

Sept. 2, 1952

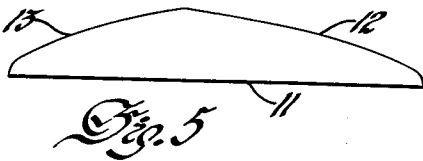
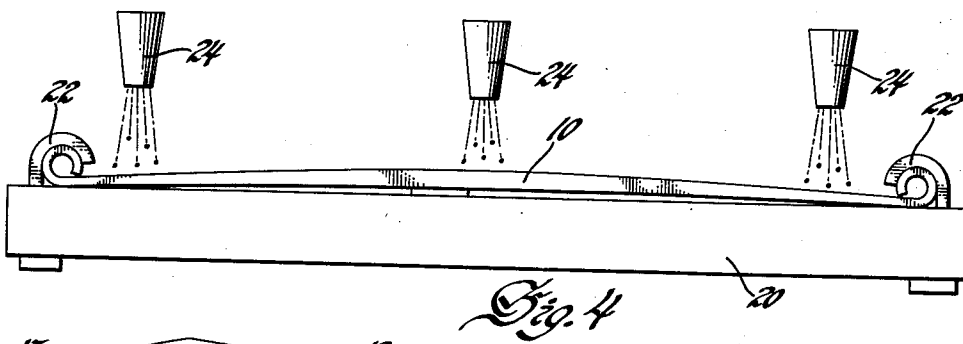
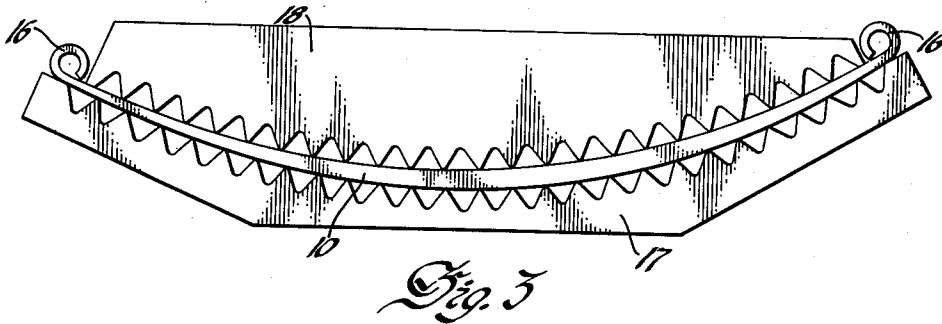
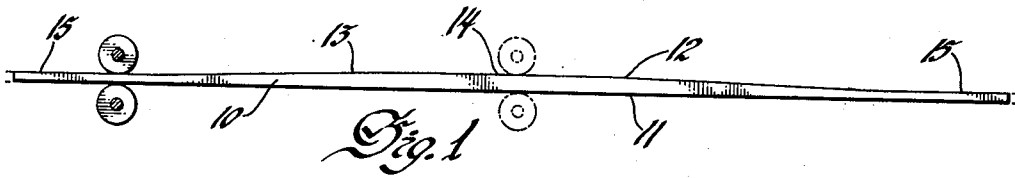
R. SCHILLING

2,608,752

METHOD OF MAKING SINGLE LEAF SPRINGS

Filed Nov. 13, 1947

2 SHEETS—SHEET 1



Inventor
Robert Schilling
By
Spencer, Willits, Helwig & Co.
Attorneys

Sept. 2, 1952

R. SCHILLING

2,608,752

METHOD OF MAKING SINGLE LEAF SPRINGS

Filed Nov. 13, 1947

2 SHEETS—SHEET 2

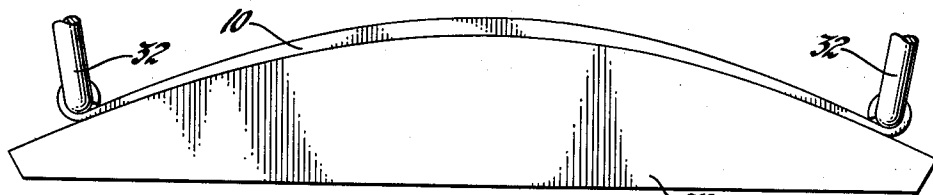


Fig. 7

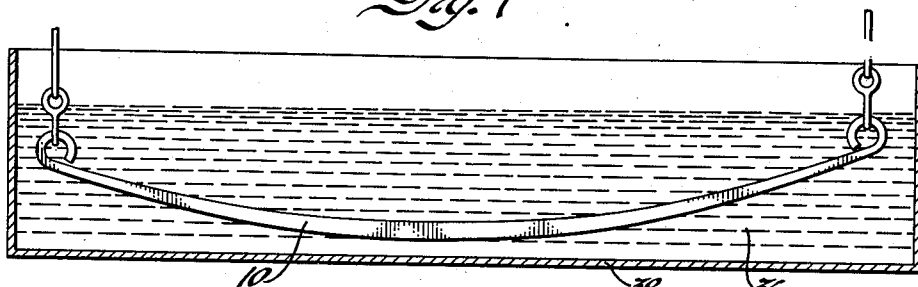


Fig. 8

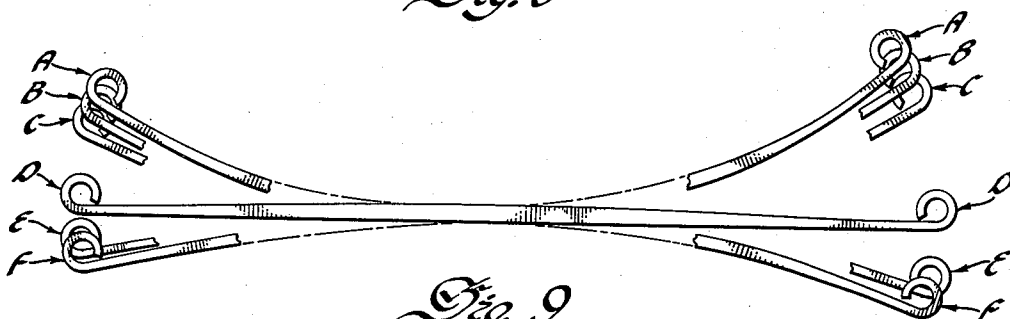


Fig. 9

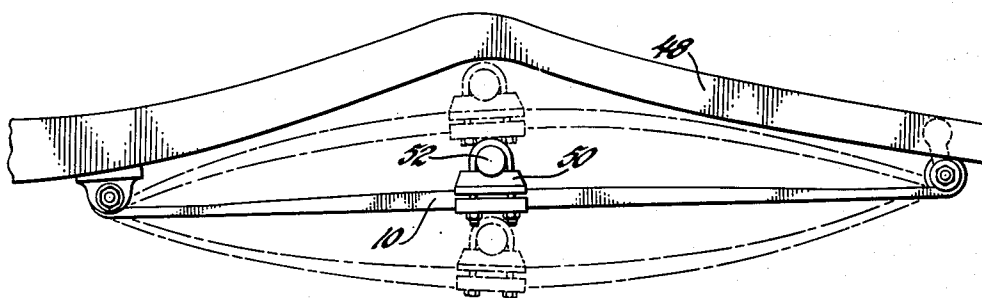


Fig. 10

Inventor

Robert Schilling

By

Spencer Willits, Helwig Baillie
Attorneys

UNITED STATES PATENT OFFICE

2,608,752

METHOD OF MAKING SINGLE LEAF SPRINGS

Robert Schilling, Birmingham, Mich., assignor to
General Motors Corporation, Detroit, Mich., a
corporation of Delaware

Application November 13, 1947, Serial No. 785,763

6 Claims. (Cl. 29—173)

1

This invention relates generally to springs and the manufacture thereof and is more particularly concerned with single leaf springs and the processing thereof.

Conventional leaf springs are laminated and consist of a plurality of blades. In contrast, the leaf spring of the present invention is made out of a single blade.

In order to arrive at a minimum weight, a leaf spring must be designed so that the operating stresses are the same at all points. Consequently a single leaf spring must then have either a variable width, a variable thickness or both. A study of these possibilities has shown that a single leaf spring of substantially constant width and with a variable thickness is most practicable. The preferred form of single leaf spring in accordance with this invention therefore is of constant or substantially constant width and varies in thickness from a maximum at the center to a minimum at points adjacent the two ends thereof. It has about the same length and width as a conventional laminated spring but is much thinner. The design becomes possible because novel processing permits the use of much higher operating stresses than is present practice.

The cross section of the spring blade of the invention may take various forms. Ordinarily it is of rectangular cross section with slightly rounded edges (corner radius $\frac{1}{8}$ to $\frac{1}{4}$ inch). However, special sections such as center groove or parabolic edges are also possible.

The single leaf spring of this invention is especially well suited for rear suspensions of passenger cars. It may be used also for front suspensions although it does not show so many advantages in such instances.

The fastenings to the axle and chassis are similar to those employed with conventional laminated springs. It is preferred not to use a direct metal-to-metal clamp at the spring center, because such a clamp causes a certain amount of chafing which may lead to failures at the high stresses used. A liner of flexible or plastic material is used between the spring blade and clamp, to insure uniform surface pressures and prevent chafing. It is preferred also to avoid the conventional center bolt hole, and to use instead a pair of grooves at the side of the spring at the neutral axis for the purpose of centering the spring and taking longitudinal loads. It is possible to omit the grooves and locate the spring by cementing it to the rubber seat pads.

One important advantage of the single leaf spring of this invention compared with a laminated leaf spring, is its greatly reduced weight. This is brought about by the increased operating

2

stress and the reduction of inactive spring material. The manufacturing cost is reduced in proportion to the lower raw material weight and to the smaller number of parts to be processed.

In operation an important advantage is the elimination of static friction of laminated leaf springs. Spring covers or liners are not needed and the spring requires no servicing. The ride does not change because the variable friction is no longer present.

The primary objects of the invention are to provide a single leaf spring having the advantages outlined above and to provide an improved method or methods of processing such spring. Another object is to provide an improved step or steps in a method of spring processing which is applicable also to other springs than single leaf springs. Other objects and advantages of the invention will be apparent from the description which follows.

Reference is herewith made to the accompanying drawings illustrating a single leaf spring and the processing thereof in accordance with a preferred embodiment of the invention.

In the drawings:

Figure 1 is a view illustrating the step of hot rolling a steel spring blank of substantially uniform width and of a variable thickness.

Figure 2 illustrates the step of forming the eyes on the ends of the spring blank of Figure 1.

Figure 3 illustrates the step of quenching the spring on a curved fixture in the hardening operation.

Figure 4 illustrates the shot peening of a heat treated spring while the spring is under load.

Figure 5 is a diagrammatic view of the ideal contour of a semi-elliptic spring of uniform width and variable thickness having uniform operating stresses at all sections, the spring thickness being shown on a larger scale than is the length.

Figure 6 is a diagrammatic view showing a modification of the ideal contour of Figure 5, the spring thickness being shown on a larger scale than is the length.

Figure 7 shows one form of apparatus which is used for prestressing the spring after it has been shot peened.

Figure 8 illustrates applying a corrosion-resistant coating to protect the spring from corrosion in service.

Figure 9 is a composite view of the different positions or shapes of the spring at different points in the processing and/or operating cycles.

Figure 10 is a view showing the spring installed, the static load position of the spring being shown in full lines and the maximum load position and

the unloaded position being shown in dotted lines.

In forming the single leaf spring, steel or other spring material is hot formed as by rolling or otherwise into the required shape such that the operating stress will be the same or substantially the same at all sections. In Figure 1 is diagrammatically shown the operation of hot rolling a spring blank 10. The blank shown is of constant width and of variable thickness with the portion of maximum thickness at the center of the blank where the spring will be attached to the axle. The bottom face of the spring blank is flat and the upper face is of a contour such that the operating stresses will be substantially equal at all sections.

The ideal contour of a semi-elliptic spring of constant width having uniform operating stresses at all sections is diagrammatically shown in Figure 5. The bottom face 11 is flat and the upper face is formed of two parabolic contours 12 and 13. Figure 6 shows diagrammatically the manner in which the ideal contour of Figure 5 is modified in the design illustrated in the several drawings herein. At the center the two parabolas of Figure 5 are faired by a circular arc 14 which slightly reduces the thickness within the spring length which will be clamped by the center clamp. At the ends 15, 15 the thickness is held constant at a minimum value in order to provide sufficient stock to form eyes. In Figures 5 and 6 the thickness of the spring is shown on an enlarged scale as compared with the spring length in order to illustrate more clearly the contour of the single leaf spring.

The rolling operation may be carried out in any desired way. For example, the rolling may be accomplished in a single pass and in continuous strip form at the steel mill. This may be done at the last pass of the strip rolling process, so that no separate heating is required. The rolling also may be carried out in a number of successive passes in a manner analogous to the taper rolling on blades for laminated springs.

Figure 2 illustrates the step of eye forming. This step is similar to that on the main leaf of laminated springs. The eyes are shown at 16.

After forming the eyes the blade is heat treated. In this operation the spring steel blade is heated to a hardening temperature above A_{c3} . It is then mounted on a quench form such as shown in Figure 3 so shaped as to impart a desired curvature to the heated spring. The fixture shown comprises a lower portion 17 and an upper portion 18 between which the heated spring is held. It is then quenched with oil or by other suitable means to harden the spring. The quench form is designed to allow for changes in shape during subsequent processing steps so that the spring will have the desired shape and standing height in service. The hardened spring is then removed from the quench form and tempered without restraint. This operation consists in reheating the hardened spring to a spring tempering temperature considerably lower than that employed in the hardening operation. The tempering treatment does not change the curved shape of the spring resulting from quenching the spring in the curved fixture. The hardening and tempering temperatures may be the same as those employed in heat treating conventional springs. As a specific example of heat treatment, the spring may be heated to 1600°F. and held at this temperature for about two hours. It is then quenched in oil to harden the same. It is thereafter reheated to a tempering temperature on the

order of $750^{\circ}\text{--}920^{\circ}\text{F.}$, the lower tempering temperatures being employed with steel of lower carbon content and the higher temperatures with spring steel of higher carbon content.

After being hardened and tempered the single blade is shot-peened while under load. The spring blade which is curved when free, is clamped to a form or fixture so that it is approximately flat and under a stress between 125,000 and 200,000 lbs. per square inch (mostly about 175,000 lbs. per square inch) with the tension side exposed. In general the shot-peening is carried out while the spring is loaded in the direction of service loading to a tensile stress on the order of about 60% to 80% of its yield point. The shot-peening is carried out by causing hardened steel shot to impinge upon the tension surface of the spring blade. The shot may be directed by a high velocity air stream against the tension surface, or the shot may be thrown from the periphery of a wheel which is rotating at high speed and caused to impinge upon the tension surface. The spring is passed through the shot-peening machine so that the entire tension side is thoroughly shot-peened. Best results are obtained when the corners adjacent the tensile side are also shot-peened. The shot are caused to travel at such high speed that they effect a cold working of the spring surfaces contacted thereby. Since the spring is already stressed near to its yield point, the effect of the peening is more severe and penetrates more deeply than it would on an unstressed spring. The peening greatly improves the load carrying capacity and the endurance of the spring. At the same time the spring takes a considerable set during peening which must be allowed for when designing the quench form. One means for carrying out the shot-peening operation on the tension side of the spring is illustrated in Figure 4. In this figure, 20 represents a form to which the spring is clamped by means of similar clamps 22. Shot-peening nozzles are shown at 24. For peening the corners adjacent the tension side, the nozzle or nozzles may be arranged at an angle; for example, very effective peening is obtained when the nozzles are at an angle of 45° to the vertical. The peening operation may be carried out in one or more passes through the machine. So far as I am aware, the operation of shot-peening while under load, is novel per se. It can be used also in treating other springs than single leaf springs in order to improve greatly the endurance and load carrying capacity thereof.

After the shot-peening operation the single leaf spring is preset by deflecting it in the direction of service loading without application of heat by an amount which is in excess of the maximum service deflection by between ten and thirty per cent. During presetting the spring takes a further set which also must be considered and taken into account in designing the quench form. The presetting accomplishes two main purposes (1) it minimizes subsequent settling in service and (2) it allows a readjustment of standing height, so that variations due to material and processing can be corrected. One form of apparatus for carrying out the presetting operation is illustrated in Figure 7. In this figure, 30 represents a form against which the spring is deflected by loading means 32. The presetting also may be performed by clamping the blade between male and female forms, or simply by loading it with a load which is in excess of the maximum service load by between ten and thirty per cent.

After presetting the spring has the correct free

5

shape, which shows less curvature than that of the quench form.

The spring preferably is coated after presetting with an anticorrosion coating, such as one of the phosphate treatments (Parkerizing, bonderizing) or painting. The coating operation is illustrated in Figure 8 in which the spring is shown immersed in a coating solution 36 in a tank 38.

Figure 9 is a view showing the various shapes of the spring during processing and operating superimposed. In this figure A illustrates the shape after hardening and tempering, B illustrates the shape after shot-peening, C represents the free shape of the finished spring, D represents the approximate shape at static load, E represents the shape at maximum service load and F represents the shape to which the spring is preset. The difference between shapes A and B is that due to the shot-peening, and the difference between shapes B and C is the set due to presetting. The operating range extends from the free shape of the finished spring (shape C) to the shape at maximum load (position E). The difference between the shape at maximum load (position E) and the shape to which preset (position F) is the margin by which presetting exceeds the maximum operating deflection.

Figure 10 illustrates the single leaf spring as installed. The ends of the spring are shown connected to the chassis 48 in the same general manner as conventional laminated leaf springs. The center of the spring is clamped by the clamp 50 to axle 52. The full line position of the spring shows it in its static load position. The upper broken line position is the maximum load position, while the lower broken line is the unloaded position.

Load capacity and endurance of a spring may be increased if the shot-peening operation is repeated after the presetting of the spring. This can be done with a spring in the free shape condition or in a stressed condition as shown in Figure 4. Best results have been obtained when during the second shot-peening operation the spring was held under approximately the same stress as in the first shot-peening operation. The additional settling of the spring during this operation must also be allowed for in the quenched shape of the spring.

While I have shown what I consider to be a preferred embodiment of my invention, it will be understood that various modifications and rearrangements may be made therein without departing from the spirit and scope of the invention.

I claim:

1. The method of making a single leaf spring characterized by high load carrying capacity and endurance which comprises providing a hardened and tempered steel leaf spring of substantially uniform width and of variable thickness ranging from a maximum at a point substantially midway between the ends to a minimum adjacent each end, flexing said leaf spring to produce a tensile stress on the order of 60% to 100% of its yield point on the tension side of said leaf spring; shot-peening the tension side and adjacent corners of said leaf spring while it is under said tensile stress and then presetting said leaf spring by deflecting it in excess of maximum service deflection by between ten and thirty per cent.

2. The method of making a single leaf spring characterized by high load carrying capacity and endurance which comprises, providing a hardened and tempered steel leaf spring, loading said leaf

6

spring to produce a tensile stress on the order of 125,000 to 200,000 pounds per square inch on the tension side of said leaf spring, shot-peening the tension side of said leaf spring while it is under said tensile stress and subsequently presetting said leaf spring by deflecting it in excess of the maximum service deflection by between ten and thirty per cent.

3. The method of making a single leaf spring characterized by high load carrying capacity and endurance which comprises, providing a hardened and tempered steel spring blade of substantially uniform width and of variable thickness ranging from a maximum at a point substantially midway between the ends to a minimum adjacent each end, flexing said spring blade to produce a tensile stress on the order of 60% to 100% of its yield point on the tension side of said spring blade and shot-peening the tension side and adjacent corners of the spring blade while it is under said tensile stress.

4. The method of treating springs which comprises shot-peening a steel spring while it is loaded in the direction of service loading to a tensile stress on the order of 60% to 100% of its yield point.

5. A method as in claim 1 in which the spring also is subjected to a shot-peening operation after the presetting of the spring.

6. The method of making a single leaf spring characterized by high load carrying capacity and endurance which comprises hot forming steel into a single leaf spring of substantially uniform width and of variable thickness ranging from a maximum at a point substantially midway between the ends to a minimum adjacent each end whereby said steel spring will have substantially uniform operating stresses at all sections, heating said steel spring to a hardening temperature, quenching said heated steel spring to harden the same while the spring is held in a fixture to impart a curvature thereto, reheating the hardened and curved leaf spring to a tempering temperature, flexing said leaf spring to produce a tensile stress on the order of 60% to 100% of its yield point on the tension side of said leaf spring then shot-peening the tension side and adjacent corners of said leaf spring while it is under said tensile stress, and thereafter presetting said leaf spring by deflecting it in excess of maximum service deflection by between ten and thirty per cent.

ROBERT SCHILLING.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
318,863	Brown	May 26, 1885
937,180	Ridd	Oct. 19, 1909
1,101,586	Thomas	June 30, 1914
1,859,104	Munro	May 17, 1932
2,155,073	Ziska	Apr. 18, 1939
2,211,647	Collier	Aug. 13, 1940
2,234,850	Wallace	Mar. 11, 1941
2,249,678	Wallace	July 15, 1941
2,252,823	Wallace	Aug. 19, 1941
2,422,431	Melrose	June 17, 1947

OTHER REFERENCES

Publication, "Machinery," vol. 51, No. 12, August 1945, pages 141-149.