, while wearing a swim suit, has tried to sit down on the seat of a convertible car that has been out in the hot sun, knows that such heat conditions of the seat can be unbearable.

Some prior art seats have been made of spaced-apart wires, but in them the spacing has been such that too much load has been concentrated on too few wires, and this textural discomfort has made the use of upholstery pads requisite for such seats.

An ideal seat therefore has:

1. Proper shape (including proper compound curvatures).
2. Proper resilience and firmness (resilience provides shape adaptability to each sitter).
3. Proper heat dispersion.
4. Proper surface contact area.

One object of this invention is to provide a compactly folding chair with a seat more nearly approaching the ideal than has been achieved in the past.

Each seat or back of this invention comprises a series of sinuous spring wires, partially held together by a thin sleevelike plastic coating around each of the wires, bridging the wires where they touch.

A disadvantage of some prior chairs was that the chair seat and back were substantially planar, and, even if they did have a slight bowing, they were installed in a generally flat at-rest shape of the spring, so that there was little spring tension or cushioning action. In the present invention, it becomes possible to obtain much more tension, cushioning, and resilient support from flat springs by virtue of making the unit as a cylindrical segment that is somewhat flattened when it is put on a chair frame, rather than making chairs from a series of substantially flat springs. The tension of the wires pulling inwardly is one of the main forces retaining the assembly in place.

Another important feature of the invention is the provision of a two-way stretch, which is obtained by using plastic coatings lying within a prescribed range of Shore durometers. The springs can continue their flexing in the usual manner without being overly limited by the coatings, and also the spring assembly can flex and stretch the plastic when it bridges the wires.

Even two-way stretchability and proper wire gauge alone have been found to be insufficient. Resistance to bounciness is an important property when considering the resilience necessary for a comfortable seat and is especially necessary in transportation seating, where up-and-down motion tends to result in harmonic vibration, for harmonic vibrations subject the sitter to vertical oscillations for some time after a bump has been traversed. Bounce dampening is thus requisite, and is partly accomplished in the present invention by proper choice of durometer of the plastic coating. If the durometer is too low a value, the springs are too free and are too ready to bounce. If the durometer is too high, the seat is too stiff and lacks the proper two-way stretch quality desired. Proper choice of durometer according to the principles of this invention, enables the plastic to serve as a shock absorber and provides a snubbing action against bounce.

Additionally bounce-dampening can be achieved in this invention by employing in the assembly some wires that differ from the other wires in gauge, shape, or spring tension or temper, so that their harmonic vibration periods are different.

The amount of the seating area occupied by the metal thickness, and the thickness of the plastic coating are also important features to be considered, and little, if any, thought on these features is evident from the prior art. I have found that for proper results the spring steel should occupy a minimum of 17 percent of the silhouette of the area and, preferably, but less important, a maximum of about 75 percent, with the range of about 17 percent to about 25 percent generally preferable. The coating should generally be about one-half as thick as the wire, in order to give bridging, proper heat dissipation, and proper stretchability, but a range from about one-fifth of the wire thickness to about equal to the wire thickness can be used. Also, the size of the void areas between the coated wires should be no greater than about 75 percent of the seat area used to accommodate one adult sitter and should not be less than about 2 percent with about 60 percent to 75 percent being preferable.

SUMMARY OF THE INVENTION

The present invention comprises a folding chair incorporating the sub-assembly set forth and claimed in my patent application Ser. Nos. 126,808 filed Mar. 22, 1971 and 268,907 filed July 3, 1972. Basically, the subassembly is a cylindrical segment, later flattened somewhat upon installation, placing the springs in tension. Sometimes it has a rim, which usually has straight ends, typically parallel, joined by parallel sides which are made as circular arcs; sometimes there is no rim. There is a series of sinuous spring wires, each of which is attached at its opposite ends to the rim, if there is one. The wires extend between their ends in a circular arc which, when there is a rim, is parallel to the circular arc of the parallel sides of the rim. In most seats and backs each of the two extreme spring wires is tangent at each cycle to one of the rim sides, and each wire touches or closely approaches its adjacent sinuous spring wires at least once per cycle.

A thin sleevelike plastic coating surrounds both the rim wires (if they are present) and the sinuous spring wires, following the sinuous shape of the spring wires and bridging between and joining them at points where they are tangent to each other or touch each other, and also joining and bridging between the rim and some positions of the wires. This thin plastic coating, while leaving most of the area of the seat open in between the wires, does link the wires and the rim together into a unitary assembly, shaped as a cylindrical arc. When the unitary assembly is installed on a frame as either a seat or a back, it is flattened out somewhat but not fully. When used as a seat, the rise between one end and the other after flattening is between a quarter of an inch and an inch, preferably. For the back, the curvature may be somewhat greater, preferably a radius of 7 to 20 inches. The plastic preferably is in the range of Shore A durometers between 45 and 90, and seems to be best at about 75, so that the two-way stretch action previously referred to is attained.

In some forms of the invention other shapes of rims are used, and in still other forms, no rim as such is necessary, being replaced by a special welded subassembly.

A folding chair of this invention has:

a. a first frame having at least two spaced-apart rigid frame portions and two legs,

b. a seat assembly having

a series of arcuate, continuous, sinuous wires, each having two ends, each wire closely approaching each of its immediately adjacent wires at frequent intervals, and

a thin sleevelike plastic coating surrounding the wires, following the sinuosity of the wires, and joining the wires together where they closely approach each other, the approaches being close enough for effective bridging between them by the coating,

whereby the wires and plastic coating comprise a unitary assembly defining a cylindrical arc,

c. first mounting means for securing the seat assembly to the rigid frame portions of the first frame across a space that flattens the arc to a flatter arc and places the seat assembly in tension along the flatter cylindrical arc, which is convex upwardly,

d. a second frame having at least two spaced-apart rigid frame portions and two legs,

e. a back assembly having the structure recited for element (b) above,

f. second mounting means for securing the back assembly to the rigid frame portions of the second frame across a space that flattens the arc to a flatter arc which is convex rearwardly,

g. pivot means connecting the first and second frames together for enabling folding,

the seat, when the chair is folded, nesting within the back, with part of the lower surface of the seat lying within the chord across the back.

Note that in this invention the wires cannot go straight across. They must undulate in order to be stretchable. Moreover, they must be connected to each other by *stretchable* means. This contrasts with an earlier patent of mine which may allow flexible joints but does not require stretchable joints. A 150-pound person sitting normally on a chair of the present invention will depress it by at least 1 inch (or at least one-eighteenth part of seat height) and, at most by about 3 inches (about one-sixth part of seat height). As stated, the junctures are stretchable and flexible, but they are also so tough that they cannot be pulled apart under usual human sitting conditions. Putty and kneaded erasers have a rubbery quality, but not the elasticity, stretchability, flexibility or resilience requisite. To get the best results in this invention, the area of the silhouette of the wires prior to coating should be at least **17%** of the seat area, especially of a typical area. For sufficient bridging, heat dissipation, and surface cushioning, the coating should be at least 20 percent of the wire diameter. If the seat were made from springs alone, the comfort would be insufficient, particularly when used in moving vehicles. It would be too bouncy. Proper durometer and proper thickness of the coating relative to the wire thickness help to prevent this bounciness. The reason is similar to the reason why a car is not comfortable with metal springs along; it also needs the rubber, air, and hydraulic fluid in the combination of rubberpneumatic tires and hydraulic shock absorbers, before it can be comfortable.

The folding chair of this invention has its seat convex upwardly and its back convex backwardly. Extraordinary compactness is achieved by having the seat fold into the back, such that the lower surface of the seat lies within the chord across the back of the chair.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a view in perspective of a folding chair embodying the principles of the invention.

FIG. **2** is a view in perspective on an enlarged scale of a seat or back unit or sub-assembly embodying the principles of the invention, shown before being installed on the chair frame of FIG. **1.**

FIG. **3** is a view in section taken along the line **3—3** in FIG. **1.**

FIG. **4** is a view in perspective of the fastener used in FIGS. **1** and **3** to secure the sub-assembly of FIG. **2** to the chair frame in FIG. **1.**

FIG. **5** is a diagrammatic view in end elevation showing the difference in radii of the cylindrical assembly of FIG. **2** and the installed seat of FIG. **1,** which has been somewhat flattened out, thereby placing the spring wires under tension.

FIG. **6** is a fragmentary enlarged view in perspective of a corner portion of the assembly of FIG. **2,** somewhat flattened out. Some portions are broken away to show other portions that would otherwise be obscured.

FIG. **7** is a further enlarged view in section taken along the line **7—7** in FIG. **6.**

FIG. **8** is a view in section taken along the line **8—8** in FIGS. **6** and **7.**

FIG. **9** is a view in section taken along the line **9—9** in FIG. **7.**

FIG. **10** is a view like FIG. **7** showing how the springs may be installed from the opposite direction in the same rim unit.

FIG. **11** is a view in front elevation of a modified form of folding chair embodying the principles of the invention, wherein the back frame is fixed to a riser as for use in a stadium or theater.

FIG. **11A** is a front elevation of the seating unit of FIG. **11.**

FIG. **12** is a view in side elevation of a seating unit of FIG. **11** in its seat-down position.

FIG. **13** is a view like FIG. **12** with the seat folded up to rest in the back, a portion of the back being broken away to show the nesting.

FIG. **14** is a view in side elevation of the chair of FIG. **1.**

FIG. **15** is a view in side elevation of the chair of FIGS. **1** and **14** in its folded position.

FIG. **16** is a diagrammatic view of the relative arcs and radii of the back and seat for the chairs of FIGS. **1** and **11–15,** looking along the line C—C in FIGS. **13** and **15.**

FIG. **17** is an enlarged top plan diagrammatic view in two halves illustrating the two-way stretch effect of the wires and plastic assembly.

FIG. **18** is a fragmentary view in perspective of a portion of a modified form of seat assembly of the invention installed on a chair as the seat thereof and showing a corner near the rear of the seat. This view illustrates the adaptability of the invention to double curvature in the seat, as occasioned by curvature of the supporting frame.

DESCRIPTION OF SOME PREFERRED EMBODIMENTS

An example of a folding chair embodying the invention (FIGS. **1, 14** and **15**)

Many, many types of folding seating units may embody the principles of this invention, including folding chairs, folding sofas, folding davenports, stadium seating, theater seating, and so on.

A folding chair **20** is shown in FIG. **1** for the purpose of giving one example of a type of seating unit that can embody the principles of the invention. This example is not to be construed as representing all types of folding seating units or even all types of the folding chairs, which can vary greatly in frame structure, appearance, and so on. The basic part of this invention is concerned with the seating and back unit more than with the framework of the chair itself.

Embracing all these units within the term "folding chair," the essential features are shown in FIGS. **1, 14** and **15,** which show a folding chair **20.** The chair **20** has a first frame **21** having at least two spaced-apart rigid frame portions or side frame portions **22** and **23** and two legs **24** and **25.** The seat **26** itself is made from a seat assembly **70** (FIG. **2**) having a series of arcuate, continuous, sinuous wires **76, 76*a*, 76*b* . . . 76*n*.** Each wire has two ends **77** and **78,** and each said wire **76,** etc. closely approaching each of its immediately adjacent said wires at frequent intervals. A thin sleevelike plastic coating **79** surrounds the wires **76, 76*a*,** etc., following the sinuosity of those wires and joining the wires together where they closely approach each other. The approaches are close enough for effective bridging between them by the coating **79.** As a result, the wires **76, 76*a* . . . ,** etc., wires and the plastic coating **79** comprise a unitary assembly **70** defining a cylindrical arc.

Suitable mounting means (See FIGS. **3, 4, 6–10,** and **18**) secure the seat assembly **70** to the side frame portions **22** and **23** of said first frame **21** across a space that flattens the arc to a flatter arc (See FIG. **5**) and places the seat **26** in tension along the flatter cylindrical arc, which is convex upwardly.

A second frame **31** for the back has at least two spaced-apart rigid frame portions **32** and **33** and two legs **34** and **35.** This second frame **31** supports a back assembly **36,** which also comprises an assembly **70A** like that constituting the seat **26,** but not necessarily identical in size, wire gauge, and so on. Again, suitable mounting means secure the back assembly **36** to the rigid frame portions **32** and **33** across a space that flattens the arc to a flatter arc, which is convex rearwardly.

Pivot means **40** and **40A** connect the first and second frames **21** and **31** together for enabling folding. An important feature is that when the chair **20** is folded, the seat **26** nests within the back **36,** with the lower surface of the seat **26** lying within the chord across said back. This is shown in FIG. **16.**

The number of pieces used in making the chair frames is immaterial to this invention, and whether the frames are continuous or are pieces, are welded or otherwise secured together does not matter, so far as the present invention is concerned. The use of bracing and top members is not significant in the present invention, though some such members are shown in the drawing, and there must be some rigid means for holding the frame members 22 and 23 apart and for holding the frame members 32 and 33 apart. In this particular form of the invention the back frame members 32 and 33 are rigidly held parallel to each other and the side frame members 22 and 23 are rigidly held parallel to each other. This parallelism need not always be preset, but it is preferred.

The structure of the units 70 and 70A is highly important in this invention. So is the attachment of the units 70 and 70A to a chair frame. The units 70 and 70A may in some instances be identical, but usually the back unit 70A is somewhat smaller than the seat unit 70 and is usually made from a smaller gauge of wire.

The Seat Unit 70 (FIG. 2)

FIG. 2 shows the seat unit 70 before it is incorporated into the chairs; the view also represents basically what the unit 70A looks like, although the unit 70A may be different in size or even in structure or appearance, where desired.

In this example, the unit 70 comprises a rim 71 having spaced-apart straight ends 72 and 73 joined by parallel side members 74 and 75, which are shaped as circular arcs. The member 74 which is to extend across the front of the seat may be of thinner gauge than the wires 76, etc., in the remainder of the seat. Lest there be some confusion in the mind of the reader, it is pointed out that the straight end members 72 and 73 are secured to the side frame members 22 and 23 of the chair, and thus extend from front to rear at each side of the chair 20, while the side members 74 and 75 become the front and back edges of the seat in the assembled chair 20. However, so far as the seat unit 70 itself is concerned, the members 72 and 73 are the ends and the side members 74 and 75 are arcuate or circular sides. As shown in FIG. 18, there need be no members 72 and 73.

Extending from end to end across the two end members 72 and 73 is a plurality of sinuous spring wires 76, 76*a*, 76*b* . . . 76*n*, which are naturally arched into a circular arc of the same size and shape as that of the side members 74 and 75. These springs 76, 76*a*, etc., may have many shapes, some of which are shown in the parent patent applications. They may be of the type often called non-sagging springs and sometimes sold under the trademark No-Sag. Typical wires 76, etc., of this type are of spring steel, having 0.60 to 0.75 percent carbon and 0.90 to 1.20 percent manganese. Tensile strength typically runs about 215,000 to 265,000 p.s.i., and their Rockwell hardness is about 39–41 RC range. The diameter of the wires 76, etc., preferably lies in the range of 0.05 to 0.15 inch. Too thick a wire tends to concentrate the stiffness too much and the seat is too firm, while too thin a wire makes the seat too soft. Some of the wires may have different vibration frequencies than others, and some may be thicker than others, to snub vibration. Some wires may be of different arc-cycle length than others, and some may be of different temper from others, to accomplish this purpose of snubbing vibrations.

Each end 77, 78 of each spring 76 (See FIGS. 6–10) may be firmly anchored to and secured to one of the end members 72, 73 of the rim 71. Various means are employed to achieve this firm anchorage, and some of these are described below in following sections. They include friction grips and welding, among the many types of mechanical connections.

The spring members 76, 76*a*, 76*b*, . . . 76*n* are placed tangent to each other, each of the two extreme spring wires 76 and 76*n* being substantially tangent at each cycle to one of the side members 74 and 75. Each wire 76 touches its adjacent wires at least once per cycle. The touching may be actual contact or it may be approximate touching or close approach, because, as will be seen, the assembly 70 is held together in a way that does not require actual physical contact of the metal at each tangent point, but it is always a very close relationship if not an actual touching.

A thin sleevelike plastic coating 79 surrounds the spring wires 76, follows their sinuous shape, and bridges the wires 76, 76*a*, etc., where they substantially touch each other. Preferably, the plastic coating 79 is about one-half of the wire thickness, or in the range of about one-fifth of the wire thickness to about equal to the wire thickness. At the junctures, the thickness may be mostly greater, though the wires themselves may touch each other. This plastic coating 79 also surrounds the rim 71 and links the wires 76 and the end and side members of the rim 71 together into the unitary assembly 70. The plastic coating 79 holds the wires 76 to each other as they span between the rim ends 72 and 73, and it holds the side wires 74 and 75 to the extreme springs 76 and 76*n* at each point of tangency. The result is the arcuate or cylindrical arc shape, typically like that shown in FIG. 2, although the arc may be somewhat flatter or somewhat rounder.

Thus, the complete assembly 70 is a unit which can be sold or shipped as a unit and can be assembled to the chair 20 of FIG. 1 or to many other kinds of chairs, so long as the proper size and shape is accommodated for in one way or another, that is, either by the chair itself being shaped to go with the seat unit 70 or the seat unit 70 itself made so that it will go with a chair frame or other type of seating unit frame. The unit 70 by itself is capable of mass production, and is easily assembled into a chair or other seating unit by securing the two end members 72 and 73 to a suitable rigid frame.

An Independent Type of Securing Means (FIGS. 3 and 4)

Various securing means may be used, as described in the parent applications. Basically, the securing means may be an integral part of the unit 70, or may be an integral part of the chair frame or other frame to which the unit 70 is to be secured, or it may be an independent member not an integral part of either of these. An example of the last-mentioned type is the securing member 80 shown in FIGS. 3 and 4. This may be a suitable metal or plastic member having a generally tubular rim-receiving portion 81, with an opening 82 therethrough that fits snugly around a rim member 72 or 73. The member 80 has a pair of flanges 83,84 having an opening 85 through them. As shown in FIG. 3, the chair frame member 22 may have a series of openings 86 adapted to receive the two wings 83 and 84, after the member 80 has been fastened around the rim member 72 or 73. Then a suitable screw 87 may be inserted through a suitable opening 88 of the frame member 22 and secured by means of the openings 85 to the wings 83 and 84. As shown in FIG. 1, there may be several of these units 80 to secure the seat unit 70 and the back unit 70A to the chair 20.

From this it will be apparent that the assembly 70 and the assembly 70A may be made as units by one manufacturer and sold to another manufacturer who makes the chair frames. So long as the dimensioning is correct, the two manufacturers need not know precisely what each other is doing, for the unit **70**, if made in the correct dimensions, can be secured to a variety of different types of chair frames, — or to other frames of seating members, for that matter, including benches, automobile frames, and so on. The unit **70** enables the chair manufacturer to secure the seat or back in place in the most attractive and pleasing and most practical way.

As will be seen from later portions of the specification, there are many, many ways in which the fastening of the member **70** to the chair **20** can be done, and this is just one example.

The Significance of Flattening the Cylindrical Arc (FIG. 5)

FIG. **5** shows diagrammatically what happens when the unit **70** of FIG. **2** is put into the chair **20** of FIG. **1.** The round cylindrical arc of FIG. **2** with radius **R1** is flattened from the shape shown at the bottom of FIG. **5** to the shape shown at the top of FIG. **5,** where it has a larger radius **R2.** The unit **70** then has a broader span and its arc is somewhat flattened, so that it can be used as a seat. It has a crown height *h*, shown on the drawing, and it is still a cylindrical arc, though much flatter.

This flattening of a round assembly is an important feature of the invention. By forming the unit **70** initially as a cylindrical arc, which is quite round and fairly well closed, and then flattening it considerably, a large amount of desirable tension is placed into the completed unit **70,** so that the seat has a springy feel to it, acting substantially as though there was a large cushion instead of simply an assembly of thin springs. The exact amount of crown height *h* or of curvature depends, of course, somewhat on taste, but generally there will be about a maximum of 1-inch crown height *h* in a 16-inch wide seating unit **70,** and the proportion is usually best considered as being a crown height *h* of one-sixty-fourth to one-sixteenth of the span.

The amount of force required to flatten a seat of typical dining chair size is important as well. For purposes of the present invention it has been found that a collection of springs in an assembly **70,** requiring a force of between 340 pounds and 680 pounds to flatten it gives a seat of proper tension (preferably around 500 pounds). This is the force exerted in pulling the two ends **72,73** apart to be of an appropriate distance to fit onto the chair frame members **22,23.**

For the chair back, somewhat different rules apply and it will be noticed that in the chair of FIG. **1,** as in most such chairs, the arc of the back extends rearwardly and is not something that the sitter tends to flatten; rather, he tends to increase the arc curvature, reducing its radius.

In both the seat and the back, the tension of the wires pulling inwardly, which results from flattening, is also one of the main forces retaining the wires in place.

Significance of the Plastic Coating **79** (FIG. 17)

The plastic coating **79** may be chosen from various types of plastic, such as polyvinyl chloride, polyvinyl acetate, mixtures thereof, other vinyl compounds, polyethylene, butadiene, acrylic elastomers, and so on. The material may be transparent, where that is desired, or may be opaque and impart its own color to the unit. It may contain dye or pigment which imparts a desired color, completely preventing view of the wires **76** themselves and giving the appearance of constituting the actual seating material. The plastic coating **79** may be semi-transparent and may give shade or tone to the overall color.

It will be noticed that in this invention the plastic is confined to the unit **70** or **70A** and is not applied at all to the chair frame, so that the chair frame may have any surface or treatment that is desired without interference from the nature of the plastic coating.

The sinuous wires **76** are preferably not welded to each other at their points of tangency but are held together only by the plastic coating **79,** with the wires **76** either touching each other or even slightly apart but closely approaching each other. The same is true of the connection between the wires **76** and the arcuate side members **74** and **75** of the rim **71.**

An important feature of the plastic coating **79** is that by choosing the proper range of durometer, a two-way stretch effect can be obtained, as illustrated in FIG. **17.** The springs **76** not only stretch in the well-known manner of non-sagging springs, but also the plastic coating **79** between the adjacent springs **76** may be stretched, and this two-way stretch effect gives a wide range of resilience to the seat. If the plastic **79** is too hard, there can be substantially no such stretch, and if the plastic **79** is too soft, there will be too much stretch, the springs **76** themselves are not properly availed of, and the unit **70** might even be torn apart after short use. By holding the Shore durometer of the plastic coating within critical values, the effect is right, with sufficient rigidity so that the springs **76** are taken advantage of and so that they are held apart with sufficient resilience so that the whole is not simply encased in a rigid covering. I have found that the durometer range necessary to achieve this critical action is from about **45** to about 90 Shore A-scale durometer, with a preferable value of about **75.**

In FIG. **17** there are two portions. The left portion illustrates part of a seat **70** before it is sat upon, with the springs **76** therefore in their normal configuration. A typical area **280** is shown outlined, this area comprising one complete cycle of wires **76,** so that it is representative of the total area of the seat **70** so far as the percentage of metal silhouette per total area is concerned. This area can therefore be used for determining accurately the silhouette of the wire and its average occupation of the seat area. Taking the gauge or wire diameter as G, the length of the wire can be determined in terms of G by measuring the length of the center lines of all the wires **76** in the area **280** in terms of G, and the value is found to be 34G. The area **280** itself measures 14.6G by 10.7G, which is $156.22G^2$. The silhouette area of the wire in the area **280** is $34G^2$, which is 21.76 percent of the area **280.** This value lies within the required range of 17 percent to about 75 percent of the seat area, mentioned earlier, and also within the range of the preferred range of 17 percent to about 25 percent.

Also, the empty spaces between the coated wires should be no greater than about 75 percent and no less than about 2 percent of the area of the seat surface, and the range of about 60 percent to about 75 percent is preferred. The minimum of about 2 percent barely provides sufficient air ventilation.

The wires **76** in the seat **70** lie closely adjacent each other and nearly touch at points of near-tangency, where the distance **D1** between them, as shown in FIG. **39,** may be as low as zero, and where the overall distance from the outside to the outside is **T1.** The plastic coating **79** forms a bridge fastening the wires **76** together at **281** and has a thickness *t*.

The right portion of FIG. **17** illustrates what happens when the seat **70** is stretched, as when it is sat upon. The length L1 in the left portion extends to the longer length L2 in the right portion. The width W1 in the left portion extends also to become the width W2 in the right portion. The distance D1 in the left portion has stretched to become the distance D2 in the right portion, and the distance T1 has stretched to become the distance T2. Thus is seen the importance of the bridge or juncture **281** and of the stretchability of the plastic **79** at this bridge or juncture **281.** This, of course, is related also to the thickness *t* of the plastic coating **79.**

A glance at the seat **70** might lead one to conclude that the surface configuration would be texturally uncomfortable. However, this conclusion would be mistaken, for the seat **70** acts differently than one might at first conclude, for the following reasons:

1. The average occupation by the wire of the typical area (i.e., 17 to 75 percent) is so great that the human posterior is supported without concentrating the load too much. In contrast, if the wire occupies less than about 17 percent of the area (e.g., the 14.4 percent occupation of the FIG. 2 area in U.S. Pat. No. 2,803,293), the seat would be texturally uncomfortable.
2. The empty spaces constitute at least 2 percent of the seat area, in order to give sufficient air ventilation, and preferably occupy much more of the seat area, up to about 75 percent.
3. The wire **76** is not exposed bare metal, which would be highly heat conductive and therefore unpleasant and uncomfortable. The wire **76** is adequately coated with plastic **79** which is low in heat conductivity; so it is pleasant and comfortable to sit upon.
4. The coating **79** lies within the range of Shore A durometers (45–90) where it is neither too hard nor too soft; in fact it tends in itself to provide some cushioning effect, and its action at the bridges **281** adds to the comfort. Without this, the seat **70** could be too hard or too soft.
5. The two-way stretch discussed above provides automatic contouring, offering minimal resistance to the human posterior. Without this two-way stretch, the seat **70** might become increasingly uncomfortable.

Friction Fastening of the Wires to the Rim (FIGS. **6–10**)

While many means of fastening the spring **76** to the rim **71** may be employed, some are naturally preferred above others. The preference depends on many factors, such as manufacturers' capabilities and preferments, specifications given by customers, and various features of cost and capital equipment required.

One desirable type of fastening employs a friction lock principle, shown in FIGS. **6** to **10.** In this form, the rim **71** has end members **72** and **73** that are generally tubular; they may be made as a solid tube, but, preferably, as shown in the drawings, each member **72** or **73** is an open tube that may be made by curling a narrow strip of metal in a generally circular shape. As shown, the member **72** or **73** has a flat bottom portion **90** which is punched through at intervals to provide openings **91** and wings **92** and **93,** extending at an angle such as about 30°. Machines for making these on either a batch basis or on a substantially continuous basis are readily devised, so that the members **72** and **73** may be made as long strips cut into desired lengths.

As will be seen by comparing FIGS. **7** and **10,** the member **73** may be considered as being the same as the member **72,** so that they are reversible; in other words, the same piece may be used in either direction and at either end of the rim. Of course, bending in one direction in reversal is a possibility, but no such reversal or sense of direction is required when the wings **92** and **93** are made as shown.

A series of side openings or slots **94** provide an entryway for the wire end **77** or **78.** The wire end **77** or **78** is inserted in the opening **94** and then moved lengthwise of the member **72** or **73** until it is stopped by engaging one of the wings **92** or **93.** When inserted, the wire **76** depresses the wing **92** (or **93**) under pressure, but when it engages the end of the far wing **93** (or **92**), it can progress no farther. Thus, accurate positioning is assured, and this can be made to provide automatically the desired tangencies of the wires **76** with each other and within the side members **74** and **75** of the rim **71.** Once inserted, the wire end **77** or **78** cannot be retracted, because on retraction, the depressed wing **92** (or **93**) digs into the wire **76** and prevents outward movement. The intention is to prevent any relative movement between the wire end **77** or **78** and the member **72** or **73** after assembly. The wire **76** can move across a depressed wing **92** in the direction toward a stop wing **93** but cannot move back against the wing **92,** once it has been moved in. As shown in FIGS. **7** and **10,** the movement can be in either direction with the same effect exactly; it may be, of course, in opposite directions at opposite ends of the rim **71.** Thus, the wires **76** are locked into the complete assembly by friction in this form of the invention. The plastic coating **79** is applied after this assembly is completed.

Friction Fastening of the Wires to the Rim (FIG. **18**)

In FIG. **18** a frame member **41** is provided with a securing member **42** which is a cylindrical segment, as seen in cross section, and has a main body portion **43** that may be welded to the frame member **41,** a similar one being welded to the opposite frame member, not shown here. A series of projecting tongues **44** is provided; they may be initially bent up and then bent down into place as shown in FIG. **5,** after the wire ends **78** have been approximately positioned so as to lock the wire ends **78** into place firmly by the members **44,** clamping them between the members **44** and the frame **41.** As shown in FIG. **18,** this may extend along a curve, but a straight line is equally possible in the present invention; this is a very important and unique effect of the present invention. It will be seen that with the members **42** welded on the frame members **41,** installation is a relatively simple matter, involving principally flattening out and stretching the arc of the subassembly **70,** anchoring one end of it first and then anchoring the other end. The plastic **79** may cover the ends **77** and **78** or may not, but installation is the same in this instance in both forms. Preferably a plastic bearing block lies below each tongue **44,** preferably being made from plastic that is stiffer in consistency than the coating **79,** and it serves as a cushion preventing the tongues **44** from abrading or cutting through the coating **79.**

The Folding Chair of FIGS. **1, 14** and **15** considered further

FIGS. **14** and **16** show a significant feature of the invention. The seat **26** is crowned upwardly and the back **36** is crowned rearwardly, so that when the chair **20** is folded, the seat **26** can nest within the back **36** as shown in FIGS. **15** and **16.** This enables very compact folding of the chair **20,** so that the thickness of the chair **20,** in a stack of such folding chairs need be no greater than the frame thickness.

Some of the features of the folding chair part are illustrated also in the diagrammatic view of FIG. **16.** This shows that the seat **26** may be curved less than the back **36,** and in most examples this provides a more comfortable chair **20** than if they were curved only to fit each other. The back concavity should be equal to or greater than that of the seat; in other words the radius of curvature of the seat **26** is greater than the radius of curvature of the back **36.** The back **36** may vary from having a radius identical to that of the seat **26,** to a radius no less than half of the radius of the seat **26,** in order to secure both comfort and adequate folding. Of course, when the curvatures are different, the stacking may be somewhat less compact, but this is a disadvantage to be weighed against the other disadvantage of having the seat and back be uncomfortable when sat upon.

In FIG. **16** is illustrated another unique feature of the invention. The seat member **26** has a crown height of between ¼ and 1 inch. When the seat **26** is folded into the back **36,** its under side **27** — as well as its upper surface **28** — fits within the chord **37** of the back **36.** Preferably, the back **36** should have a radius of curvature R3 less than the radius of curvature R4 of the seat crown **26.** The preferred radius R3 is between 11 and 25 inches, and preferred R4 is 33 to 88 inches for 17-inch span.

A Stadium or Theater Seat (FIGS. **11–13**)

FIGS. **11–13** show a seating assembly **100** having a back frame **101** which is secured to a riser **102** that extends up between two floor levels **103** and **104.** The back frame **101** may be permanently welded or removably secured to a metal plate **105** which may be secured to the riser **102** by bolts **106.** Other structures may be used to secure the back frame members **107** and **108** rigidly in place. Of course, the plate-and-riser structure may be replaced by another sort of frame supporting a whole series of chairs, like other theater chairs used on a sloping floor.

The seating assembly **100,** one of many in a series, also includes a seat frame **110,** which may comprise two rigid rods **111** and **112** each separately pivoted to a back member **107** or **108** by a pivot pin **113** or **114.** There may be, but need not be, a rigid member between the rods **111** and **112.**

The back frame **101** supports a back assembly **70A,** and the seat frame supports a seat assembly **70** as before, and FIG. **16** applies to the relationship of the folded structures.

The thinness of the seats and backs of this invention are especially important. Thus, the thickness of the coated wire — which is the seat or back thickness — should be between one two-hundredths and one-fifteenth of the cylindrical arc length of the assembly **70,** i.e., of what is to be the span of the seat or back.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. A folding seating apparatus, including in combination:

a. a first frame having at least two spaced-apart rigid frame portions,

b. a seat assembly having

a series of arcuate, continuous, sinuous wires, each having two ends, each said wire closely approaching each of its immediately adjacent said wires at frequent intervals, and

a thin sleevelike plastic coating surrounding said wires, following the sinuosity of said wires and joining said wires together where they closely approach each other, said approaches being close enough for effective bridging between them by said coating,

whereby said wires and plastic coating comprise a unitary assembly defining a cylindrical arc,

c. first mounting means for securing said seat assembly to said rigid frame portions of said first frame across a space that flattens said arc to a flatter arc and places said seat assembly in tension along the flatter cylindrical arc, which is convex upwardly,

d. a second frame having at least two spaced-apart rigid frame portions,

e. a back assembly having the structure recited for element (b) above,

f. second mounting means for securing said back assembly to said rigid frame portions of said second frame across a space that flattens said arc to a flatter arc which is convex rearwardly, and

g. pivot means connecting said first and second frames together for enabling folding,

said seat assembly when said seating apparatus is folded nesting within said back assembly, with part of the lower surface of said seat assembly lying within the chord across said back assembly.

2. The folding seating apparatus of claim **1** wherein each said assembly (b) and (e) includes

a rim defining a closed area of a cylindrical surface arched in one direction and straight in another direction normal to said arched direction, and having springy flexing action along said arched direction,

said series of sinuous wires each being positively anchored at opposite ends to said rim and extending across said rim in a generally circular arc parallel to the arching of said rim, the longitudinal axes of said wires being parallel to each other, and

said thin sleevelike plastic coating surrounding said rim, linking said wires to said rim in a unitary assembly shaped as a cylindrical arc having a curvature of less radius than that desired in said seat or back.

3. The folding seating apparatus of claim **2** having means for mounting said rim on said frame members, and for flattening said wires somewhat to place the wires in tension along said flatter cylindrical arc.

4. The folding seating apparatus of claim **1** having mounting means separate from said coating for securing said assemblies (b) and (e) to respective fixed locations of their respective said rigid frame portions (a) and (d), thereby preventing relative sliding movement of said wires therealong, said frame portions being so spaced apart that installation flattens said arc to a flatter arc and places each assembly (b) and (e) in tension.

5. The folding seating apparatus of claim 4 wherein said mounting means comprises means for anchoring each of said wires adjacent their ends, the tension under which the wires are placed helping to retain them in place.

6. The folding seating apparatus of claim 5 wherein each said mounting means engages the actual wire ends to prevent movement of the two ends of each said wire toward each other.

7. The folding seating apparatus of claim 4 wherein said wire ends lie in the same arc as the remainder of their wire.

8. The folding seating apparatus of claim 7 wherein said mounting means comprises a member having transversely outwardly extending tongues to which said wire ends are engaged, said tongues being bent down over said wires.

9. The folding seating apparatus of claim 8 wherein said mounting means is an integral portion of said frame, said tongues being bent out portions of said frame.

10. The folding seating apparatus fo claim 1 wherein said second frame is adapted to be secured to a riser on a rigid structure.

11. The folding seating apparatus of claim 10 wherein a plurality of said second frames are attached to a single riser.

12. The folding seating apparatus of claim 1 wherein the seat crowns to a height above the ends of one sixty-fourths to one-sixteenth of the seat width.

13. The folding seating apparatus of claim 1 wherein said first frame is curved and said seat is attached to the frame curve and is imparted a compound curvature.

14. The folding seating apparatus of claim 1 wherein the wires in the seat lying closest to the forward edge of the chair are of lighter gauge than the wires of the seat in the central portion thereof, thereby imparting increased comfort.

15. The folding seating apparatus fo claim 1 wherein some of said wires have a different vibration frequency from other wires, in order to dampen bounce.

16. The folding seating apparatus of claim 15 wherein some of the wires are of different thickness than others, to afford the bounce dampening to said assembly.

17. The folding seating apparatus of claim 15 wherein some of the wires are of different configuration and arc-cycle length than others, to afford the bounce dampening.

18. The folding seating apparatus of claim 15 wherein some of the wires are of different spring temper from others, to afford the bounce dampening.

19. The folding seating apparatus of claim 1 wherein said plastic coating is stretchable.

20. A folding chair, including in combination:

a. a first frame having at least two spaced-apart rigid frame portions and two legs, one attached to each of said frame portions,

b. a seat assembly having

a series of arcuate, continuous, sinuous wires, each having two ends, each said wire closely approaching each of its immediately adjacent said wires at frequent intervals, and

a thin sleevelike stretchable plastic coating surrounding said wires, following the sinuosity of said wires and strechably joining said wires together where they closely approach each other, said approaches being close enough for effective bridging between them by said coating,

whereby said wires and plastic coating comprise a unitary assembly defining a cylindrical arc,

c. first mounting means for securing said seat assembly to said rigid frame portions of said first frame across a space that flattens said arc to a flatter arc and places said seat assembly in tension along the flatter cylindrical arc, which is convex upwardly,

d. a second frame having at least two spaced-apart rigid frame portions and two legs, one attached to each of said frame portions,

e. a back assembly having the structure recited for element (b) above,

f. second mounting means for securing said back assembly to said rigid frame portions of said second frame across a space that flattens said arc to a flatter arc which is convex rearwardly, and

g. pivot means operatively connecting said first and second frames together, the legs being operatively connected to their respective frames and to each other, thereby enabling folding of said chair,

said seat assembly, when said chair is folded, nesting within said back assembly, with part of the lower surface of said seat assembly lying within the chord across said back assembly.

21. The folding chair of claim 20 wherein said coating constitutes the sole means holding the wires of said seat and back assemblies together.

22. The folding chair of claim 21 having mounting means separate from said coating for securing each said assembly to respective fixed locations on their respective said rigid frame portions and thereby preventing relative sliding movement of the wires along said frame portions, said frame portions being so spaced apart that installation flattens said arc to a flatter arc and places the assembly (b) in tension, whereby resilience for seating comfort is obtained both by the arcing and tensioning of said wires and by the stretchability of said coating where it bridges between said wires.

23. The folding chair of claim 20 wherein said assembly comprises

a rim defining a closed area of a cylindrical surface, arched in one direction and straight in another direction normal to said arched direction, and having springy flexing action along said arched direction,

said series of sinuous wires each being positively anchored at opposite ends of said rim and extending across said rim in a generally circular arc parallel to the arching of said rim, the longitudinal axes of said wires being parallel to each other,

said thin sleevelike stretchable plastic coating surrounding said rim, stretchably linking said wires to said rim in a unitary assembly shaped as a cylindrical arc having a curvature of less radius than that desired in said seat or back.

24. The folding chair of claim 23 having means for mounting said rim on said frame members, and for flattening said wires somewhat to place the wires in tension along said flatter cylindrical arc.

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