Oct. 3, 1944. W. E. LAY ET AL 2,359,318

SPRING CONSTRUCTION AND METHOD OF ASSEMBLING

Filed June 12, 1941 3 Sheets-Sheet 1

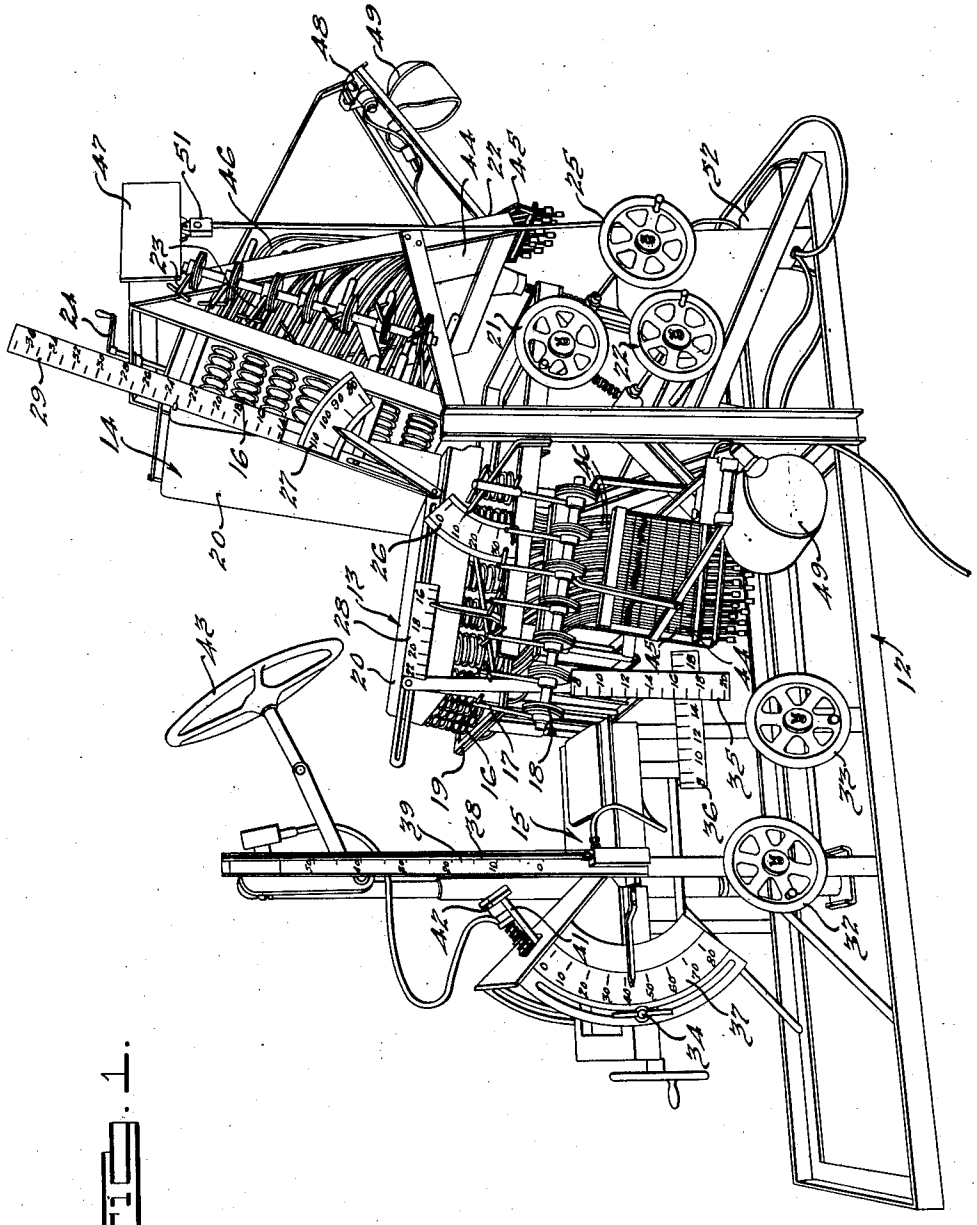

Fig. 1.

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FIG. 2.

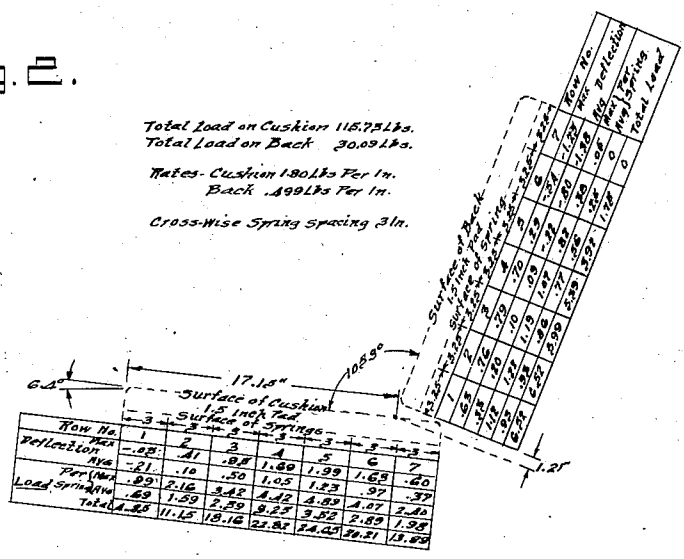
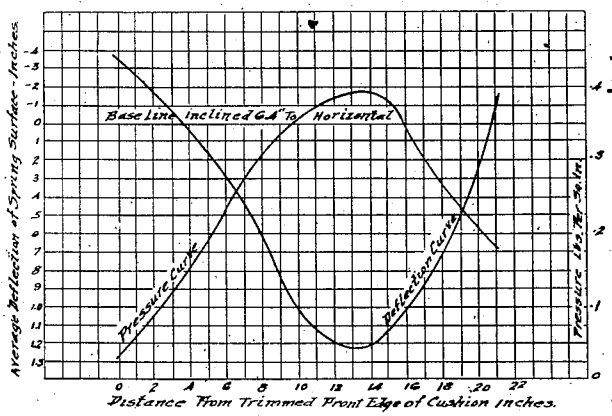


FIG. 3.



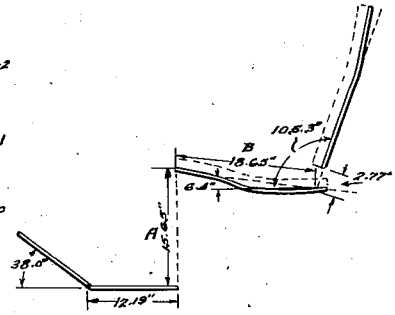


FIG. 5.

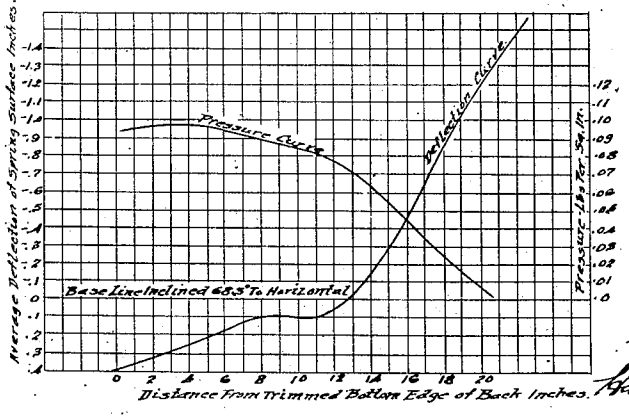


FIG. 4.

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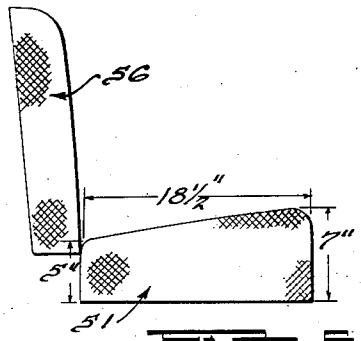

FIG. 6.

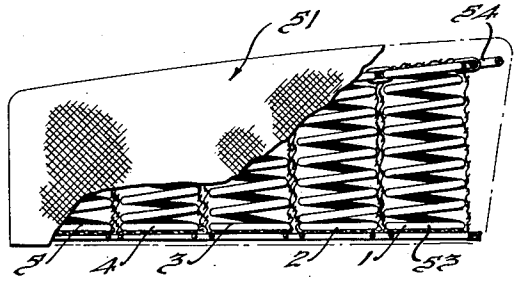

FIG. 8.

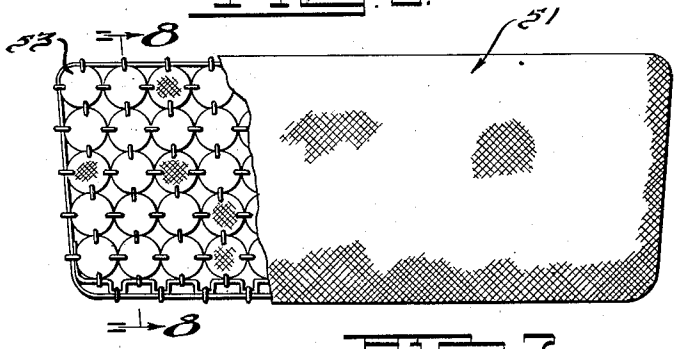

FIG. 7.

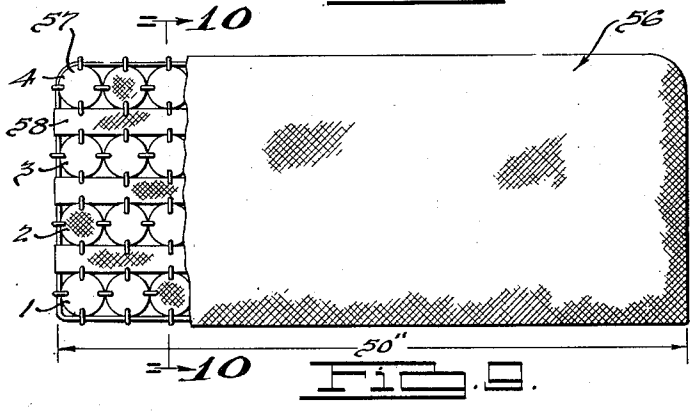

FIG. 9.

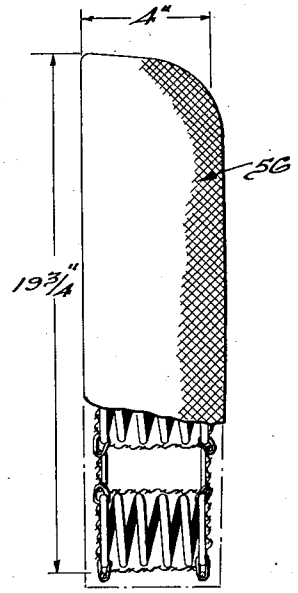

FIG. 10.

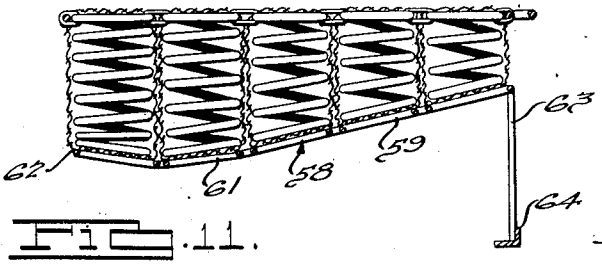

FIG. 11.

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SPRING CONSTRUCTION AND METHOD OF ASSEMBLING

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Application June 12, 1941, Serial No. 397,802

5 Claims. (Cl. 155—179)

Our invention relates to spring constructions, and particularly to a new and novel method of forming a spring assembly from scientifically collected data.

It is the practice in the art to construct spring assemblies in an empirical manner by more or less guessing at the size and type of springs from past experience and assembling the springs into several upholstering units which are compared for comfort. The present method differs therefrom by ascertaining the contour and unit pressures most desirable and from this data the springs are computed and the assembly constructed.

To obtain this data for the contour and pressures it was necessary to construct an elaborate machine in which a large number of subjects were tested to obtain data relative to each individual as to the most desirable inclination of the back and seat cushions, the unit pressures with the resulting contour and other data. After several hundred subjects were tested in this manner, the average data provided the pressure and contour curves from which the spring structures could be built. The average contour and unit pressures were obtained from the front to the back for the seat cushion and from the bottom to the top of the back cushion. When spring structures were to be built for automobile seats, davenports and the like on which an individual may occupy any point of the lateral area the spring construction was the same from one to the other end thereof.

For individual seats, the lateral deflections and pressures will vary and these differences are employed for constructing the spring assembly for individual seats. The same data may be employed for constructing a seat from metal, wood, or other substance which is non-resilient, but which is extremely comfortable in view of the predetermined contours. On such solid surfaces the pressures on the occupant's body are uniformly distributed.

Accordingly the main objects of our invention are; to form a seat arrangement from data compiled from the averages obtained by tests on a large number of subjects; to form a seat arrangement of predetermined contour from the data obtained by averaging the contours suitable for a large number of subjects; to form a spring assembly to produce a predetermined contour and corresponding unit pressures which produces the average of the contours and pressures most suitable for a larger number of subjects; to form a spring assembly from unlike rows of like springs to provide a predetermined contour and unit pressure from the front to the back of the spring assembly while maintaining low rates in the springs; to form a spring assembly for a back cushion which provides a predetermined contour and unit spring pressure from the bottom to the top of the assembly formed by rows of laterally extending springs having low rates; to form a spring assembly for a cushion having a base which follows somewhat the surface contour obtained when the springs are occupied and may be placed on a frame built to have the surface located a desirable distance above the floor of a vehicle or room; and in general to form a spring assembly from deflection and pressure data which comprises the average for a large number of subjects from which the gauge of wire, the free and pocket height of the springs, the number of coils and the number of springs are obtained to thereby eliminate the empirical method heretofore utilized in constructing spring assemblies.

Other objects and features of novelty of our invention will be either specifically pointed out or will become apparent when referring, for a better understanding of our invention, to the following description taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a side perspective view of a test machine which was employed to obtain the data from which the spring assemblies are computed;

Fig. 2 is a diagrammatic view of seat and back cushions illustrating the relationship of one to the other and the average spring characteristics in deflection and load obtained from the machine of Fig. 1;

Fig. 3 is a pressure and deflection curve for the seat cushion illustrated in Fig. 2;

Fig. 4 is a pressure and deflection curve for the back cushion illustrated in Fig. 2;

Fig. 5 is a view of a seating arrangement which illustrates the location of the base lines and average contour of the surfaces of the seat and back element with respect to the floor and toe board;

Fig. 6 is a view in elevation of a seat and back cushion which was constructed from the data plotted on the curves illustrated in Figs. 3 and 4;

Fig. 7 is an enlarged broken view of the seat cushion illustrated in Fig. 6;

Fig. 8 is an enlarged broken sectional view of the structure illustrated in Fig. 7 taken on the line 8—8 thereof;

Fig. 9 is an enlarged view in elevation of the back cushion illustrated in Fig. 6;

Fig. 10 is a broken sectional view of the structure illustrated in Fig. 9 taken on the line 10—10 thereof; and

Fig. 11 is a view of structure similar to that illustrated in Fig. 8 showing a modified form of our invention.

As pointed out hereinabove, the method which we have developed for constructing seating arrangements is unique in that the surface contour of the seat and back cushions, as well as the unit pressures corresponding thereto, are employed for constructing the contour or building up a spring structure which produces the contour when occupied while distributing the pressures in a manner which produces the most comfort over the area of the individual which contacts the seat.

To obtain this initial data it was necessary to construct the machine which we have illustrated in Fig. 1. The machine is completely adjustable having arrangements to vary the distribution of the supporting pressure in any manner which seemed most comfortable to the occupant. This method of adjusting the seat dimensions, seating position, supporting area, contours and pressure distribution depends upon the occupant's idea of pain or discomfort from his sensory nerves and muscular reactions and may be compared to that of an oculist fitting a person with spectacles. The test seat is composed of four major assemblies. The frame assembly 12, the seat cushion assembly 13, the seat back assembly 14, and the floor and toeboard unit 15. The three latter assemblies can be moved up or down, forward or back, or tilted at various angles to suit the comfort requirements of any individual, or to produce any desired sitting posture.

The seat cushion contains 49 calibrated coil springs 16. These springs are arranged in seven crosswise rows of seven springs each. Each crosswise row is mounted on a separate plate which can be raised or lowered independently by one of the levers 17 in the bank of levers marked 18. With a subject seated on the cushion the spring can be compressed under him any desired amount by means of these levers. That is, the distribution of supporting pressure can be adjusted for maximum comfort. The top ends of the springs are attached to a light canvas sheet by tin clips riveted to the canvas (not herein illustrated). This, in turn, is covered by a light pad and the conventional upholstery fabric 20.

This entire assembly is mounted on a rectangular base 19 which is moved forward and back in the frame by a hand wheel 21. The cushion is tilted in the frame by turning the hand wheel 22. The construction of the seat back cushion is practically identical with that of the seat cushion. The combination of the rows of springs is varied by levers 23. The whole back unit is moved up or down by the crank 24 and tilted to any position by the hand wheel 25. The relative positions of the seat cushion and back cushion are shown on the scales 26, 27, 28, and 29. The scale 26 shows the angle which the surface of the cushion makes with the horizontal. The scale 27 shows the included angle between the surfaces of the seat cushion and seat back. The scale 28 shows the distance from the front edge of the cushion along the surface of the cushion to the bottom edge of the back. The scale 29 shows the height of the back above the cushion, as well as the location of the shoulders and the total seated height of the individual above the cushion.

The floor and toe board unit 15 rests upon the base of the frame 12. This unit is provided with three adjustments to vary its position to conform to the lower leg length and sitting posture of the individual. The scale 31 discloses the portion of the total weight of the individual which is transmitted through his feet to the floor, and is that portion of the weight of the individual not supported by either the seat or back cushions. The hand wheel 32 adjusts the height of the floor above the base of the machine. The hand wheel 33 varies the length of the floor while the angular position of the toeboard may be varied by loosening the clamp 34. The scale 35 shows the vertical distance from the floor board to the front edge of the surface of the seat cushion. Scale 36 shows the horizontal distance from the front edge of the seat cushion to the point at which the toe board intersects the floor, which is the floor length.

The scale 37 shows the angle of the toe board with respect to the horizontal. The mercury column 38 on the scale 39 gives that portion of the weight of the occupant which is supported by the floor. The toe board is provided with a clutch 41 and a brake pedal 42 placed in an average position. The brake pedal is fitted with a pressure measuring device so that studies could be made of the effect of pedal operation on the seat and back cushions. An adjusting steering wheel 43 is included in this unit.

The construction of this unit makes it possible for rapid measurement of individuals since all angles and dimensions can be very quickly and accurately measured from a position on one side of the seat with the scales in full view of the operator at all times. Below the seat cushion we have provided a chart 44 which shows the actual deflection from the free spring surface of each one of the 49 springs in the seat cushion when occupied. This chart also shows the amount of compression introduced in each crosswise row of springs by the adjustment of the bank of levers 18. The difference between these values is the actual compression of each of the springs. Since the springs are calibrated the load supported on each spring is readily obtained.

Cords 45 are attached to the center of the tin clip which secures each of the 49 springs to the canvas upper spacer. The cords pass down through the spring through a clearance hole in the sub-plate on which the springs are mounted and enters a small copper tube 46 attached to the bottom plate of the cushion by a standard coupling. The copper tube leads to the upper edge of the chart to which they are attached. The cords pass down over the chart in front of the scale through a guide hole at the bottom edge below which a weight serves to keep it under constant tension.

The cords follow very accurately the movement of deflection of the upper ends of the spring. The position of the movable sub-plates is indicated on the chart in the same manner. The zero position of the upper ends of the springs and the sub-plates is indicated on the chart by white bands painted around the black cords. A chart 47 is provided on the machine on which is recorded the age, height, weight and make and year of the car used by the individual being tested.

A similar arrangement of tubes and cords are made to the springs of the back cushion which extends over a chart 45 at the back of the cushion. Cameras 48 are used to photograph the charts 45 after the adjustment is made, the charts being illuminated by the lamps 49. A third camera records the entire picture of the adjusted assembly along with the occupant, which photographs

the various scales in their adjusted positions and includes the data applied to the chart 47. The camera shutters are all tripped simultaneously by solenoids when the portable push button 51 is operated. This is accomplished through a relay system contained in the box 52 at the rear of the frame.

The following routine of adjustments was used. Only adult subjects, 21 years old or over, were measured. They were first weighed, measured for height, and then seated in the test seat. If the subject being tested was a driver, the steering wheel was adjusted, if the subject was a passenger and not a driver, the wheel was moved out of the position illustrated. Tentative adjustments were made on the seat dimensions to satisfy the subject as to cushion inclination, included angle between cushion and back, length of cushion from front to back, height from floor, floor length and toe board angle. The compression of the various rows of springs in the seat and back cushion was thereafter varied until the subject felt entirely comfortable with the feeling of support over the entire cushion and back contact areas, yet with no excess pressure at any point. The setting required to produce this result was found easily by increasing the compression until severe local discomfort was felt and then reducing the compression gradually until the feeling disappeared.

After the seat and back cushion were adjusted to fit the subject comfortably by this method, the seat dimensions were then varied to the subject's satisfaction. The alternate adjustment of the seat dimensions and supporting pressures was continued until both the subject and operator were satisfied that no further improvement could be made. The position of the adjustable element, the compressions and deflections of each of the 98 springs were photographed simultaneously. The procedure required from 20 to 45 minutes to please a single subject.

In Fig. 2 is illustrated a diagrammatic layout of the rows of springs in the seat and back cushions in their exact positions. It also shows the load and deflection data read from the deflection indicator charts. These data include the average load and the average deflection for the springs of a crosswise row; as well as the maximum load and the maximum deflection for a single spring of the row and the total load borne by the row, for each of the seven crosswise rows of springs. Arranged in this manner the data shows the load distribution which is desirable in back and seat cushions as well as the deflections which such a load distribution produces on the upper surface of the springs.

In Fig. 3 is shown a curve plotted from the average load and deflection data for the seat cushion. The load is expressed as pressure in pounds per square inch and is computed by dividing the average of the loads applied to each of the seven springs of a row, obtained from Fig. 2, by the area each spring occupies and drawing a smooth curve through the seven points when they were plotted against the distance from the front edge of the cushion. A smooth curve means a gradual change of pressure from point to point which is one of the essential requirements for comfort. The average deflection of the upper surface of the springs away from a base line is also plotted against distance from the front edge of the cushion. This base line represents the location and inclination of the upper surface of the springs without load and with the movable subplates which carry the springs in their lowest or zero position. Plus values of deflection indicate that the upper surface of the loaded spring has been compressed to a point below the base line and conversely minus values indicate that the surface is above. The minus values occur when the sub-plates have been raised far enough to position the upper surface of the springs above their original positions on the base line to provide the desired supporting pressure. Obviously, this base line bears no relation to the free unloaded surface of a commercial cushion and can be used only to locate the contour of the loaded cushion. By changing the position of the base line all of the deflection values can be made plus, as will be shown hereinafter.

In Fig. 4, I have illustrated a similar curve plotted from corresponding data for the back cushion against the distance upwardly from the trimmed bottom edge of the back cushion. Here again positive values indicate the disposition of the upper spring surface toward the rear away from the base line, the inclination of which is illustrated.

Fig. 5 is a diagrammatic figure which shows the location of the base lines from the charts of Figs. 3 and 4 with respect to the floor and toe board to secure the proper seat dimensions. Dimensions A and B are based on a pad thickness of 1½". Obviously, dimensions A should be increased and B decreased for thinner pads to maintain the seat dimensions as the values found most desirable. The converse is true for thicker pads.

Having this data at hand, it was a comparatively simple matter to construct the seat and back cushion. The pressure in pounds per square inch on a 1" wide strip at points starting from the front or bottom respectively of a seat or a back cushion may be read from the pressure curves of Fig. 3 or 4, respectively. Knowing these pressures and the area which must be supported, the load on each spring is computed. The position of the upper end of the loaded spring is determined by the deflection curve and the dimensions on Fig. 5. The other spring characteristics may be chosen according to the space available and the softness desired. The seat back is designed in the same manner. The seat and back cushions designed in this manner meet the requirements for static comfort in the loaded condition regardless of the condition of the unloaded surface. Within limits its location and contour may be varied as desired.

Referring to Figs. 6 to 10, we have illustrated an automobile seat and back cushion constructed from the data which was obtained from the tests outlined above. Since such seats accommodate more than one person, it is not possible to predict where people will sit across the seat. Even the driver moves from his normal position when more than two persons sit in the front seat. For this reason the cushion must be alike from side to side. That is to say, it can not have clearly defined places where people must sit to be comfortable. To take care of this condition in utilizing the load and contour data for the average adult, a mean was taken of the values of load and deflection for the seven springs in each crosswise row in the cushion and back. These are the values from which the curves in Figs. 3 and 4 were plotted. When these are used in the design of the cushion the unit may be made of any length to accommodate any number of persons irrespective of where they sit across the cushion while providing maximum comfort.

It is evident from Figs. 6 to 10 that the dimensions of the seat cushion, as well as its external shape, are first selected. The diameter of the springs is then chosen and from this the number of crosswise rows, the number of springs in each row, and the height of each row of springs in the unloaded cushion can be determined from the external shape and dimension of the units. With this information the area each spring must support and its position relative to the front edge of the cushion can then be found. The load on each spring can then be computed from the load curves by summation of the loads given on the curve for each strip of one inch width from front to rear of a seat cushion and from bottom to top of a back cushion which is supported by the springs and multiplying this by the inches of width which the spring supports. When the seat cushion is to be constructed the base line is located with respect to the surface of the cushion and the deflections of the various rows of springs below their cushion height can be found from the contour curve. These deflections subtracted from their respective cushion heights give the loaded heights of the several rows of springs. That is, the heights at which the loads computed for the springs in the preceding paragraph must be supported to provide maximum comfort for the average adult.

Various springs can be designed which will support these loads at the height required for maximum comfort for the average adult. However, with proper care in designing the springs it is possible to make the cushion equally comfortable for persons of other than average build. "A heavier than average" individual will sink further into the cushion to obtain sufficient support, whereas a "lighter than average person" will not deflect the cushion quite as much as the average adult. Therefore, in selecting the springs they should be of such construction to produce a relation between the loads of the various rows of springs which remains practically constant, the loads increasing or decreasing in the same ratio for individuals who are heavier or lighter than average. When this is so the shape of the contour curve remains a constant moving up or down relative to the contour surface of individuals who are lighter or heavier than average. Accordingly, the springs must be so designed that the distribution of load among them remains constant while the contour as a whole moves up or down according to the weight of the occupant. The exact movement of the contour is not important as far as static comfort is concerned. However, if this movement of the contour is made to correspond with the motion of a passenger on the cushion in a moving vehicle the cushion will maintain the distribution of load required for maximum comfort for persons of heavier weight and build under riding conditions as well as static conditions.

Slow motion picture photography was used in determining the motion, relative to the cushion and back, of a passenger in a moving vehicle. This motion can be visualized most easily by considering the body as a hinged structure of rigid members. The feet, which rest on the floor, are the only stationary points in the structure. Because of the low placement of seats in most vehicles, the feet must be placed somewhat ahead of the cushion, with the lower leg inclined forwardly rather than vertical. Thus inclined, the lower leg hinges about the ankle joint, so that the knee joint moves down and backward in an arc about the ankle. The upper leg, being hinged to the lower leg at the knee, has a compound motion arising from this motion of the knee about the ankle, and its own hinging action about the knee. The trunk, hinged to the upper leg at the hip, and the head attached to the trunk both are capable of various types of motion. Actually, however, the seat back, being approximately at right angles to the cushion and upper leg, prevents that member from moving backward any large amount, so that the knee motion at the forward part of the cushion is limited. The hinging of the upper leg about the knee allows any degree of vertical motion at the rear of the cushion. The motion picture camera shows that this motion of the upper leg, and hence of the cushion contour used in design, is essentially an angular motion about a stationary center in the plane of the contour and approximately ten inches forward of the front edge of the front row of springs for all motion of any magnitude. The motion of the trunk of the individual, and hence of the back contour, is such that it is always essentially parallel with its static position under all conditions.

If the distribution of the pressure on the cushion and back be maintained with these types of motion, the seat will provide maximum comfort for persons of varying weight and build under riding conditions. To accomplish this it is necessary to select the springs for a cushion in a definite manner. Consider a correctly designed cushion with an average person seated on it. To accommodate a lighter person, the contour will move upwardly, with angular motion about its stationary center ten inches forward of the front edge of the unit. Each spring will therefore increase in height an amount proportional to its distance from this stationary center. At the same time the loads on the several rows of springs must all decrease in the same ratio in order that the distribution of load be maintained. As the contour moves upwardly more and more, with angular motion about this stationary center, as when an occupant arises from the seat, the loads continue to decrease until they become zero at the same moment providing the springs are entirely unrestrained. The springs are then at their free heights and their upper surfaces still form the same contour in its uppermost position. It is, therefore, apparent that the deflections, from free heights to loaded heights, of the several rows of springs, must always be proportional to their respective distances from the center of angular motion of the contour.

To complete the cushion design which will accomplish this result, it is only necessary to assume the deflection, from free height to loaded height, for one row of springs. The deflections for the other rows are determined by direct proportion, i. e., the deflection of a particular row is to its distance from the center of angular motion as the assumed deflection of one row is to its distance from that center. The free heights of the various rows are obtained by adding these deflections to their respective loaded heights.

The rates or spring constants of the springs are found by dividing the load which each spring must support by its deflection from free to loaded height.

It should be noted that the one deflection assumed above for one row of springs controls the deflections for all the other rows, their free heights, and their spring constants or rates. It

is desirable that the rates of the springs be low, so that the motion of the cushion under the passenger in a moving vehicle should vary the forces which support him as little as possible. Low values for the rates also result in a low natural frequency of passenger motion on the cushion, which is also desirable from the standpoint of comfort. Therefore, the assumed deflection should be as large as possible without making the springs unduly large and the rates so low that the passenger will strike bottom in the cushion under riding conditions.

To disclose how the accumulated data is applicable to the cushion constructions illustrated in Figs. 6 to 10, we will now show the computation which was employed to obtain the data for each of the rows of springs in both the seat and the back cushion.

The seat cushion **51** has a width from front to back of 18½''. This dimension was submitted by the automobile manufacturer requiring the seat cushion. Since the data on the curve of Fig. 3 was computed for a weight distribution over a seat cushion of 21'' in width, interpolation was employed for producing a new curve in which the widths and proportions were evenly distributed over the 18½'' depth of cushion. The manufacturer also submitted a dimension of 7'' in height for the front edge of the cushion and 5'' in height at the back thereof. Accordingly, the figures which will be set out below for the seat cushion which was computed from the data obtained from the test seat will not conform to the data on the curve because of the use of the new curve made from such data for the seat cushion having an 18½'' dimension from front to back. For each variation of the front to back dimension of a seat cushion from that of the test seat cushion, it will be necessary to compile a new chart which is readily obtained from proportioning weight distribution so that the total weight supported remains the same.

Front

	Row No.				
	1	2	3	4	5
In. from ft. edge (min.-max.)	0–4½	4½–8	8–11½	11½–15	15–18½
Summation of loads on strip 1'' wide	.066	.097	.338	.206	.391
	.096	.229	.370	.423	.355
	.127	.264	.395	.425	.318
	.159	.303	.207	.413	.142
	.097				
1. Total	.545	.893	1.310	1.467	1.205
2. Width or row at center line	46½	47⅛	47¾	48⅜	49
A. Spring dia	3½	3½	3½	3½	3½
3. Difference (2—A)	43	43⅝	44¼	44⅞	45½
4. No. spaces between springs	11	11	11	11	11
5. Width supported by each spg. (3÷4)	3.91	3.97	4.02	4.08	4.14
6. Total load per spring (5×1)	2.13	3.55	5.26	5.98	4.99
A. In. from ft. edge to C/L of row	2¾	6¼	9¾	13¼	16¾
B. Cushion ht	7.00	6.50	6.00	5.50	5.00
7. Contour base ht	7.00	6.50	6.00	5.50	5.00
8. Deflection (proportional curve)	.20	.34	.62	.62	.23
9. Contour ht. (7—8)	6.80	6.16	5.38	4.88	4.77
Def. factor 6A+10''	1,275	1,625	1,975	2,325	2,675
10. Deflection by load	3.26	4.13	5.00	5.87	6.74
C. Free ht. (9+10)	10.06	10.29	10.38	10.75	11.51
11. Free ht.—Adjusted	10	10.25	10.50	10.75	11.50
12. Def. by load (adj.) (11—9)	3.20	4.09	5.12	5.87	6.73
Rate (6÷12)	.67	.87	1.03	1.02	.74
Load at solid ht	4.36	8.40	10.30	10.57	8.13
D. Gage	13	12	11½	11½	12
Wire dia	.0915	.106	.113	.113	.106
Pitch dia	3.41	3.39	3.39	3.39	3.39
E. Total turns	5½	7	7¾	7¾	8

Springs **53** were selected having a diameter of 3½''. Since 1'' of frame **54** extends forwardly of the springs, the 3½'' diameter of the spring permits five rows of the springs to be disposed laterally across the seat. The seat has a dimension of 46½'' at the front and 49'' at the rear so that the width of area supported by each of the springs of the row was readily obtained. The deflection factor (between 9 and 10) is the distance of the center line of the spring from the stationary center about which angular motion occurs. It is the sum of the distance from the center line of the spring to the front edge of the seat and the distance from the front edge to the stationary center. It will be noted that the deflection under load had been selected as 5'' for the springs of the central row. By proportioning the deflection factors relative to the deflection of the central row, the deflection by load (10) is obtained for the adjacent rows of springs. After the adjusted deflection by load (12) is obtained, the rate, the pounds supported divided by deflection, can then be computed. Knowing the rate and free height and assuming a reasonable solid height the load at solid height can be computed from the formula:

$$P=R(H_f-H_s)$$

P=Load at solid height
R=Rate
H_f=Free height
H_s=Solid height

Knowing P, load at solid height, the gauge of wire can be computed from the formula:

$$d=3\frac{\sqrt{2.55PD}}{S_{s.\ max.}}$$

S/s max. is assumed at a value which will make certain that the spring will not fatigue or set in use.

D is diameter of the coil; *d* is diameter of wire in inches.

After the diameter of the wire is obtained, the number of turns is computed from the following formula:

$$N=\frac{Gd^4}{8D^3R}$$

R equals rate; N equals the number of turns less the end turns; G equals 11,500,000, which is the torsional modulus of the wire; *d* equals wire diameter, and D equals diameter of the coil. To the resulting number of turns obtained from this formula 1¾ turns are added to take care of the two end portions.

The free height and gauge of wire is obtained in this manner for the springs of each row from the front to the back of the cushion. When assembled the coil springs are sewed in pockets to provide the desired pocket height for each spring which produces the height and shape of the top surface of the seat when unoccupied.

After the seat cushion **51** has the springs formed in this manner for each of the five rows, the back cushion **56** has the springs computed in the same manner. In view of the reduced load on the back cushions four rows of springs **57**, indicated by numerals 1 to 4, reading from the bottom to the top of the cushion, are employed. The springs were also selected of 3½'' diameter with 1½'' burlap spacers **58** connecting the rows together. From computation similar to that set forth above, relative to the seat cushion, and from the width, thickness and depth of the

back as furnished by the automobile manufacturer, the following spring data was obtained:

Spring	Free height	Gauge	Total turns
	Inches	*Inches*	*Inches*
1	12¼	13	10½
2	9¼	13	8½
3	6¼	13	6
4	4	12	4¾

The thickness of the back cushion was limited to 4 inches. The springs **57** are disposed in pockets and pulled down to the pocket height of 4'' and the resulting spring structure follows the deflection and unit pressure distribution obtained in the chart illustrated in Fig. 4 for a seat 19¾'' in height instead of the 22¾'' height of the test seat.

We have provided above all the information required to construct any type of seat whether of solid or spring construction to produce a contour for an average person with distributed pressures which will provide maximum comfort. We have further disclosed how the proper selection of the springs produce a spring cushion, having a desirable contour and the proper distribution of pressures, which is comfortable for persons of greater or lesser than average weight. We have illustrated the application of the data in an actual construction of a seat and back cushion disclosing step by step how the data is computed. We have, therefore, reversed entirely the art of building up cushion constructions from that heretofore practiced which embodied the construction of a number of cushions and by actual trial selecting one which appeared most appropriate. We have employed data obtained for a seat which is satisfactory for an average person and from such data computed a spring structure meeting a manufacturer's requirements as to dimensions while providing in the cushions, characteristics which are capable of producing a desirable contour and distribution of pressure conforming to that which is most satisfactory for the average person.

It will be noted from the curves of Figs. 3 and 4 that the deflection for both the back and seat cushions have positive and negative values. Since the base line is useful only for positioning the curve in space this may be tilted without affecting the form of the resulting curves. By changing the base line of the curves for the seat cushion to 7.7 degrees instead of 6.4 degrees, all of the values become positive and are as follows:

Distance from front edge in inches	Average load in pounds per square inch	Average deflection in inches
1	.051	.18
2	.080	.26
3	.109	.35
4	.140	.44
5	.173	.53
6	.207	.63
7	.240	.73
8	.278	.85
9	.312	1.01
10	.342	1.18
11	.366	1.31
12	.382	1.39
13	.391	1.42
14	.391	1.42
15	.378	1.37
16	.355	1.27
17	.317	1.11
18	.278	.93
19	.243	.72
20	.210	.51
21	.177	.30

Similarly, for the back cushion, when a 71 degree base line is employed in place of the 68.3 degree, the base line utilized in the test seat, the values for the deflection curve of the back cushion become positive and are as follows:

Distance from bottom edge in inches	Average load in pounds per square inch	Average deflection in inches
1	.087	.49
2	.090	.54
3	.093	.59
4	.095	.64
5	.097	.68
6	.098	.71
7	.096	.70
8	.092	.66
9	.086	.61
10	.082	.60
11	.078	.63
12	.075	.68
13	.072	.72
14	.067	.73
15	.060	.69
16	.051	.59
17	.041	.49
18	.030	.48
19	.020	.27
20	.010	.14
21	0	0

The four corner springs of the seat cushion must be made stronger because of the concentration of the load on the corners when the occupant moves onto the seat from the side as occurs in automotive vehicles. Depending upon the type of springs employed in the cushion construction, the strength of the corner springs may be increased as much as 140% to 300%.

In Fig. 11 we have illustrated a modified form of seat construction; that wherein a standard form of structure may be provided and this structure employed in all makes of frames or automobile bodies by building up the supporting structure to dispose the cushion surface in a predetermined relation to the floor. The cushion is made with an idea of permitting free movement of the springs and the degree of deflection required, while eliminating portions of the spring which are not necessary but which are employed to obtain the desired height to the resulting cushion construction. In the figure the base frame **58** has a downwardly sloping portion **59**, a central horizontal portion **61**, and an upwardly sloping portion **62**.

The form of the base follows somewhat the contour above referred to, obtained when the cushion is loaded, and deviates therefrom by the solid height of the springs. Because it is essential to maximum comfort that the predetermined contour is maintained while moving downwardly about the stationary center, the base is of such form that the springs reach their solid height simultaneously. Therefore, the predetermined contour and proper load distribution is maintained even under shock conditions when the springs bottom. Maximum comfort is therefore maintained in all positions of deflection and when the springs reach solid height under shock or static load conditions because the proper contour is maintained at all positions.

To obtain the height and slope of the surface of the seat cushion which may be required, framing may be built up on the floor of the automobile or on chairs, davenports or the like which supports the standard spring unit. In Fig. 11, we have illustrated a downwardly extending wire frame portion **63** which terminates in an angle element **64** to form a base which may extend en-

tirely around the spring assembly or may be disposed across the front while additional framing is provided in the element in which the seat cushion is disposed for providing additional support. The springs in free height are computed in the same manner from the base portions **59**, **61**, and **62** and the rows of springs will have the same characteristics as the springs in the frame of Fig. 8. In Fig. 8 the seat cushion has a horizontally disposed base frame but this oftentimes is sloped at an angle which would be taken into consideration when computing the free height of the springs.

What is claimed is:

1. A seat cushion made up of a plurality of rows of springs extending from front to back of the cushion, the springs of each row being constructed to maintain a selected contour for a given load distribution for each spring, and for a plurality of different total loads having the same proportional load distribution, the deflection characteristic of said springs being such that the deflection of each spring for a given change in total load so distributed is proportional to the distance from the centerline of the spring to a point approximately 10'' in front of the cushion.

2. A seat cushion made up of a plurality of rows of springs extending from the front to the rear edges thereof, the springs of each row being constructed to maintain a selected contour for a given load distribution, said contour changing its position angularly about a point extending forwardly of the front edge of the seat in the presence of different total loads having the same proportional load distribution.

3. A seat cushion having a plurality of rows of coil springs extending from front to back, a supporting base for said springs, the free height of said springs increasing from front to rear, means for drawing said springs down to a predetermined height, which decreases from front to rear, planes through the top coil of the springs in their free and drawn-down positions intersecting at a point forwardly of the cushion.

4. A seat cushion having a plurality of rows of coil springs extending from front to back, a supporting base for said springs, the free height of said springs increasing from front to rear, means for drawing said springs down to a predetermined height, which decreases from front to rear, planes through the top coil of the springs in their free and drawn-down positions intersecting at a point forwardly of the cushion, the load characteristics of said springs providing a predetermined contour which shifts angularly about said point of intersection as the load on the cushion varies while maintaining the same proportional distribution from the front to the rear of the cushion.

5. A seat cushion made of a plurality of rows of springs extending from the front to the rear edges thereof, a pad disposed on said row of springs, the springs of each row being constructed to maintain a selected contour to the pad for a given load distribution, said contour changing its position angularly about a point extending forwardly of the front edge of the seat in the presence of different total loads having the same proportional load distribution.

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