United States Patent [19]

Rowland

[11] **3,774,967**

[45] **Nov. 27, 1973**

[54] **SEATING AND SUB-ASSEMBLY FOR SEATS AND BACKS**

[76] Inventor: **David L. Rowland,** 49 W. 55th St., New York, N.Y. 10019

[22] Filed: **July 3, 1972**

[21] Appl. No.: **268,870**

Related U.S. Application Data

[62] Division of Ser. No. 126,808, March 22, 1971, Pat. No. 3,720,568.

[52] **U.S. Cl.** **297/445,** 160/404, 267/111, 297/456, 297/453

[51] **Int. Cl.** **A47c 7/00,** A47c 7/14

[58] **Field of Search**......297/56–57, 445, 452, 457; 267/111; 5/353, 354; 160/403, 404

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Primary Examiner—Casmir A. Nunberg
Attorney—Robert E. Wickersham

[57] **ABSTRACT**

Seats and backs for chairs and other seating units are made as a sub-assembly of sinuous spring wires. For example, a rim, typically having straight ends joined by usually parallel sides shaped as circular arcs, encloses, and its straight ends are attached to, the opposite ends of each of a series of the sinuous spring wires, which extend between them in a circular arc paralleling those of the rim sides. Each of the two extreme spring wires is preferably tangent at each cycle to one of those sides, and each wire touches its adjacent wire at least once per cycle. A thin sleevelike plastic coating surrounds the wires and follows their sinuous shape. It also surrounds the rim and links the wires and the rim together and links the wires themselves together wherever they touch, into a unitary assembly shaped as a cylindrical arc and intended to be flattened somewhat when installed on a chair frame, to place the springs in tension along a flatter cylindrical arc. The ends serve to mount the assembly on the frame, and the parallel sides enclose the springs and minimize their catching on clothing, while the tension provides one of the main forces retaining the assembly in place. In preferred forms of the invention the plastic coating has an A-scale Shore durometer between 45 and 90, so that the assembly is held together by the plastic coating without substantially restraining the flexing of the spring wires, while the coating also provides a spring action itself between the adjacent wires, by stretching and contracting, giving a two-way stretch.

30 Claims, 53 Drawing Figures

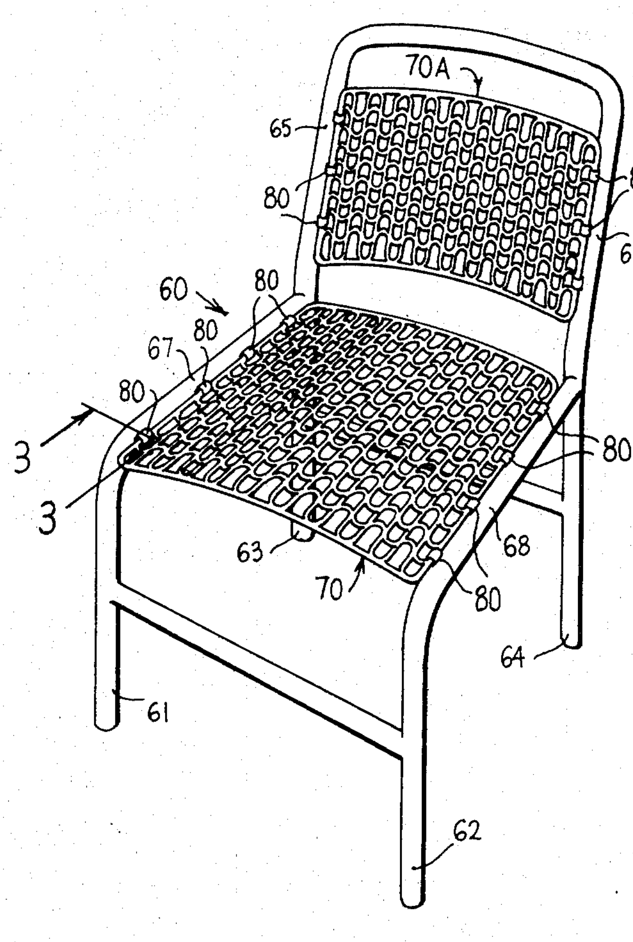
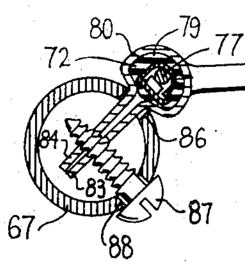


FIG. 3



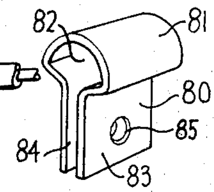


FIG. 4

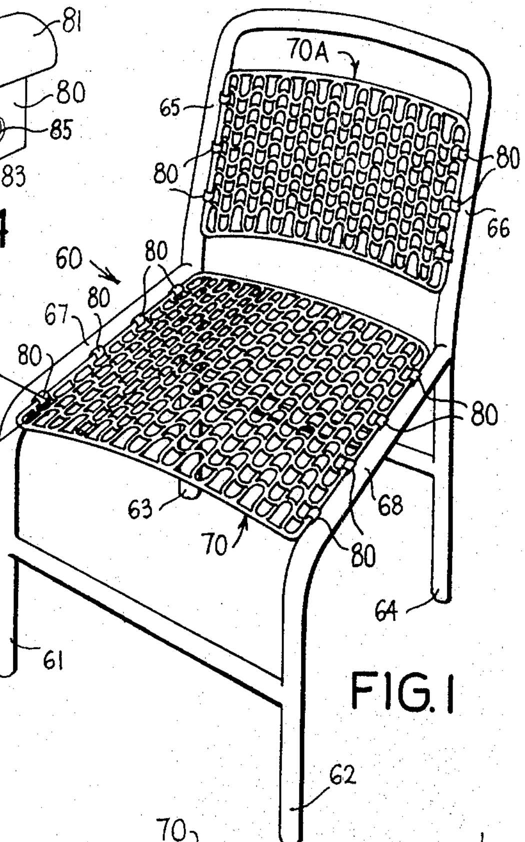


FIG. 1

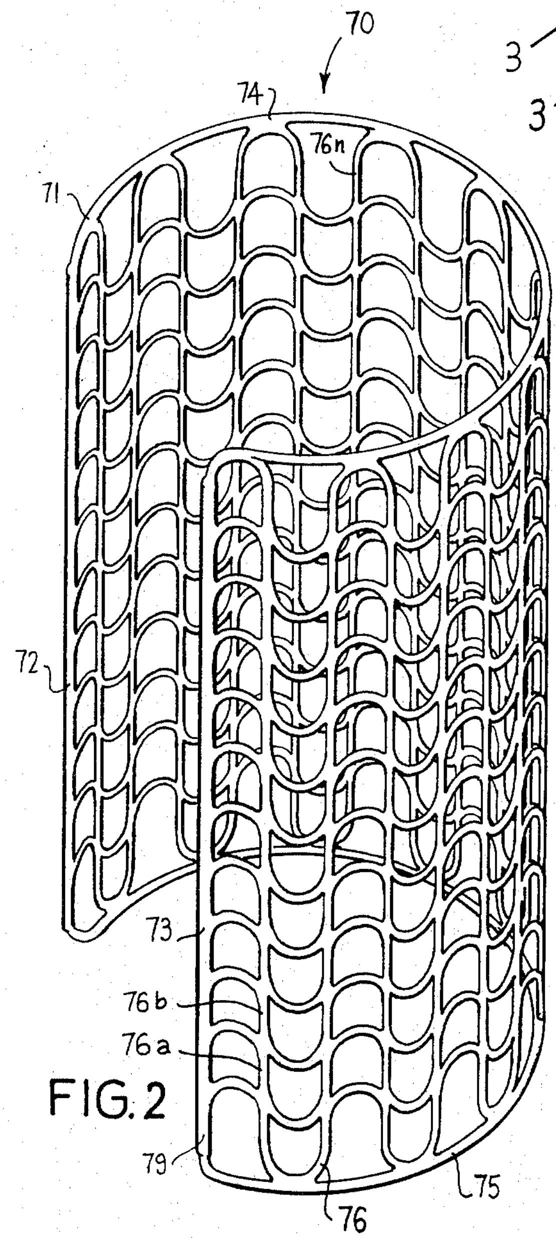


FIG. 2

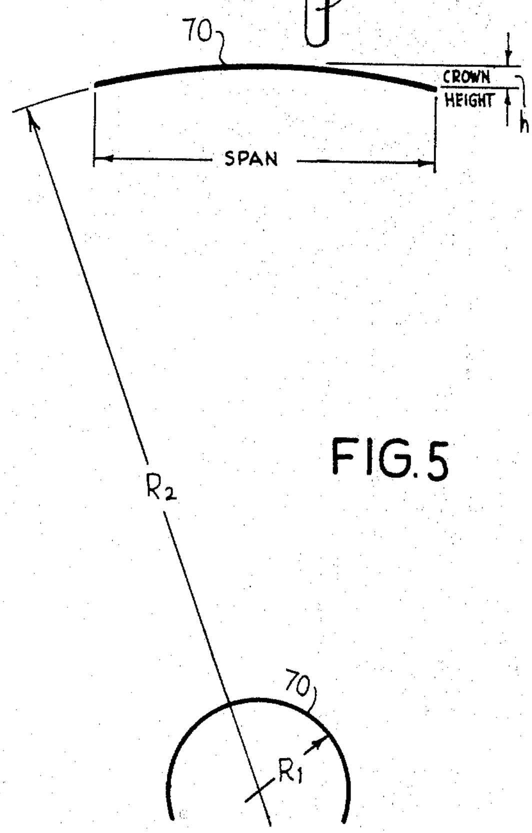


FIG. 5

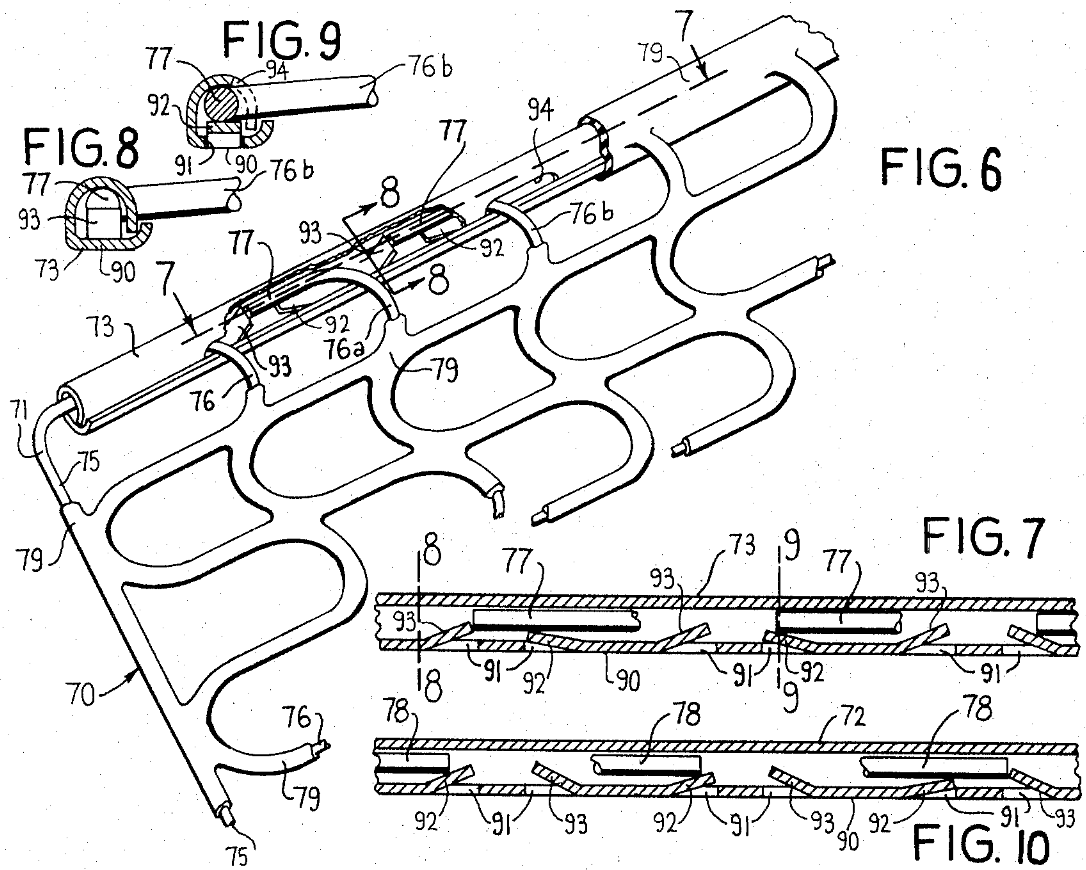
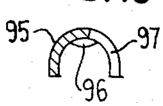


FIG. 13



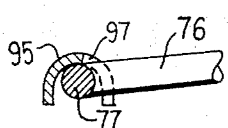


FIG. 12

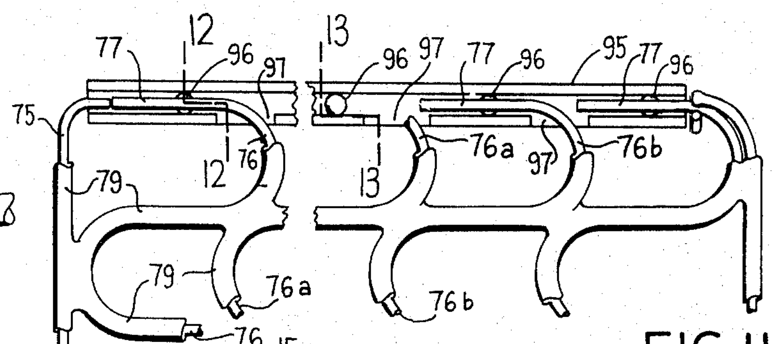
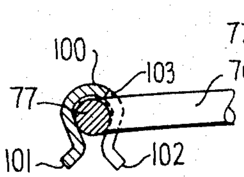


FIG. 11



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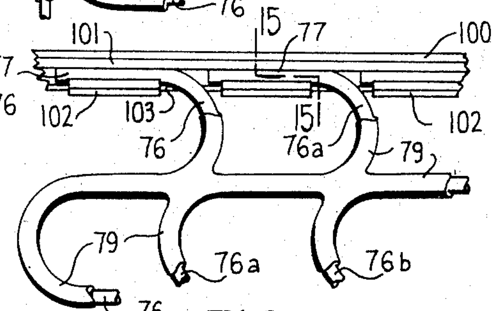

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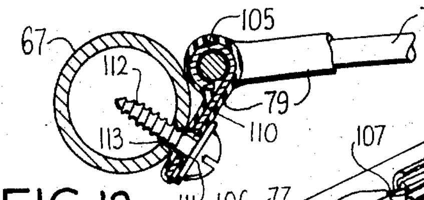


FIG.18

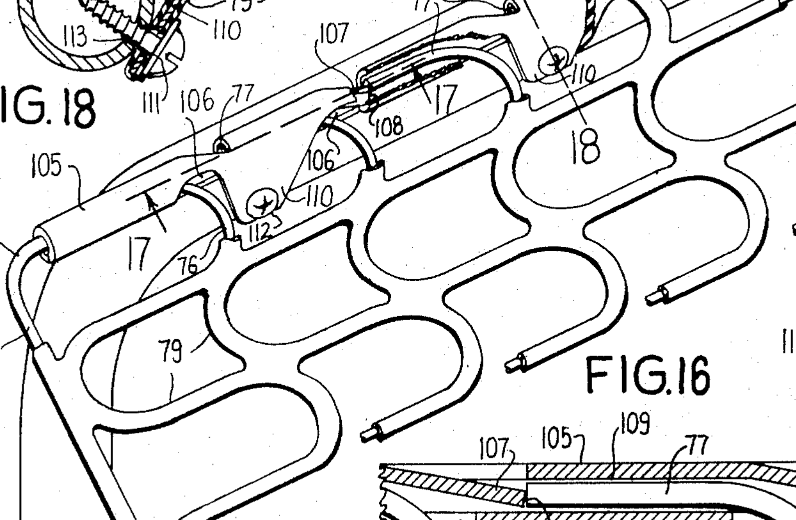
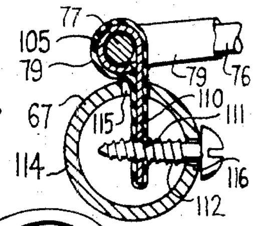


FIG.16



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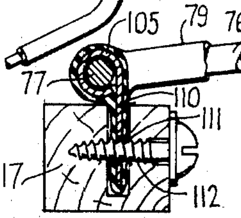
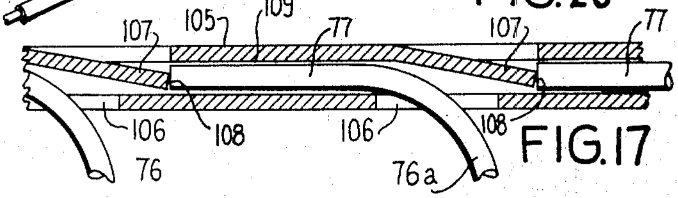


FIG.20



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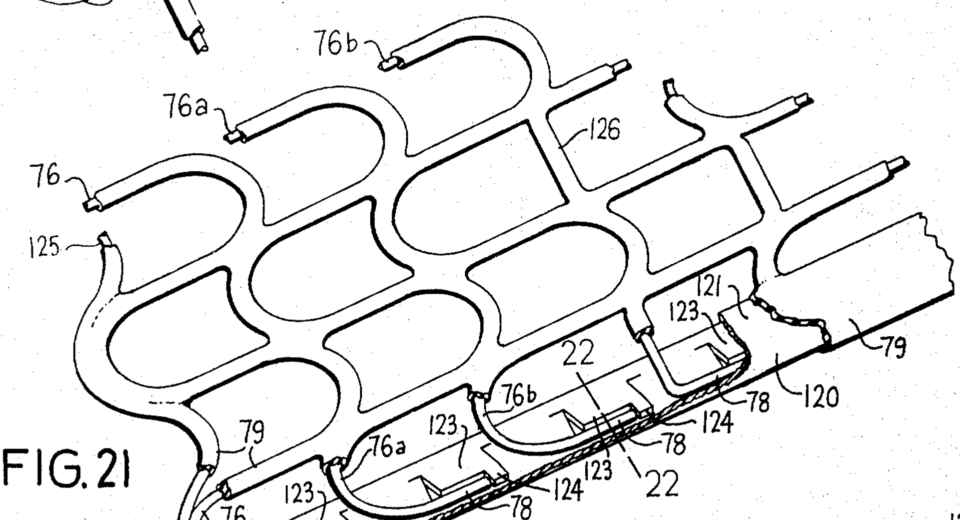

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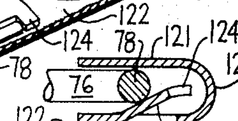

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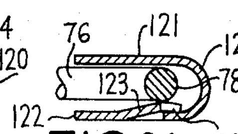

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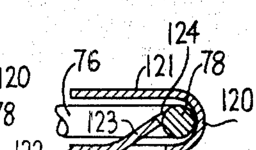
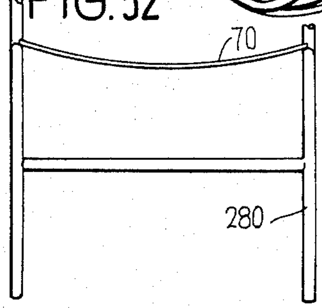


FIG.22

FIG.52



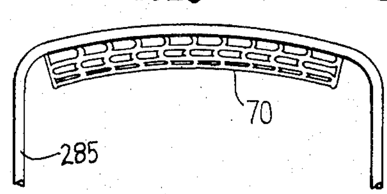
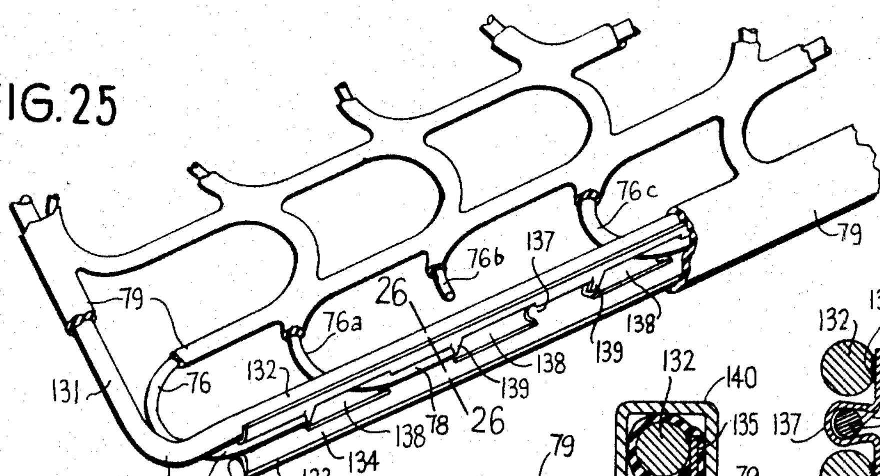
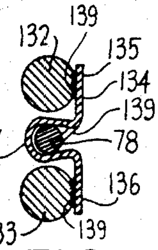


FIG.53

FIG. 25





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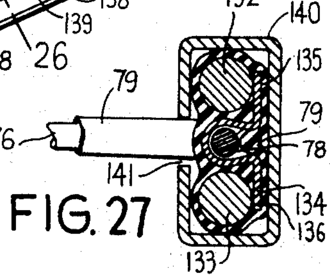
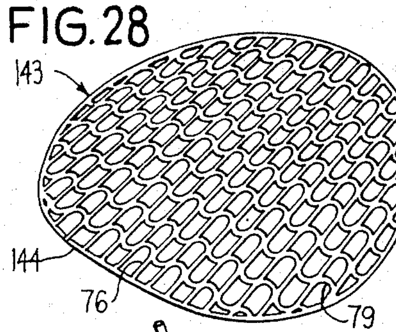


FIG. 27

FIG. 28



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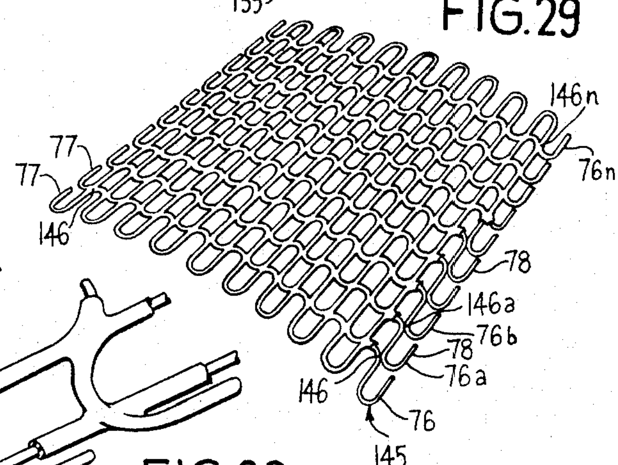


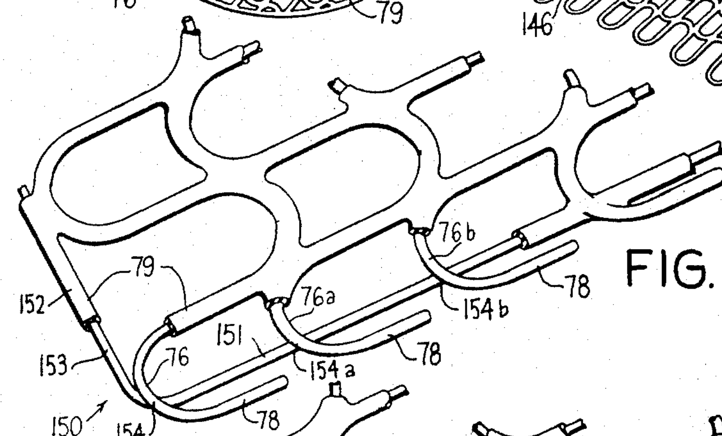


FIG. 30

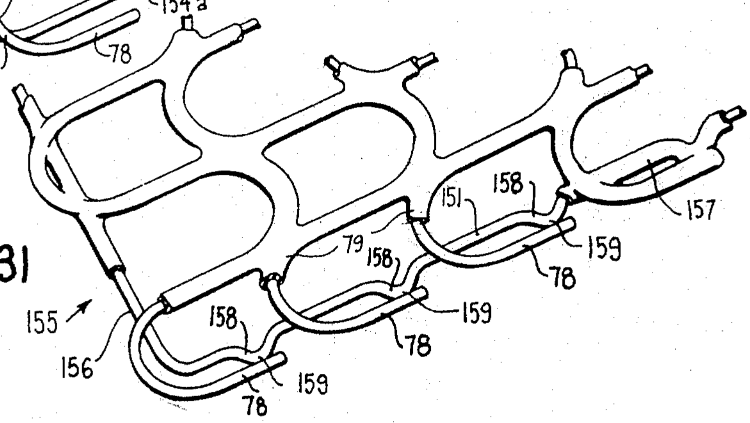


FIG. 31

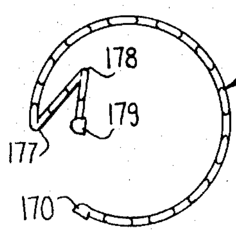
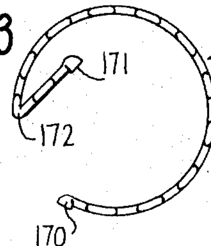


FIG.35

FIG.33



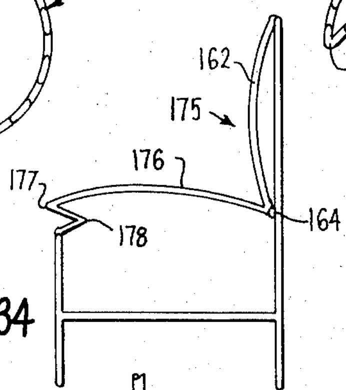
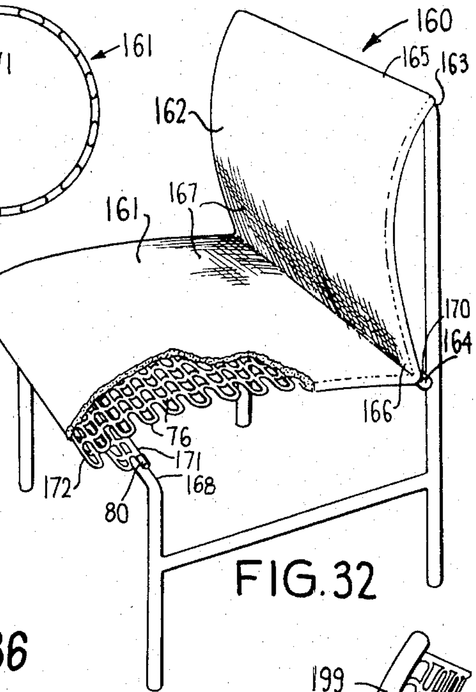


FIG.34



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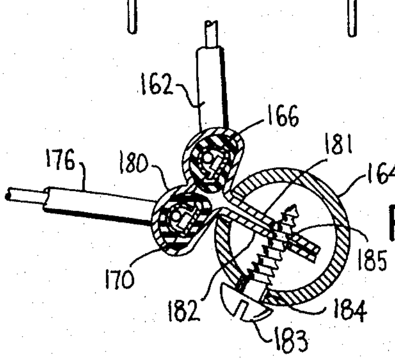

FIG.36

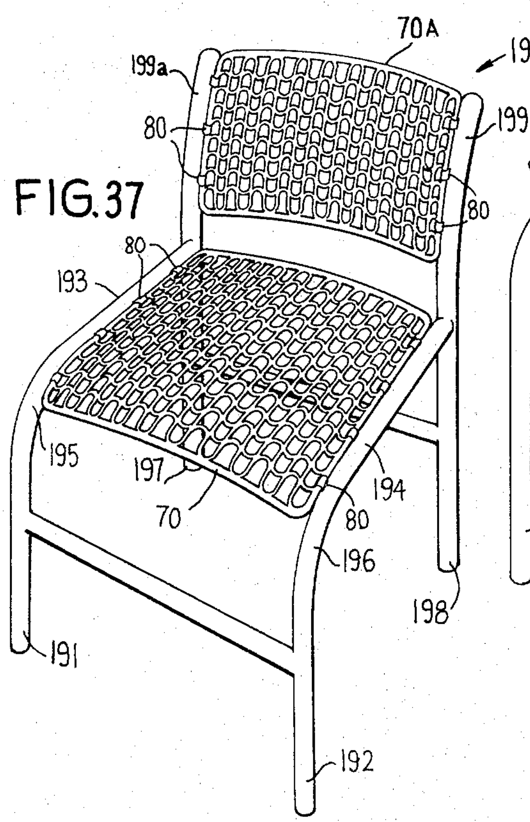

FIG.37

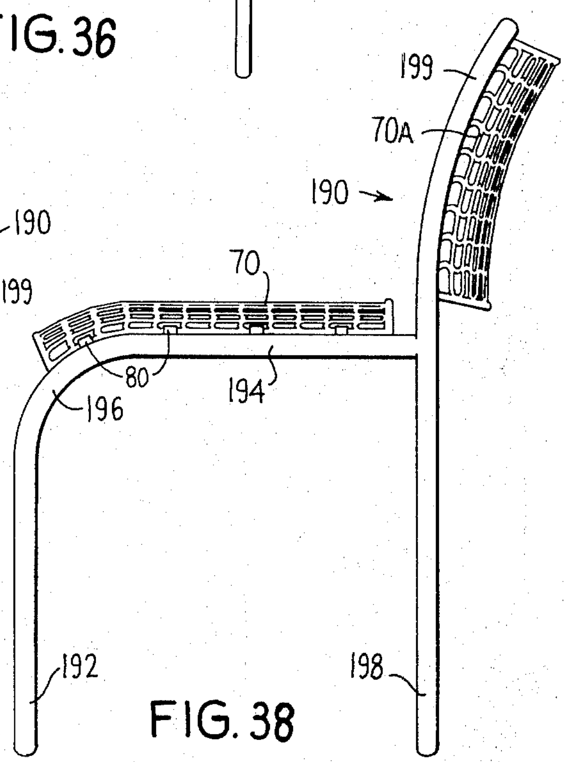

FIG.38

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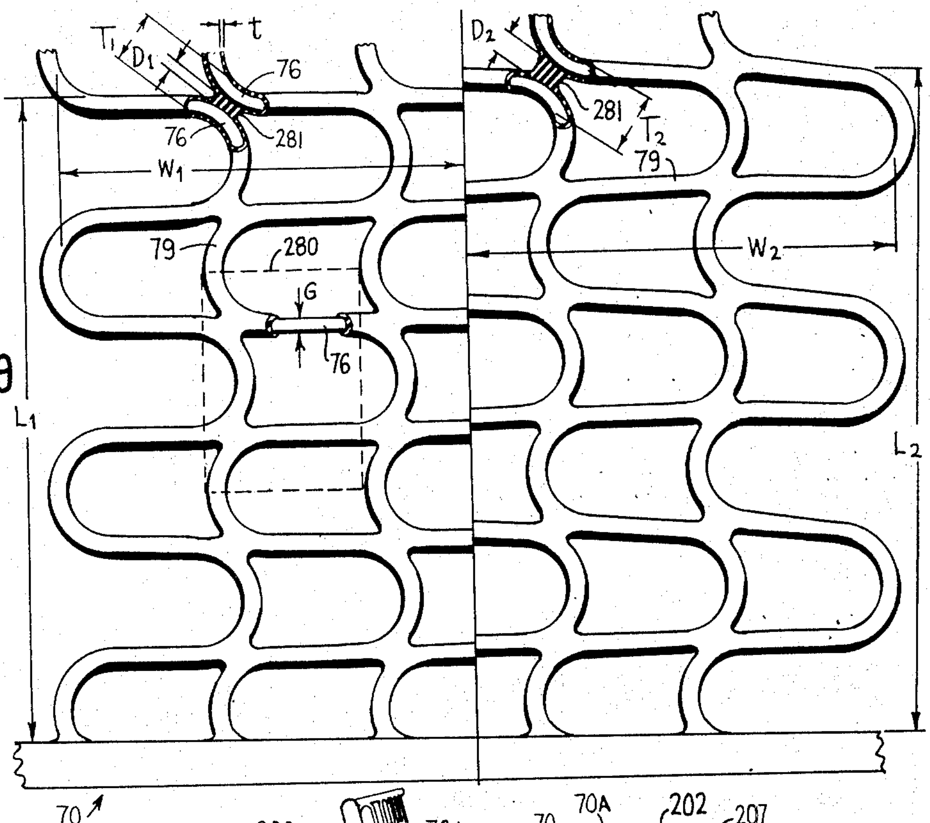


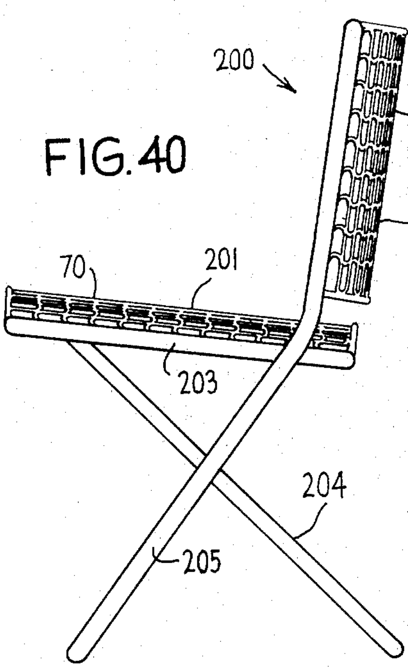


FIG.40

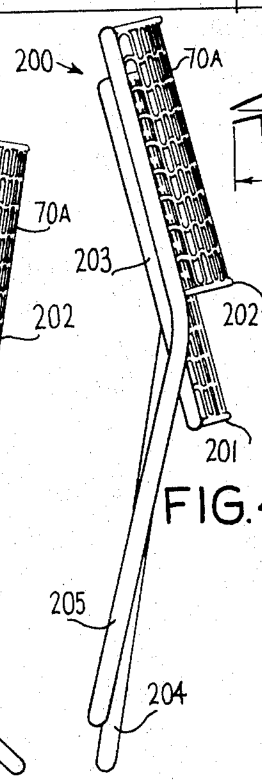


FIG.41

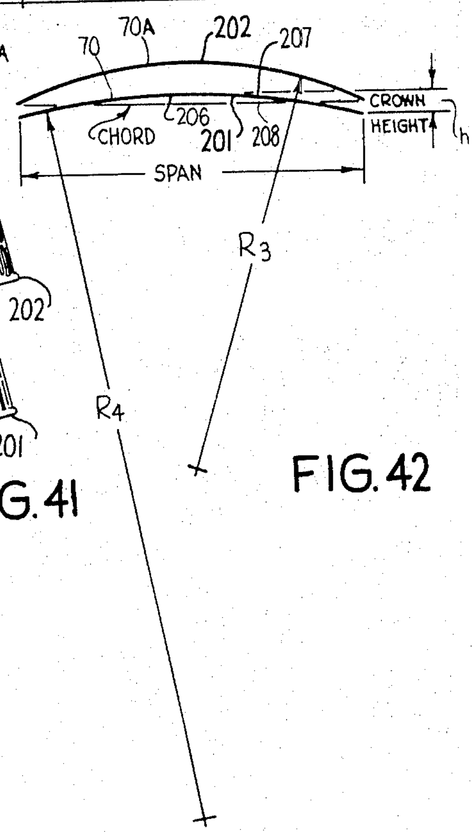


FIG.42

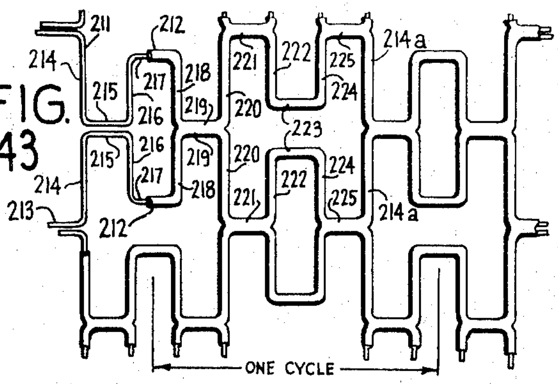


FIG. 43

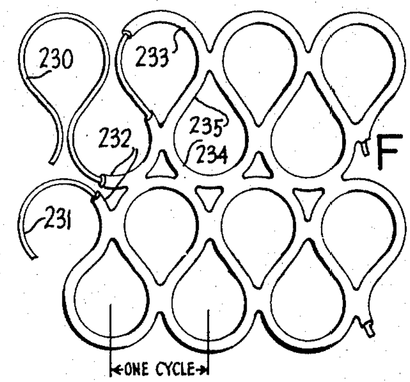


FIG.44

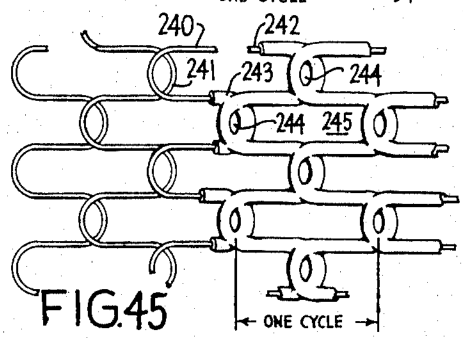
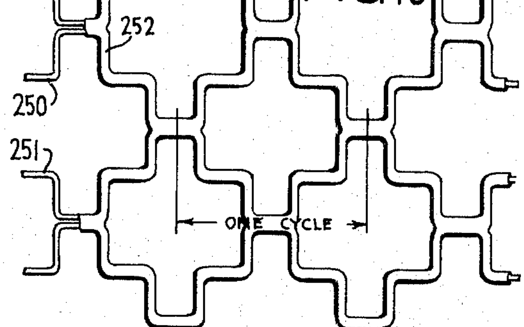


FIG.45

FIG.46



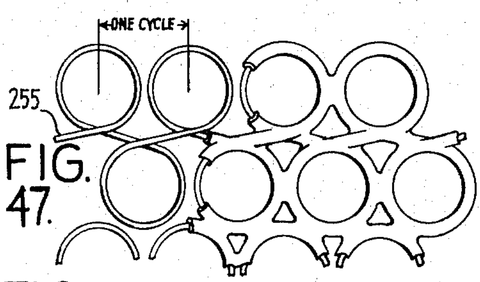


FIG. 47.

FIG.48

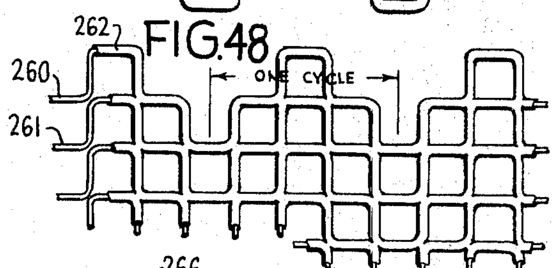
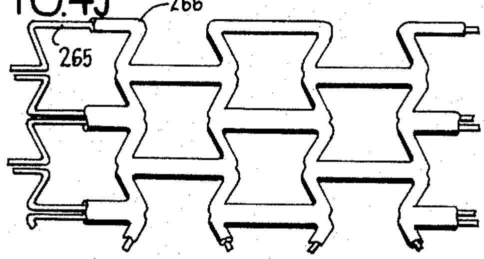


FIG.49



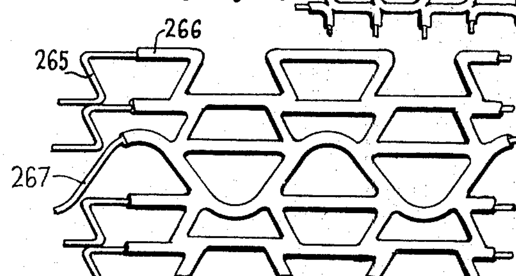


FIG.50

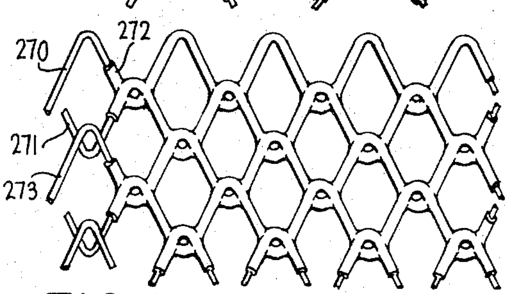


FIG. 51

SEATING AND SUB-ASSEMBLY FOR SEATS AND BACKS

This is a division of application Ser. No. 126,808, filed Mar. 22, 1971 now U.S. Pat. No. 3,720,568.

BACKGROUND OF THE INVENTION

This invention relates to an assembly for seats and backs, usable in chairs, sofas, stools, benches, automobile and other transportation seating, and the like. The seat and back units are sub-assemblies applicable to any of various types of frames to provide seating assemblies embodying the invention.

A hard seat can, at best, only approximate a comfortable shape, since human posteriors vary greatly. While seats theoreti-cally might be tailor-made for each individual, this would be costly and would require carrying seats to whereever they would be used. A seat which automatically tends to shape itself to each user's posterior is a better solution to the problem. A seat with proper resilience in the right places is thus an object of this invention.

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 inch to 2 inches 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 curvature).
2. Proper resilience and firmness (resilience provides shape adaptability to each sitter).
3. Proper heat dispersion.
4. Proper surface contact area.

An object of this invention is to provide a seat more nearly approaching the ideal than has been achieved in the past.

Each unit or sub-assembly 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. In addition, however, each unit or sub-assembly of this invention is secured together at or near the ends of the spring wires, either by a rim or by welding them to each other or to another member.

The invention may be considered as an improvement over my earlier U.S. Pat. No. 2,803,293. In that patent each of the sinuous springs had a hook on each end which partially encircled a rigid frame member. This hooking did not positively prevent movement of the wires relative to the frame, nor did it hold them in proper position relative to each other prior to their being coated with plastic. Partly because there was only line contact at best between the wire and the frame (and unless the chair frame size was exactly matched with the size of the hook, there would be contact at only two points), the hook tended to rotate when subjected to force, as when someone sat on the chair. Even after the chair had been coated with plastic, this instability was such that when the chair was being sat upon, the wire hooks tended to walk along the chair frame as the sitter shifted his position, thereby distorting the seat area, with the result of making the seat uncomfortable. The chair of that patent was expensive to manufacture because the springs had to be put on individually, carefully positioned, and then either the entire chair had to be dipped, or at least the upper portion of the chair, from the seat up, had to be dipped. Such dipping meant that all parts of the chair that were dipped would be coated with plastic unless something could be put on some parts of the chair to repel the plastic. Either alternative added substantially to the cost. Also, the coating dulled the appearance of chrome metal furniture, and wood furniture was given a rather unpleasing appearance. Each chair had to be made individually, and the springs themselves had to be put on to a full chair frame individually, so that easy handling required by mass production was not possible. Also, great care had to be taken that the springs themselves were not distorted by the spring manufacturer during his manufacture; otherwise, the springs could not be properly bridged across by the plastic.

These difficulties are overcome in the present invention, which makes mass production quite feasible. Only the seat unit or back unit is dipped, and assembly is relatively inexpensive, and its manufacture is capable of automation and other mechanical aids. A very important feature is the provision of a sub-assembly capable of use on a wide variety of frames for different kinds and designs of seating units. The same sub-assembly may be sold to various manufacturers for incorporation into any of a wide variety of frames.

Another disadvantage of my prior chair 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 the 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 coating, and also the spring assembly can flex and stretch the plastic when it bridges the wires. In the prior patent, it was possible to use a wide variety of materials, including hard plastics such as nylon, which would certainly hold the wires together but would not itself stretch, so that all the stretch had to be accomplished by the wires when such a material was used. This would give the seat some yieldability, but usually in a cylindrical surface, rather than in the compound curve which results in a seat that has two-way stretch. Nor was this two-way stretch recognized or found in this type of chair until a desired range of durometers was discovered in the present invention and used in proper relationship to suitable gauges of wires and so enabled achievement of this goal.

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. For example, in the drawings for U.S. Pat. No. 2,803,293, it can be shown that the metal occupies only about 14 percent of the silhouette of the area, whereas I have now 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 insulation, 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 seat or back sub-assembly which can be secured to various frames in various manners. Basically, the sub-assembly is a cylindrical segment, later flattened somewhat upon installation, placing the springs in tension. Usually, but not always, it has a rim, which usually has straight ends, typically parallel, joined by parallel sides which are made as circular arcs. These frames enclose a series of sinuous spring wires, each of which is attached at its opposite ends to the rim, preferably the end members. The wires extend between the rim ends in a circular arc that 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 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 seven to eleven 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 sub-assembly.

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 my earlier patent 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 1/18 part of seat height) and, at most about 3 inches (about 1/6 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 percent of the seat area, especially of a typical area. For sufficient bridging, heat insulation, 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 alone; it also needs the rubber, air, and hydraulic fluid in the combination of rubber-pneumatic tires and hydraulic shock absorbers, before it can be comfortable.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a view in perspective of a 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 fragmentary bottom plan view of a portion of a modified assembly of the general type of FIG. **2**, with some portions broken away.

FIG. **12** is a view in section taken along the line **12—12** in FIG. **11**.

FIG. **13** is a view in section taken along the line **13—13** in FIG. **11**.

FIG. **14** is a fragmentary bottom plan view in section similar to FIG. **11** of a modified form of rim member.

FIG. **15** is a view in section taken along the line **15—15** in FIG. **14.**

FIG. **16** is a fragmentary view in perspective of a chair frame.

FIG. **17** is a further enlarged view in section taken along the line **17—17** in FIG. **16**, omitting the chair frame.

FIG. **18** is a further enlarged view in section taken along the line **18—18** in FIG. **16.**

FIG. **19** is a view similar to FIG. **18** showing installation of the same unit assembly on a modified form of chair frame.

FIG. **20** is another view similar to FIG. **18** showing installation of the same unit assembly on another modified form of chair frame.

FIG. **21** is a fragmentary view in perspective and partly in section of another modified form of unit assembly.

FIG. **22** is a view in section taken along the line **22—22** in FIG. **21.**

FIG. **23** is a view in section similar to FIG. **22** showing the same parts at an early stage of assembly.

FIG. **24** is another similar view showing a stage of assembly intermediate between FIGS. **22** and **23.**

FIG. **25** is a fragmentary view in perspective of another form of unit assembly.

FIG. **26** is a view in section taken along the line **26—26** in FIG. **25.**

FIG. **27** is a similar view in section of the unit of FIG. **25** fastened to a chair frame.

FIG. **28** is a view in perspective of a modified form of unit assembly having a round rim and shown flattened to the position it assumes when fastened to a chair frame.

FIG. **29** is a view in perspective of yet another modified form of unit assembly, wherein the rim is eliminated and the springs secured together by a series of welds, the parts being flattened to the arc they assume when secured to a chair frame.

FIG. **30** is a fragmentary view in perspective of a portion of a further modified form of unit assembly.

FIG. **31** is a view like FIG. **30** of an additional modified form of unit assembly.

FIG. **32** is a view in perspective of a modified form of chair embodying the principles of the invention.

FIG. **33** is an end view of the unit assembly for the seat of a chair like that of FIG. **32.**

FIG. **34** is a view in side elevation of another modified form of chair embodying the principles of the invention.

FIG. **35** is an end view of the unit assembly for the seat of a chair like that of FIG. **34.**

FIG. **36** is a fragmentary view in section showing how the seat assembly and back assembly are both fastened to a single frame member in the chairs of FIGS. **32** and **34.**

FIG. **37** is a view in perspective of a modified form of chair embodying the principles of the invention, wherein the seat and back assembly are so mounted to a frame as to provide compound curved surfaces.

FIG. **38** is a view in side elevation of the chair of FIG. **37.**

FIG. **39** is an enlarged top plan diagrammatic view in two halves illustrating the two-way stretch effect of the wires and plastic assembly.

FIG. 40 is a view in side elevation of an opened folding chair embodying the principles of the invention.

FIG. 41 is a view in side elevation of the folding chair of FIG. 40 in folded position.

FIG. 42 is a diagrammatic view of the relative arcs and radii of back and seat for the chair of FIG. 40.

FIGS. 43 to 51 are all top plan fragmentary views of various patterns of the arcuate sinuous members, in each instance with portions of the wire shown uncovered and with plastic linking the spring members together. Various patterns are shown as illustrative of the many, many more that are possible in this invention.

FIG. 52 is a view in front elevation of the lower portion of a modified form of chair embodying the principles of the invention.

FIG. 53 is a view in side elevation of a stool embodying the principles of the invention in another modified form.

DESCRIPTION OF SOME PREFERRED EMBODIMENTS

An Example of a Chair Embodying the Invention (FIG. 1)

Many, many types of seating units may embody the principles of this invention, including chairs, sofas, davenports, benches, stools, automobile seats, bus seats, camp chairs, and so on.

A chair **60** 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 seating units or even all types of the 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.

The chair **60** has front legs **61, 62** and rear legs **63** and **64** which continue up, preferably at an angle, to form back frame portions or members **65** and **66.** The number of pieces used in making the chair frame is immaterial to this invention, and whether the frame is continuous or pieces are welded or otherwise secured together does not matter, so far as the present invention is concerned. Horizontal side frame portions or members **67** and **68** join the front legs **61** and **62** to the rear legs **63, 64** where they meet the back frame members **65** and **66.** 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 **67** and **68** apart and for holding the frame members **65** and **66** apart. In this particular form of the invention the back frame members **65** and **66** are rigidly held parallel to each other and the side frame members **67** and **68** are rigidly held parallel to each other. This parallelism need not always be present, but it is preferred.

A seat unit **70** is supported by the side frame members **67** and **68** and a back unit **70A** is supported by the frame members **65** and **66.** The seat unit **70** and the back unit **70A** are very similar to each other; they 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 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 Seat Unit 70 (FIG. 2)

FIG. **2** shows the seat unit **70** before it is incorporated into the chair; 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. 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 **67** and **68** of the chair, and thus extend from front to rear at each side of the chair **60,** while the side members **74** and **75** become the front and back edges of the seat in the assembled chair **60.** 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.

Extending from end to end across the two end members **72** and **73** is a plurality of sinuous spring wires **76,** *76a, 76b*. . . *76n*, 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,** *76a*, etc., may have many shapes, some of which are shown in FIGS. **43** to **51.** 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 percent to 0.75 percent carbon and 0.90 percent 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 inch 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.

Each end **77, 78** of each spring **76** (see FIGS. **6–15**) is 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,** *76a, 76b*,. . . . *.76n* are placed tangent to each other, each of the two extreme spring wires **76** and *76n* 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,** *76a*, 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 **60** 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 are discussed in this specification, some of them being shown for example in FIGS. **16** through **20,** and in FIGS. **26** and **27,** among others. 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 in 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 **67** may have a series of openings **86** adapted to receive the rwo 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 **67** 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 **70**A to the chair **60.**

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 **60** 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 **60** 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 R**2.** 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 one inch crown height *h* in a sixteen-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 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 **67, 68.**

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. 39)

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 **70**A 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. **39.** 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. **39** 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. **39** 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 percent 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 further. Thus, accurate positioning is assured, and this can be made to provide automatically the desired tangencies of the wires **76** with each other and with 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 invention 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.

Resistance Weld Securement of the Rim and Spring Wires (FIGS. 11 to 13)

FIGS. **11** through **13** show the use of a rim end member **95** with an inverted channel or U shape and having resistance weld protrusions **96** against which the wire ends **77** or **78** are moved. An entrance opening **97** for the wire **76** is provided. Various stop means may be employed, or the stop may simply be provided by the machine which inserts the spring wire **76** through the opening **97** into the inverted channel member **95**. In any event, the spring wire end **77**, once inserted, is held in position temporarily while the resistance weld is made, so that the protrusion **96** in effect becomes part of the spring wire **76** and the spring wire **76** part of the channel **95**, holding the rim and wire together as a single piece. The resistance welds may be made one at a time or may be made for a whole end member **95** at once, or for both ends at once. In this form of the invention, then, the assembly **70** is held together, not only by the plastic coating **79**, but also by being welded at its ends. The plastic coating **79** is, of course, applied after the welding.

A Snap Fastening (FIGS. 14 and 15)

In the structure shown in FIGS. **14** and **15**, a snap-in type of friction holding is employed. In this instance a rim member **100** has a spring-like structure, being shaped as a channel with springy lips **101** and **102** that lie closer together than the thickness of the wires **76**. While typically metal, the member **100** may be made from plastic. The lips **101** and **102** are spread apart when the spring wire **76** is inserted from the lower end, with the aid of a side slot **103**. Once inserted, the wire end **77** is snapped into place and cannot be retracted, but is held by the rim lips **101** and **102**. Stops may be provided by slight punchings or dimples that limit the course of the wire end **77**, or this may be completely unnecessary due to the use of holes or openings **103** which prevent more than limited movement of the wire **76**, being just large enough to allow insertion of the spring wire end **77** into the rim **100**. The assembly is again dipped in plastic **79** after this.

Another Friction Lock and Securement of the Unit to a Chair Frame (FIGS. 16-20)

FIG. **16** shows how a tubular rim end member **105** of metal or plastic is formed to provide a series of holes **106** to receive the ends **77** or **78** of each spring wire **76**. Approximately opposite and longitudinally apart from the holes **106** the tube **105** is formed to provide wings **107** while providing stops **108**, limiting movement of the spring wire ends **77** within the tubular member **105**. The tube interior **109** may fit snugly around the wire end **77**, and there may be no other friction retention means other than this. FIG. **17** shows that the tube **105** makes a smooth friction fit with a wire end **77** so that the wire end **77** is held by friction against going back and forth and engages the end **108** of the succeeding wing **107** to prevent further movement and to act as a stop. The plastic coating **79** helps to prevent relative movement between the tube **105** and wire **76**. There may be some additional means, such as welding if desired.

The tubular end member **105** of FIG. **16** is also shown as having depending ears **110** with an opening **111** through which suitable screws **112** or bolts or rivets may pass to secure the unit **70** to the chair frame member **65**, **66**, **67**, or **68**. For example, as shown in FIGS. **16** and **18**, a screw **112** may simply pass through the ear **110** into an opening **113** in a tubular metal frame member **67**.

FIG. **19** shows another way in which the same rim member **105** can be used. In this case, a tubular metal chair frame member **114** has been provided with top openings **115** to receive the complete ear **110**, and a screw **112** is put in from the side of that member **114**, passing through an opening **116** and the opening **111** in the wing **110** and holding it there.

A similar way is shown in FIG. **20** of employing the same rim member **105** with a wooden chair frame member **117** with the screw **112** passing through the wood into the opening **111**. Various other means of securement may, of course, be used.

A Flattened Type of Rim With a Friction Lock (FIGS. 21-24)

Another way of securing the spring wires **76** to the rim **72** is shown in FIGS. **21** through **24**. Here is shown a flattened channel rim end member **120** of metal or plastic, with an upper flat portion **121** and a lower flat portion **122**. The wire end **78** is held in position by friction by a wing **123** partly punched out and bent up from the lower portion **122**. The wire end **78** is also held against a stop **124** in the rim end member **120**. Thus, the friction holding wing **123** and the stop **124** are both provided by a series of partly punched bent-out members having the stop portion **124** of greater depth than the wing **123**. The action is shown in FIGS. **22** through **24**, FIG. **22** representing the final position, in which the wire end **78** is passed over the retaining wing **123** and cannot go back. FIG. **23** shows first the insertion, and FIG. **24** shows the pressing and flattening of the wing member **123** during the passage over it, leading to the locking action of FIG. **22**.

FIG. **21** also shows a modified form of rim side member **125**. The rim member **125** is not straight like the side members **74** and **75**, but is itself an arcuate sinuous member. In this instance, it has a different form from that of the wires **76** and is substantially a sine curve which fills in a major portion of the recess in the wire **76** that otherwise would exist unfilled; therefore, although sinuous in form, the rim member **125** does not leave the large projections exposed which would be exposed if the member **125** were not there. Instead, the projections exposed are relatively short and do not tend to catch on clothing. The whole is again coated with the plastic **79**.

FIG. **21** also shows a sinuous wire **126** that is different in length and shape from the other wires **76**. The function of the wire **126** is to introduces a member with vibration characteristics different from those of the wires **76, 76***a* etc. The effect of this introduction is to provide bounce dampening, a feature usually found necessary in transportation seating. The wires **76, 76***a* etc., characteristically having one vibration frequency are attached in the assembly to the wire **126** which has a different vibration frequency, and thereby the assembly **70** has its bounce characteristics strongly modified, if not totally eliminated.

Another Form of Rim and of Attachment to the Spring Members (FIGS. 25–27)

The forms which the rims may take are practically infinite. FIG. **25** shows a corner portion of a rim **130** in which one side member **131** is continuous with a portion **132** of the end member, which may define the complete rim end member. Another member of the same metallic wire type is shown at **133** parallel to and spaced from the member **132**, along each side member **131**. The two are held together by resistance-welding each of them at **139** to a third rim end portion **134**. The rim end portion **134** has two flat portions **135** and **136** which abut the members **132** and **133**, and between these it has an open-end tubular portion **137** to receive the wire end **78** through a series of openings **138**. The members **78** are slipped through the openings **138** and into the interior of the portion **137** and are pushed to the stop **139**. Then the composite, held together by the springiness of the members, is dipped in the elastomer **79**. After dipping, the assembly may be slid into a hollow frame member **140** which may be an integral part of the chair or seat frame and which has a continuous slot **141** through which the wires **76** extend. Note that the wires **76***c*, etc., are larger than the wires **76***a* and **76***b*. This enables the use of heavier wires where the main seating pressure is and lighter wires at the forward edge where too stiff wires can cause discomfort. It also provides bounce dampening by putting wires of different vibration frequency adjacent to each other in the assembly.

A Sub-Assembly of This Assembly Having a Round Frame (FIG. 28)

While the rectangular type of rim, like the rim **71**, is usually the most desirable, that is not always the case. It may be made in a trapezoidal shape or in other shapes. As an example of which can be done, an assembly **143** is shown in FIG. **28**. The assembly **143** has a round, that is, generally circular rim **144**, which is continuous and which is secured, as by welding, to a series of spring members **76**, etc. After the securement, the assembly is dipped in elastomer or plastic to form the completed assembly **143**. The plastic **79** again joins the wire spring members **76** together and again helps to enforce their attachment to the rim **144** and to surround it, although the attachment is adequate without that. The positive securing together is by direct welding, in this instance, of any suitable type, whether of spot welding, projection welding, or whatever. Although the rim **144** is circular, it should not be though of as being a flat circle. It is again made in the same general cylindrical shape as that in which the unit **70** is shown in FIG. **2**, but the assembly **143** has been spread out and somewhat flattened, but not completely, in FIG. **28** to show how it looks when mounted on a chair frame, but from this it should be gathered and should be remembered that the entire assembly is again a cylindrical segment of which the ends may almost meet until they are flattened.

A Rimless Assembly of the Invention (FIG. 29)

FIG. **29** shows an assembly **145** of the invention in which there is no rim member whatever. The wire members **76, 76***a*, **76***b*, . . . **76***n* are also secured together close to their ends, but in this instance, not at them, by a series of resistance welded joints **146, 146***a*, . . . **146***n*. This securing is only at one place along each end. This provision of a metal weld joining together the wires, in this instance in two places, one near each end but somewhat spaced from it, is again a firm attachment. Since all the members **76, 76***a*, etc., have the same arcuate curve, they are easily kept as a unit in the general form as shown in FIG. **2**, the illustration in FIG. **29** showing the assembly **145** flattened out as it would be in an installed seat.

In this instance, the wires **76, 76***a*, **76***b*,. . .**76***n* have free ends **77** and **78**, which may be installed in attachment members provided in the chair frame itself, or there may be members that will clamp these to the chair frame, or other attachments may be used. The assembly as a whole, after welding, is dipped in the plastic to provide the coating **79** of the wires **76** and to provide the links between the various wires.

It will be seen that, in this instance, the series of welds **146, 146***a*. . .**146***n* plus the wires **76, 76***a*. . .**76***n* in effect provides what is substantially a rim, but it is a peculiar rim, in that it is really made up of a series of segments of the wires **76, 76***a*, etc., which are in line with each other and with the weld joints **146**. But, the unit **145** is an assembly before it is installed on the chair frame. It can be shipped as an assembly and it is held together by a very strong metal means, as well as by the plastic **79**.

An Assembly Welded to a Straight-Wire Rim (FIG. 30)

A portion of an assembly **150** is shown in FIG. **30** in which the wire **76, 76***a*, **76***b*, etc., are welded to a straight end portion **151** of a rim **152** having side portions **153**. The welds are at the locations **154, 154***a*, **154***b*, ... The wire ends **78** are shown here lying outside the rim member **151**, and they may be used for fastening or they may be cut off, if that is desired, and the fastening then be by the rim portion **151**. The same cylindrical shape of the unit **150** is intended to be implied as in the previous drawings, for the assembly **150** is again substantially a cylindrical segment which must be flattened out when it is installed on a chair frame. The entire assembly **150** is coated with plastic **79** after the welding has been completed.

Another Form of Assembly with the Springs Welded to the Rim (FIG. 31)

An assembly **155** shown in FIG. **31**, has a rim **156** with an end portion **157** and side portion **158** shown. The rim **156** may be continuous. The portion **157** is provided with a series of projecting portions **158** to which wire ends **78** are welded at junctures **159** by any suitable welding means. The rim **151** comprises a welded structure, and after welding the whole is again coated with the plastic **79**.

A Modified Form of Chair (FIGS. 32 and 33)

FIG. **32** shows a chair **160** incorporating a seat assembly **161** and a back assembly **162**. The back assembly **162** is substantially like the assembly **70**A, with two exceptions. In the first place, the frame members **163** and **164** to which it is secured, extend horizontally rather than being vertical; the second exception is that the assembly **162** has end rim members **165** and **166**, and these, of course, extend horizontally so that they can be secured to the frame members **163** and **164**, but, in this particular instance, by way of example, there are no side rim members corresponding to the members **74** and **75** of the assembly **70** in FIG. **2**. Instead, the wires **76** are free at each side. Since they are at the sides of the chair, they are less likely to catch on clothing, and they may be left in their natural state. Also, the intention here is to cover them with fabric **167**, so that they are not truly exposed and do not present even that apparent hazard.

The seat member **161** is basically like the member **162** for the back, but has an important difference. The similarities are that the wires are free at each side, that the seat is covered with fabric, and that it has end members **170** and **171** which are secured to chair frame members **168** and **164**. The difference is that a bend **172** is provided, which is a sharp bend spaced from but relatively near the rim member **171**. This bend **172** functions (1) to give the chair in its fore-and-aft seating pattern, which obviously differs from the side-to-side pattern of the chair shown in FIG. **1**, a resiliency at the front which is extremely desirable, and (2) also an accentuated curve at the front end which makes the chair more comfortable than it would be if this were absent.

Another Fore-and-Aft Chair Seat Arrangement (FIGS. 34–36)

A chair **175** is shown in FIG. **34** having a seat assembly **176** and a back assembly **162**, like that of the chair **160**. The difference between the seat assembly **176** and the seat assembly **161** is that the seat unit **176** has what is sometimes called a "fishmouth" construction with two bends **177** and **178** adjacent a forward edge **179**. The rear end rim member **170** is the same as in the chair **160**. The fishmouth structure gives additional springiness and comfort and is considered desirable by some manufacturers.

FIG. **36** shows how the rim members **170** and **166** can be secured to the single horizontal frame member **164**, with the aid of a clip **180** which receives both of these members and has a pair of ears **181** and **182** that are secured to the frame member **164** by a screw **183** extending through an opening **184** in the frame member **164** and through an opening **185** in the ears **181** and **182**, approximately at right angles to the screw **183**. The attachment is similar to that already shown in a previous drawing, except that here both the seat **176** and the back **162** are simultaneously attached. It will be noted also that in this instance, the back member **162** is arched forwardly rather than rearwardly, this being because of the use of the two parallel suspensions, both being horizontal instead of vertical.

A Chair With A Compound Curve (FIGS. 37 and 38)

A chair **190** is shown in FIGS. **37** and **38**. This chair makes use of the same assemblies **70** and **70**A already discussed for the seat and the back. The difference in this chair is that the frame is so constructed that a compound curve is formed in the back and in the seat. Thus, the front legs **191** and **192** merge into side frame members **193** and **194** by relatively wide radius curve portions **195** and **196**, and the rear frame members **197** and **198** also have upper portions **199** and **199*a*** that are curved. The result is, that when the seat assembly **70** is installed, it has a front portion which is curved in the direction of the chair frame, while at the same time it is arched across between the frame members **193** and **194**, and the same is true of the back member. The compound curves give added comfort through more appropriate contouring. Straight portions at the front edge of a chair are likely to cut into the legs and to be uncomfortable, and a curved portion eases that part and eliminates the sharp cutoff, insofar as the sitter is concerned.

A Folding Chair Embodying the Principles of the Invention (FIGS. 40–42)

A folding chair **200** is shown in FIGS. **40** and **41**, having a seat **201** and a back **202**, which may be made from units **70** and **70**A embodying the principles of the invention. The folding chair **200** has a pair of side frame members **203** that support the seat **201**, a pair of rear leg members **204** extending to the front of the chair **200**, and a pair of front leg and back frame members **205** that support the back **202**.

FIGS. **40** to **42** show a significant feature of the invention. The seat **201** is crowned upwardly and the back **202** is crowned rearwardly, so that when the chair **200** is folded, the seat **201** can nest within the back **202** as shown in FIG. **41**. This enables very compact folding of the chair **200**, so that the thickness of the chair **200** in a stack of such folding chairs need be no greater than the frame thickness.

This feature of compact stackability is also applicable in a non-folding but compactly stackable chair (Cf. U.S. Pat. Re. No. 26,071) wherein seats nest compactly over seats, and backs nest compactly into backs.

Some of the features of the folding chair part are illustrated also in the diagrammatic view of FIG. **42**. This shows that the seat **201** may be curved less than the back **202**, and in most examples this provides a more comfortable chair **200** 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 **201** is greater than the radius of curvature of the back **202**. The back **202** may vary from having a radius identical to that of the seat **201**, to a radius no less than half of the radius of the seat **201**, 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. **42** is illustrated another unique feature of the invention. The seat member **201** has a crown height of between ¼ inch and 1 inch. When the seat **201** is folded into the back **202**, its under side **206**

— as well as its upper surface **207** — fits within the chord **208** of the back **202**. Preferably, the back **202** should have a radius of curvature R3 less than the radius of curvature R4 of the seat crown **201**. The preferred radius R3 is between **11** and **15** inches, and preferred R4 is **33** to **88** inches for a 17-inch span.

Some of the Many Patterns of Wire Possible in This Invention (FIGS. 43 to 51)

A substantially infinite number of wire patterns is possible under this invention. The one shown heretofore with the wire **76** is a very good pattern but it is not the only good one that can be used. Patterns can be used for their structural features, because of manufacturing convenience, or because of design features. Some of these features will appear from the selected forms shown, and in all of them it will be seen that the wires, whether in parallel pattern or alternate patterns, touch each other at least once per cycle; the touching may be flush to each other in the same plane, or may be by an overlap of planes with the unit still having substantially the same plane.

FIG. **43** shows a wire **211** with vinyl covering **212** and an adjacent wire **213** with vinyl covering **212** also on it. The wires **211** and **213** are bent in the same pattern but are set to alternate, so that one is rotated 180° relative to the other; instead of each wire **211** being strictly parallel to its adjacent wire **213**, their sinuosities are reversed, and the alternating effect is obtained. Alternation can give some interesting designs, such as the one shown here. The length of the one cycle has been marked on the drawing, and it will be seen that the cycle is rather long, partly due to the alternation and partly due to the wire pattern itself. Thus, the wire **211**, starting from the left-hand end, has a long vertical portion **214**, then a horizontal portion **215** succeeded by a short vertical portion **216**, then a horizontal portion **217** preferably the same length as the portion **215**. The portion **217** is followed by a portion **218** identical in length to the portion **216** and then leading to another portion **219** which is parallel to and in line with the portion **215** and is again of the same length. The portion **219** is followed by a portion **220** that is longer than the portions **216** and **218** and equal in length to the portion **214**, therefore raising the wire **211** up to a new level. This is succeeded by a horizontal portion **221** of the same length as the portion **215** and parallel to it but displaced from it. This in turn is succeeded by a short portion **222** the same length as the portion **218** but starting from a different place, so that the succeeding portion **223** is not in line with the portions **215** and **219**. Another portion **224** equal in length to the portion **222** is followed by a portion **225** in line with and equal in length to the portion **221**, and this is followed in turn by a portion **214***a* identical to the portion **214** and beginning a new cycle.

The wire **213** adjacent to the wire **211** has the same pattern but is reversed, so that the wires **211** and **213** touch at the portions **215** and **219**. The wires **211** and **213** touch the other wires to which they are adjacent at the portions **221** and **225**. These touching portions in this instance extend for the whole width, and the plastic coating **212** covers these portions as well as the individual wires.

FIG. **44** shows a wire **230** having a sinuous shape and and adjacent identical wire **231** both of them being covered by a plastic **232**. The length of one cycle is in this instance much shorter. The wire **230** has a flaring portion that describes what are nearly two circles **233** and **234**, with the radii displaced, and these near-circles **233** and **234** are joined by a smooth connecting curve **235**. Again the pattern is interesting, and the structural effects substantially the same as what have already been described.

FIG. **45** shows a wire **240** which is made in a sinuous pattern not unlike the wire **76**. The adjacent wires are overlapped so that the wire **240** lies over a wire **241** and beneath a wire **242**, and the plastic covering **243** joins all the wires. This pattern provides a small opening **244** through the overlaps and a large opening **245**. This makes an interesting pattern, is another way of forming the assembly, and shows that the wires do not have to actually abut or lie in the identical plane.

FIG. **46** shows a wire **250** with an adjacent wire **251** and with a plastic covering **252**. Another type of square-wave pattern is shown giving a different pattern, and again the length of the cycle is shown.

FIG. **47** shows another form of pattern. In this case, a wire **255** actually overlaps itself with a succession of circles, so that no one wire actually lies in a single plane, but there is, of course, substantially a planar configuration. The successive wires abut each other.

FIG. **48** shows another square wave configuration with steps down and up, with wires **260, 261**, etc., and plastic coating **262.**

FIGS. **49** and **50** show an angular configuration and two different uses of the same wire **265** and coating **266.** In FIG. **49** the adjacent wires are reversed to make big spaces in between, while in FIG. **50** the successive wires are parallel, to make trapezoids that are (in each row) alternately inverted. The effects are different but use the same wires. Note also that in FIG. **50** an additional wire **267** is used; this wire **267** is of different length and shape and therefore of different vibration frequency from the wires **265** and so provides a snubbing action against bounce.

FIG. **51** shows overlapped wires **270, 271** covered by a coating **272** which fastens the wires **270** and **271** together, with one wire **270** going under its adjacent wire **271**, which in turn goes under its adjacent wire **273**, and so on.

These are only examples of what can be done. Countless other patterns are possible.

SOME OTHER EMBODIMENTS

FIG. **52** shows the lower portion of a chair **280** having an assembly **70** serving as a seat but inverted with respect to FIG. **1.** While generally not preferable, this structure is quite usable. Here there is a simple trough shape; i.e., the seat **70** is concave instead of convex.

FIG. **53** shows a stool **285**, with legs broken off, having a spring seat made by an assembly **70** installed to provide double curvature, a concave arc bent into an upper or convex arc as seen from the side. This seat **70** was installed on the frame of the stool **285** in a manner similar to that illustrated in FIG. **37.**

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 1/200 and 1/50 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.

What is claimed is:

1. A seating apparatus, including in combination:

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

b. an assembly having

1. 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,

2. fastening means firmly securing said wires adjacent their ends and positively preventing relative movement of the wires to said fastening means, and

3. a thin sleevelike plastic coating surrounding said wires and said fastening means, 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, fastening means, and plastic coating comprise a unitary assembly defining a cylindrical arc, and

c. mounting means for securing said assembly to said rigid frame portions across a space that flattens said arc to a flatter arc and places said assembly in tension.

2. The seating apparatus of claim 1 wherein said frame supports two said assemblies, one for a seat and one for a back.

3. The seating apparatus of claim 2 wherein said seat arches upwardly from side to side and back arches rearwardly from side to side.

4. The seating apparatus of claim 3 wherein the wires extending across the front of the seat are of thinner gauge than the wires in the remainder of the seat.

5. The seating apparatus of claim 3 wherein the seat compresses 1 inch to 3 inches when sat upon by a 150-pound person.

6. The seating apparatus of claim 3 wherein the seat crowns to a height above the ends of 1/64 to 1/16 of the seat width.

7. The seating apparatus of claim 2 wherein in each said assembly said wires occupy a silhouette area of about 17 percent to about 75 percent of the area of their assemblies.

8. The seating apparatus of claim 2 wherein said seat arches upwardly from front to rear and said back arches forwardly from bottom to top.

9. The seating apparatus of claim 8 wherein said frame has a horizontally extending member to which the rear edge of said seat and the bottom edge of said back are both secured.

10. The seating apparatus of claim 8 wherein said frame is curved and said assembly is attached to the frame curve and is imparted a compound curvature.

11. The seating apparatus of claim 2 wherein the seat arches downwardly.

12. The seating apparatus of claim 1 wherein some of the wires are of different vibration frequency from other wires.

13. The seating apparatus of claim 12 wherein some wires are of different thickness from others.

14. The seating apparatus of claim 12 wherein some wires are of different arc-cycle length from others.

15. The seating apparatus of claim 12 wherein some wires are of different temper from others.

16. The seating apparatus of claim 1 wherein the wire diameter lies in the range of 0.05 inch to 0.15 inch.

17. The seating apparatus of claim 1 wherein the coating thickness is from about 20 percent to about 100 percent of the wire thickness.

18. The seating apparatus of claim 1 wherein the empty space between the coated wires occupies between 2 percent and 75 percent of the area of said assembly (b).

19. A chair or the like comprising

a rigid frame with two spaced-apart frame members, and

an assembly useful as a seating or back member, said assembly comprising

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,

a series of sinuous spring wires each 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, each said wire very closely approaching its adjacent said wires at least once each cycle,

a thin sleevelike plastic coating surrounding each said wire and following its sinuous shape and bridging two wires wherever they closely approach each other and also surrounding said rim, linking said wires together and 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, and

means for mounting said rim on said frame members, and for flattening said springs somewhat to place the spring wires in tension along a flatter cylindrical arc.

20. The chair or the like of claim 19 wherein there are two said assemblies, one for a seat and one for a back, both mounted on said frame.

21. The chair or the like of claim 20 wherein the arc of said seat arches upwardly from side to side of said frame and said back arches rearwardly from side to side to said frame.

22. The seating apparatus of claim 21 wherein the wires in the seat lying closest to the forward edge of the chair are of lighter gauge than the remaining wires of the seat.

23. The chair or the like of claim 20 wherein said seat arches upwardly from front to rear and said back arches forwardly from bottom to top.

24. The chair or the like of claim 23 wherein said seat and back are covered with upholstery.

25. The chair or the like of claim 23 wherein the forward end of said assembly has a sharp bend, so that said assembly extends forward of the frame member to which that end is secured.

26. The chair or the like of claim 25 having a double bend, with the second bend lying rear of the frame member to which that end is secured.

27. The chair or the like of claim 23 wherein a single frame member is secured both to the rear edge of said seat and to the lower edge of said back.

28. The seating apparatus of claim 20 wherein said frame is curved to impart compound curves to both said seat and said back.

29. The chair or the like of claim 19 wherein one surface of said assembly is completely covered with a pad.

30. The chair or the like of claim 19 wherein the thicknesses of the seat and back areas are no less than 1/200 and no more than 1/50 the height of the seat level.

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