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Takada

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[54] WOVEN FABRIC FOR SAFETY BELTS OF HIGH ENERGY-ABSORBENCY

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[21] Appl. No.: 304,190

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[63] Continuation-in-part of Ser. No. 78,774, Oct. 7, 1970, abandoned.

[30] Foreign Application Priority Data

Jan. 2, 1972 Japan 474480

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[51] Int. Cl. D03d 15/00, D03d 11/00
[58] Field of Search ..... 139/383 R, 420 R, 426 R, 139/408–415; 280/150 SB; 297/385

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[57] ABSTRACT

A safety belt web is a woven fabric band including nylon warp threads and warp threads of lesser elongation than the nylon threads, the nylon warp threads being disposed outside the low elongation warp threads so that the latter is unexposed and the low elongation threads are under tension in the relaxed web and advantageously linear. The elongation properties and amount of low elongation warp threads are such that their maximum elongation does not exceed 20 percent, at a total web tension of about 500 kilograms.

In one form of the belt web, top and bottom sets of warps and a filler which alternately interweaves successive upper and lower warp groups form top and bottom woven webs, the longitudinal lines of the filler transfer points dividing the space between the upper and lower webs into longitudinal passageways along which extend core threads of less elongation and less weave crimp than the warps. The core threads may be formed of similar filaments or of filaments having different elongation to load characteristics and are preferably linear.

12 Claims, 7 Drawing Figures

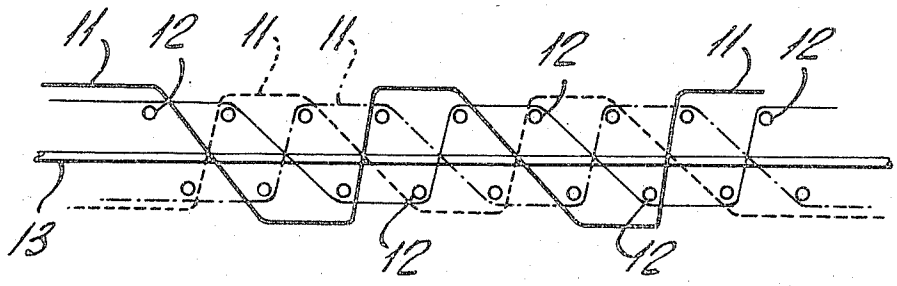

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Fig. 1.

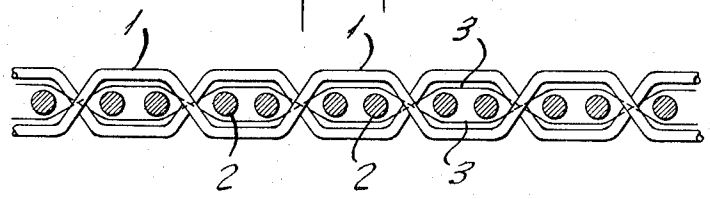


Fig. 2.

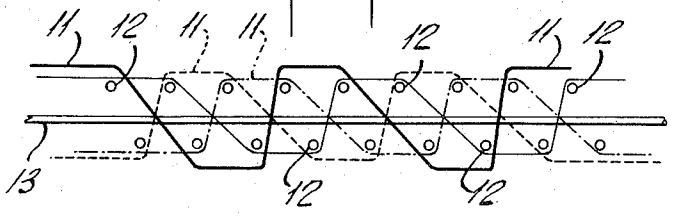


Fig. 3.

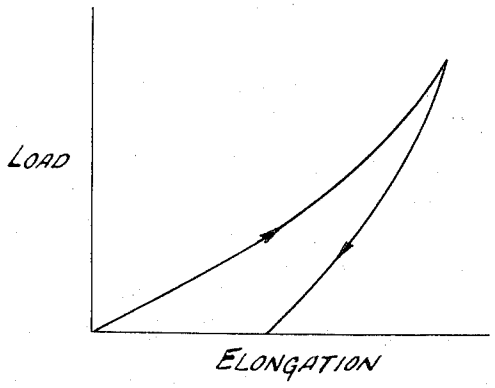
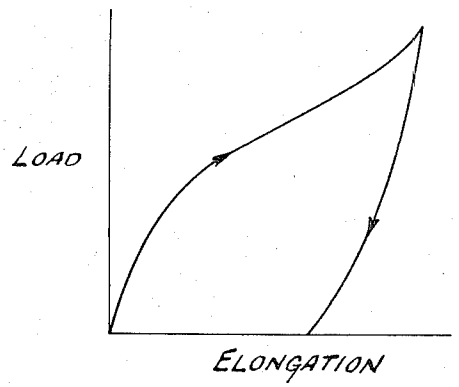


Fig. 4.



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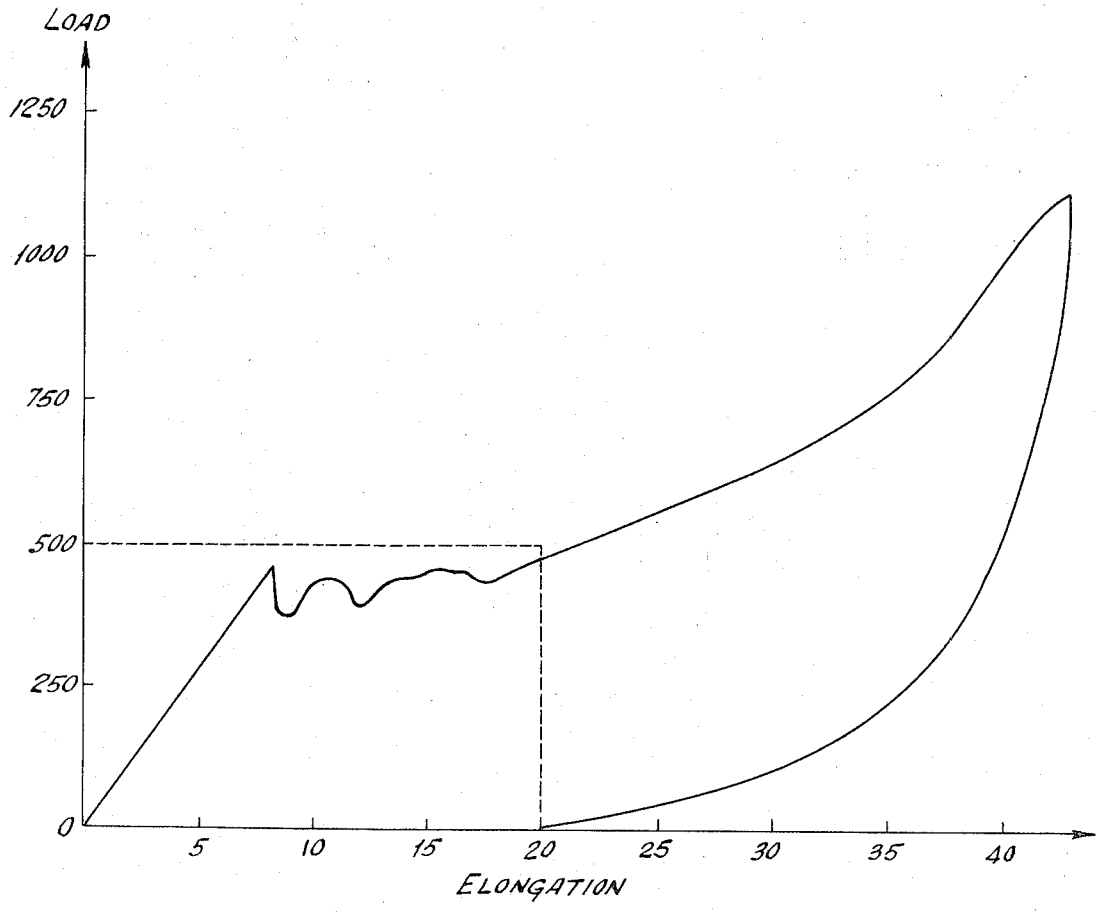

FIG. 5.

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Fig. 6.

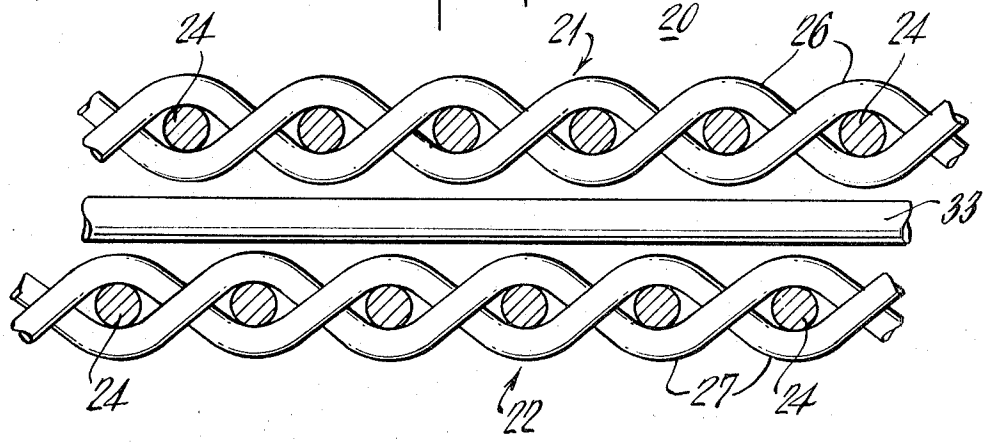
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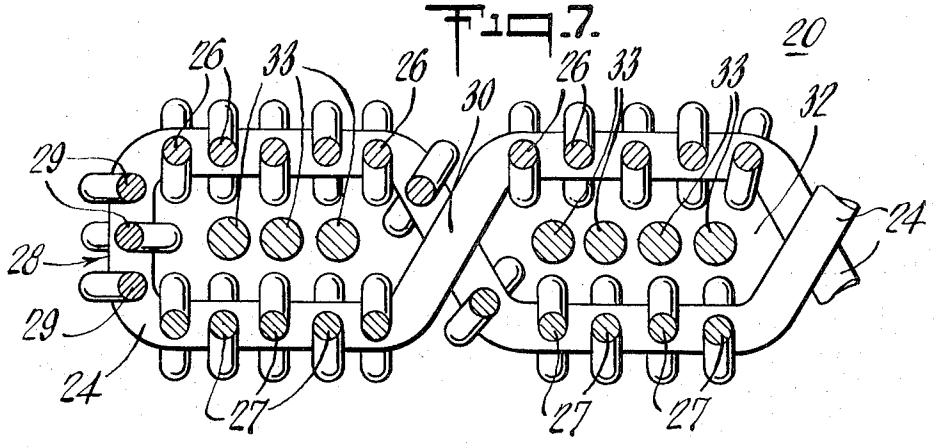
Fig. 7.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WOVEN FABRIC FOR SAFETY BELTS OF HIGH ENERGY-ABSORBENCY

REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of copending application Ser. No. 78,774, filed Oct. 7, 1970, now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates generally to improvements in woven belts, webs, bands and the like and it relates more particularly to an improved high energy absorbing web which is highly useful in safety belts such as vehicle shoulder belts and is characterized in decelerating and restraining a passenger in an optimum manner attendent to the rapid deceleration of a vehicle.

Vehicle safety belts are generally employed for securing a passenger's body to the vehicle seat in a manner to protect the passenger against any sharp impact and excessive shock consequent to traffic accidents and these belts must not only be strong enough so as not to rupture under high stress and shock conditions but must be capable of some elastic stretch as well as some non-elastic or non-recoverable extension. If the safety belt possesses very low elongation or has good elongation recovery due to its high resiliency or fast elastic recovery, it is not suitable for protecting or restraining the passenger against strong shocks consequent to a vehicle collision.

Vehicle safety belts are generally of two types, one being the waist type safety belt which extends across the passengers waist and the other being the shoulder type safety belt which extends diagonally across the passengers torso, crossing from one shoulder to the waist and functions to prevent the upper part of the passenger's body from moving or swinging forwardly and downwardly. In the shoulder type safety belt it is particularly important that the belt be capable of absorbing a high amount of energy within a certain non-recoverable or non-elastic elongation of the shoulder belt. It has been heretofore proposed to employ in shoulder safety belts, belts woven of undrawn synthetic fibers or synthetic fibers which have been heat shrunk after the drawing thereof, but such belts do not possess the optimum properties for use as shoulder safety belts. Where the belts are formed of nylon the elongation versus load characteristics as shown in FIG. 3 of the drawings, are of such values that the energy absorption within a suitable elongation range is insufficient. On the other hand, with a belt formed of polyester fibers, the load required for the desired belt elongation, as shown in FIG. 4 of the drawings, is excessive so as to impart excessive shock to the passenger. Accordingly, the shoulder safety belt structures heretofore employed and proposed possess numerous drawbacks and disadvantages and leave much to be desired.

SUMMARY OF THE INVENTION

It is a principal object of the present invention to provide an improved web or the like.

Another object of the present invention is to provide an improved woven web for shoulder type vehicle safety belts.

A further object of the present invention is to provide a web of the above nature which is highly energy absorbant during its initial non-recoverable elongation and may thereafter be subjected to recoverable or elastic elongation and which is strong, flexible and highly versatile.

The above and other objects of the present invention will become apparent from a reading of the following description taken in conjunction with the accompanying drawings which illustrate preferred embodiments thereof.

In general, the optimum elongation versus load properties of a web employed in a shoulder type vehicle safety belt are of the nature illustrated in FIG. 5 of the drawing and is characterized by little elongation during the initial or early loading, followed by further elongation upon reaching a predetermined load or stress without any additional loading, as shown by that part of the curve enclosed within the area delineated by broken lines. The distance between the car windshield and the passenger's head varies somewhat depending on the type of car but generally averages about 50 centimeters in the medium size car, and the distance between the drivers chest and the steering wheel or column is generally about 30 centimeters. In order to minimize or prevent sharp impact between the passenger and the windshield and steering wheel it is highly desirable that the elongation of the shoulder strap be less than 20 percent under a load of 500 kilograms or somewhat less. This shock is advantageously absorbed by the safety belt by a substantially non-recoverable elongation and represents the belt energy absorption which is not thereafter released in any manner which may injure the passenger. Thereafter any additional loading on the belt results in an elastic recoverable elongation thereof.

In accordance with the present invention the optimum elongation versus load characteristics of the vehicle safety belt is achieved by employing for the belt a web which includes longitudinally extending yarns or threads having different elongation versus load characteristics, the amount of the respective threads employed being such as to provide the general characteristics shown in FIG. 5. The web is preferably woven as a band in any known manner, the longitudinal threads being the warp threads which are interconnected by transverse filler or weft threads. Advantageously the low elongation warp threads, which may likewise have diffferent elongation versus load characteristics less than that of the nylon warp threads may be formed of polyester, polyvinyl alcohol, metal wire or the like or combinations thereof. The thread or yarns may be monofilaments or continuous filament or staple fiber single or multiple ply yarns. The low elongation warp or core threads may include threads of the same type and with the same elongation or threads of two or more types which may have different elongation versus load values. Moreover each of the core threads may be formed of filaments having different elongation values.

The web is woven so that the core or low elongation warp threads are unexposed, the nylon warp threads extending along the outer faces of the web. Moreover, the web construction and weaving is such that in its relaxed state the low elongation warp threads are advantageously under tension or less relaxed as compared to the high elongation threads so that upon loading of the web the low elongation threads are immediately stressed. In addition, the low elongation warp or core threads approach or are substantially linear in the unloaded web and possess relatively little weave crimp. On the other hand, the high elongation warp threads

are relatively highly undulate possessing a relatively high weave crimp so as not to be stressed more than the low elongation warp threads during initial web elongation. The web may be of either single or double weave construction and in the latter case the low elongation warp threads are disposed inside the nylon warp in a greater curvature than the weave loop of the warp so as to diminish weave shrinkage. In the web double weave construction the low elongation warp threads extend through the hollow core of the double weave. A weave structure of great advantage includes vertically spaced upper and lower warps and a filler interweaving alternate successive upper and lower warp groups, transferring between the upper and lower warps to form upper and lower woven webs which delineate with the filler along the lines of transfer between the upper and lower webs longitudinal passageways along which the core yarns extend.

The improved safety belt web overcomes the drawbacks and disadvantages of the webs heretofore employed and proposed, possessing the optimum elongation versus loading and energy absorption characteristics and being strong and highly versatile and adaptable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a woven web embodying the present invention;

FIG. 2 is a longitudinal diagramatic sectional view of another embodiment thereof;

FIG. 3 is a load versus elongation graph of a nylon fiber belt;

FIG. 4 is a load versus elongation graph of a polyester fiber belt;

FIG. 5 is a load versus elongation graph of a belt constructed in accordance with the present invention;

FIG. 6 is a fragmentary longitudinal sectional view of another embodiment of the present invention; and

FIG. 7 is a fragmentary transverse sectional view thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and particularly FIG. 1 thereof which illustrates a preferred embodiment of the present invention, the improved belt comprises a woven fabric web of single weave construction including longitudinally extending nylon warp threads 1 which define the high elongation warp threads, longitudinally extending low elongation warp threads 3, which may be formed of polyester fibers, polyvinyl alcohol fibers, cotton fibers or the like or combinations thereof and filler of weft threads 2 of any desired material interwoven with the warp threads 1 and 3 in the pattern illustrated or in any other desired pattern. The nylon warp threads 1 are disposed along the outer faces of the web and the warp threads 3 underly the warp threads 1 and are unexposed at the web faces. The ratio of the number of nylon warp threads 1 to the number of warp threads 3 depends on the denier or thickness of the respective threads and the composition of the latter as well as specific elongation load properties desired. For example the warp threads may be equal in number and or in any appropriate alternate number. Moreover, the low elongation warp threads 3 may be alike or they may be different, for example alternate warp threads 3 may be of polyester and polyvinyl fibers respectively or each of the warp threads 3 may be a combination of fibers of different elongations, for example polyester and polyvinyl alcohol fibers whereby upon elongation of the web the polyvinyl alcohol fibers are first broken followed by the breaking of the polyester fibers resulting in the absorption of kinetic energy. With the longitudinal elongation of the web in the warp direction consequent to application of a shock stress thereto, the lower elongation warp threads are first broken due to their low elasticity and extensibility and the small weave shrinkage thereby absorbing the passenger's kinetic energy upon sudden stopping of the vehicle and the nylon warp threads are then elongated due to the passenger's remaining kinetic energy.

As a specific example of a belt web of the construction described above and illustrated in FIG. 1 the warp threads 1 and the filler or weft thread 2 were both twisted nylon filament yarns of 205 filaments of 840 denier/2 ply. The warp threads 3 were twisted polyester yarn of 45 filaments of 250 denier/4 ply and twisted polyvinyl alcohol yarn of 27 filaments of 1200/denier/1 ply and were woven under greater tension than warp threads 1 to produce the web construction illustrated in FIG. 1. A safety belt produced from the aforesaid web exhibited the load-elongation curve shown in FIG. 5. This load-elongation characteristic is optimum since the work amount, that the energy required for elongation at a specified load, up to 20 percent elongation is very large and is at a load a little less than 500 kilograms, such energy corresponding to the area delineated by the elongation-load curve, the abscissa axis and the broken vertical line at the 20 percent elongation point. The load-elongated curve of the improved belt web, as illustrated in FIG. 5, demonstrates that in the initial or early loading, the combined properties of the nylon, polyester and polyvinyl alcohol fibers are first effective, after the rupture of the polyvinyl alcohol fibers, the belt web operation depends on the combination of the polyester and nylon fiber properties and after the rupture of the polyester fibers the load-elongation curve of the belt web is substantially the same as that of a nylon belt web, by which time the absorption of a great amount of the passenger's kinetic energy is achieved. It is clear from a comparison of the curves of FIGS. 3, 4 and 5 that the work amount characteristics of the improved safety belt is far superior to those of nylon or polyester alone.

In FIG. 2 there is illustrated another embodiment of the present invention in which the improved safety belt is a woven fabric web of double weave construction. The woven web comprises nylon warp threads 11, any suitable yarn filler thread 12, and longitudinal threads 13 of lower elongation than the nylon warp threads 11, such as yarns formed of polyester fibers, polyvinyl alcohol fibers, cotton or the like, woven into the inner hollow core of the web. The web is woven in the known manner in the pattern shown in FIG. 2. The relationship between threads 11 and 13 and their conditions and properties are similar to these between threads 1 and 3 of the first described embodiment and the operation of the safety belt web is like that illustrated in FIG. 1.

Referring now to FIGS. 6 and 7 of the drawings which illustrate another embodiment of the present invention the reference numeral 20 designates the improved belt which includes woven top and bottom webs 21 and 22 respectively which are formed with a com-

mon single weft or filler **24.** The top web **21** is formed of transversely spaced longitudinally extending undulating yarns **26** interwoven with filler **24** and the bottom web is formed of transversely spaced longitudinally extending undulating yarns **27** interwoven with filler **24,** the adjacent outer edges of the webs **21** and **22** being interconnected by short side webs or edges **28** formed of filler **24** interwoven with side warps **29.**

The filler **24** along with the width of the belt and along each transverse pass of the filler **24** alternately transfers between the top and bottom webs **21** and **22** at regularly spaced intervals, the point of transfer of the filler **24** at successive passes being longitudinally aligned to provide regularly spaced longitudinally extending partitions **30** to delineate with upper and lower webs **21** and **22** longitudinally extending side-by-side separate hollow passageways **32.** While in the illustrated embodiment the interval separating successive filler transfer points is shown as five warps it should be understood that the interval may include a plurality of more or less than five warps.

Enclosed within and extending for the length of each passageway **32** are a plurality of core yarns or threads **33** which are of less weave crimp than warp yarns **26** and **27** and are advantageously parallel and linear and may be under some tension in the relaxed state of the belt **20.** The core yarns **33** have less elongation than the warps **26** and **27** and possess the characteristics and relationship to the warps as described in connection with warp threads **3** and **13** of the earlier described embodiments and as related to warps **1** and **11.**

In operation, the low elongation core threads are first ruptured under sufficient tension due to their low elongation and low weave crimp, but before rupture, the core threads neck out or elongate under a predetermined constant load, whereby to absorb a corresponding amount of kinetic energy which is imparted thereto by the belt restrained passenger upon receiving a sharp forward impact force relative to the vehicle. Upon rupture of the core threads the warp threads are elongated by the passengers remaining kinetic energy.

In accordance with a specific example of a belt of the structure last described and shown in FIGS. **6** and **7,** the total number of warp threads was 190, each warp being a 1680 denier twisted nylon filament yarn with the filler being of the same nylon yarn. The core yarns consisted of 45 pieces of 250 denier, twisted 4 ply polyester filaments and 27 pieces of 1200 denier twisted single ply vinylon filaments, the core yarn being under greater tension during weaving than the warp yarns to obtain the illustrated weave structure. The core yarns are equally distributed among the passageways **32,** that is where nine passageways are provided each contains five pieces of the polyester yarn and three pieces of the vinylon yarn.

With the above belt, at up to 20 percent elongation, the response of the belt closely approximated the ideal, as earlier described. This is due to the fact that in the initial loading phase the response is due to the combined state of the nylon, polyester and vinylon yarns and after the vinylon core threads are ruptured, the load-elongation characteristics of the combined nylon and polyester yarns control the belt response, and after the rupture of the polyester yarns, the belt reacts in the manner of a nylon belt and the ideal overall response is thus achieved.

As explained above, the improved safety belt web possesses excellent operating characteristics by reason of its load-elongation relationship, which is achieved by the use of the high elongation warp threads, that is nylon, interposed with and extending along the direction of the low elongation warp threads for example of polyester fiber, polyvinyl alcohol fibers metallic wire, cotton or the like and combinations thereof. In the early belt loading the ratio of elongation to load is relatively low as compared to the corresponding ratio of a belt of only nylon, and then there is an area of further elongation without increased loading thereby resulting in a high absorption of the passenger's kinetic energy with a large work amount and a large work ratio, that is the ratio of belt absorbed energy to the energy required to elongate the belt at the particular loading. Accordingly, the improved safety belt is capable of protecting the passenger from high energy impact with the vehicle windshield and steering wheel, and is particularly useful for shoulder type safety belts.

While there have been described and illustrated preferred embodiments of the present invention, it is apparent that numerous alterations, omissions and additions may be made without departing from the spirit thereof.

I claim:

1. A woven energy absorbing safety belt web comprising first and second groups of warp threads of relatively low and relatively high elongation respectively, and a filler thread interwoven with said warp threads, said second group warp threads having a weave crimp exceeding that of said first group warp threads and said first group warp threads comprising a plurality of core threads having elongations different from each other and lower than that of said second group warp threads, and said first group warp threads having a non-recoverable extensibility under a substantially constant predetermined load for a predetermined elongation before the rupture of said first group warp threads of maximum elongation.

2. The safety belt web of claim **1** wherein said second relatively high elongation warp threads are disposed outwardly of said first low elongation warp threads relative to the opposite outer faces of said web.

3. The safety belt web of claim **1** wherein said first warp threads are under tension relative to said second warp threads when said web is in an overall relaxed condition.

4. The safety belt web of claim **1** wherein said first warp threads of maximum elongation extends substantially linearly between said filler threads disposed along opposite sides of said first warp threads and said second warp threads interweave said filler threads and are disposed along opposite faces of said web.

5. The safety belt web of claim **1** wherein said first threads have a rupture elongation of 20 percent and at a total load on said web of about 500 kilograms.

6. The safety belt web of claim **1** wherein said second threads comprise nylon.

7. The safety belt web of claim **6** wherein said first threads are selected from the class consisting of polyester fibers, polyvinyl alcohol fibers, cotton, metallic threads and combinations thereof.

8. The safety belt of claim **1** wherein said first threads extend substantially linearly and said second threads are of undulate configuration.

9. A safety belt web comprising upper and lower longitudinally extending transversely spaced warps, a filler interwoven alternately with successive upper and lower groups of said warps and transferring at spaced intervals between said upper and lower warps to form upper and lower weaves which delineated in said web a plurality of longitudinally extending passageways transversely separated by said filler along the longitudinal lines of the transfer points thereof, and core threads extending longitudinally in said passageways, said core threads having less elongation versus load and less weave crimp than said warps and at least some of said core threads having elongations different from other of said core threads, and said core threads having a nonrecoverable extensibility under a substantially constant predetermined load for a predetermined elongation before the rupture of said core threads of maximum elongation.

10. The web of claim 9 wherein a plurality of said core threads is disposed in each of said passageways.

11. The web of claim 9 wherein said core threads are substantially linear.

12. The web of claim 9 wherein said core threads have a rupture elongation of about 20 percent at a total web loading of about 500 kilograms.

* * * * *