

Sept. 6, 1949.

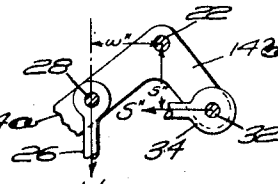
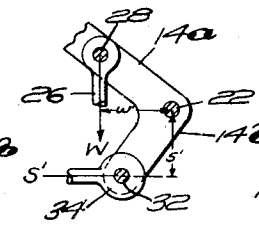
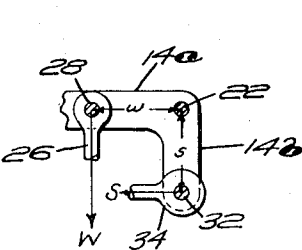
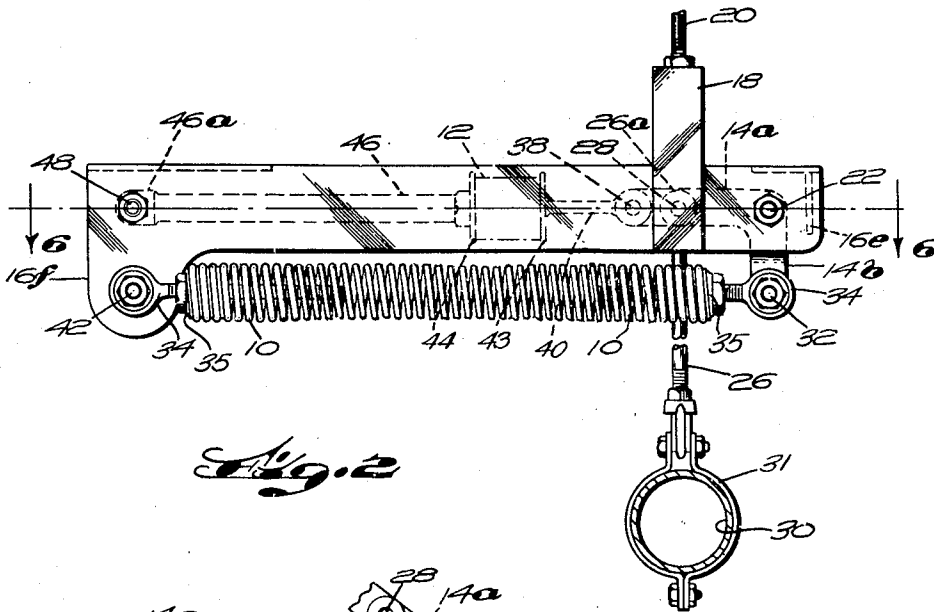
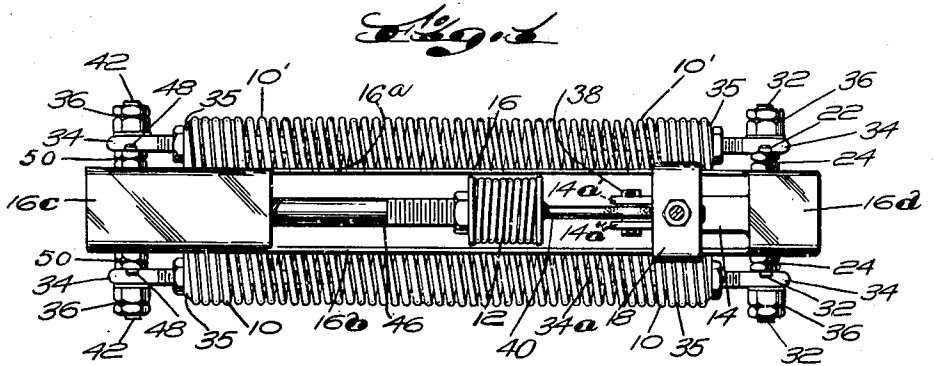
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2,480,864

SPRING SUPPORT

Filed April 30, 1947

4 Sheets-Sheet 1



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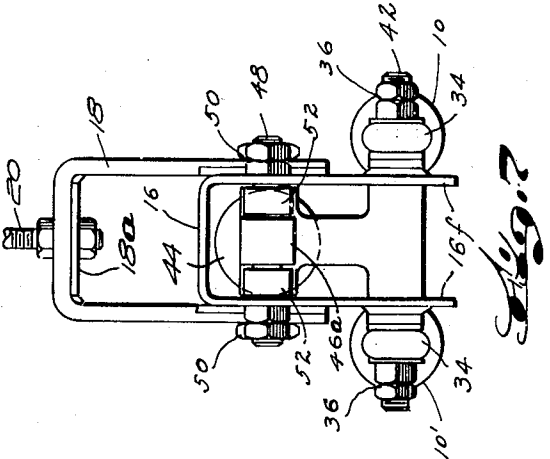
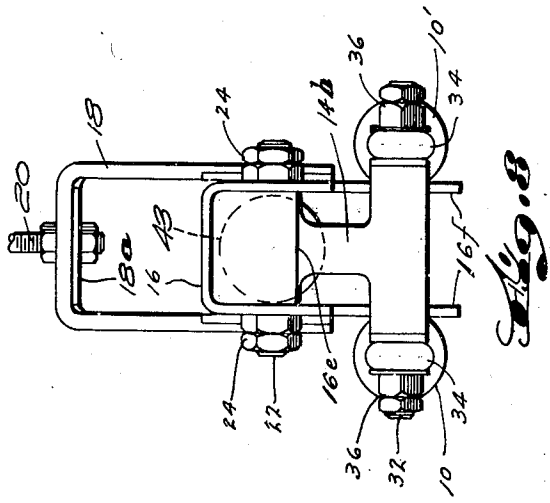
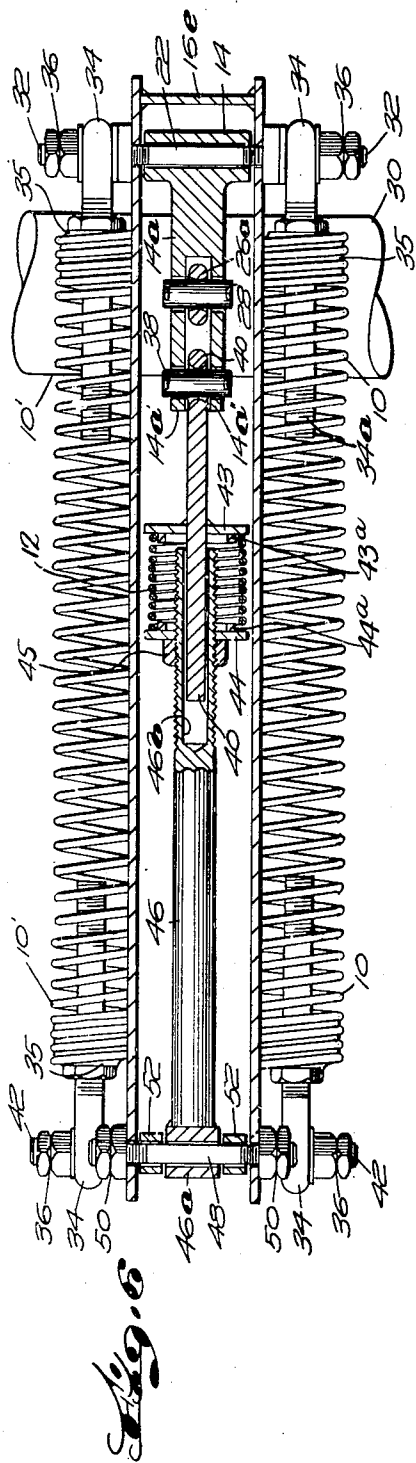
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SPRING SUPPORT

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4 Sheets-Sheet 2



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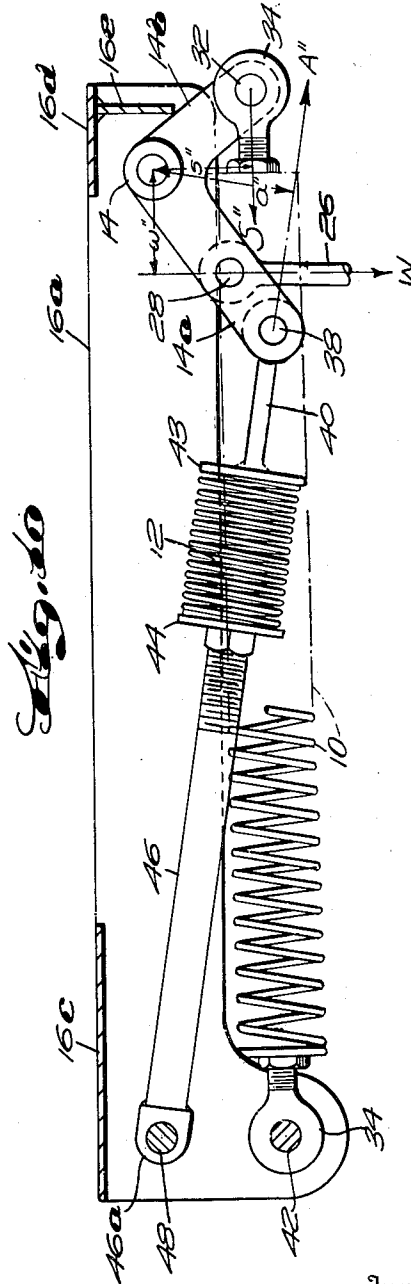
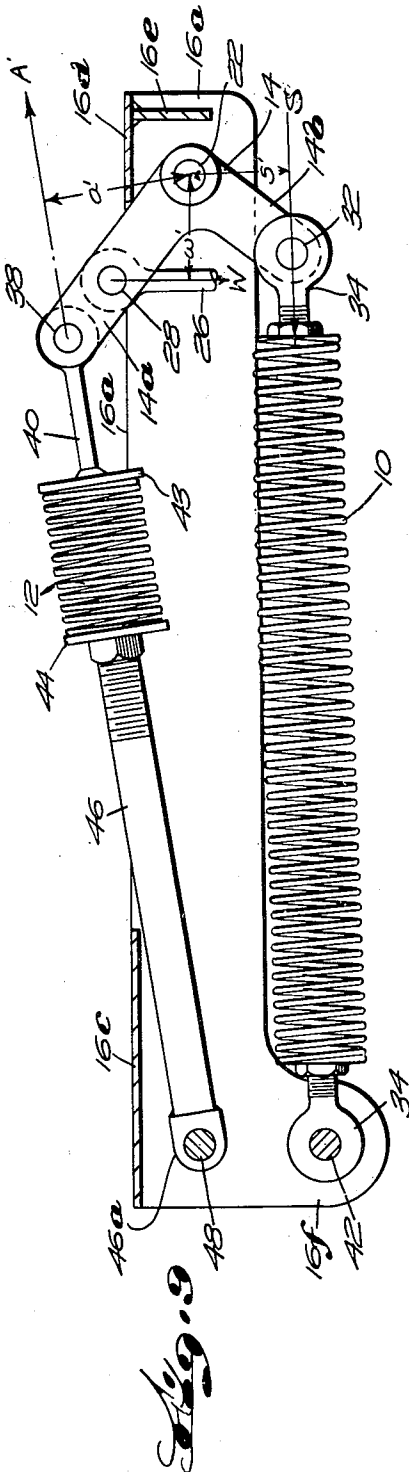
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SPRING SUPPORT

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4 Sheets-Sheet 3



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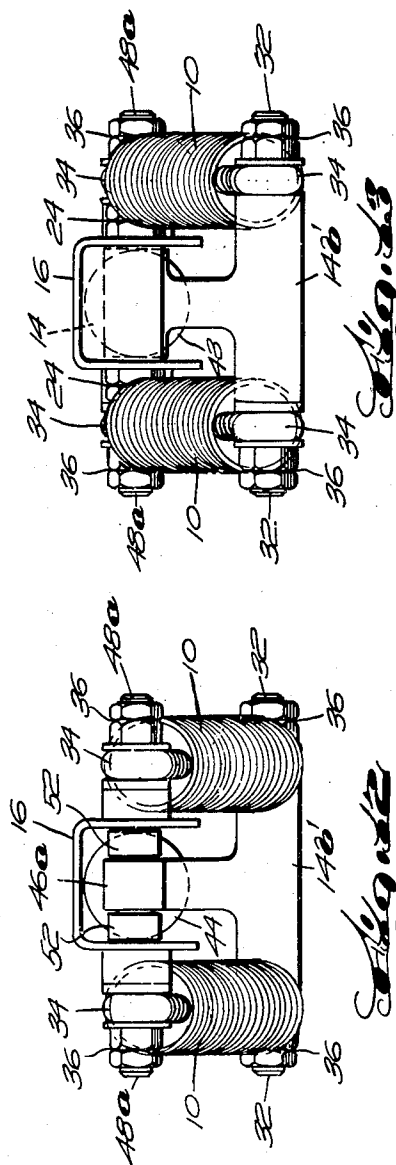
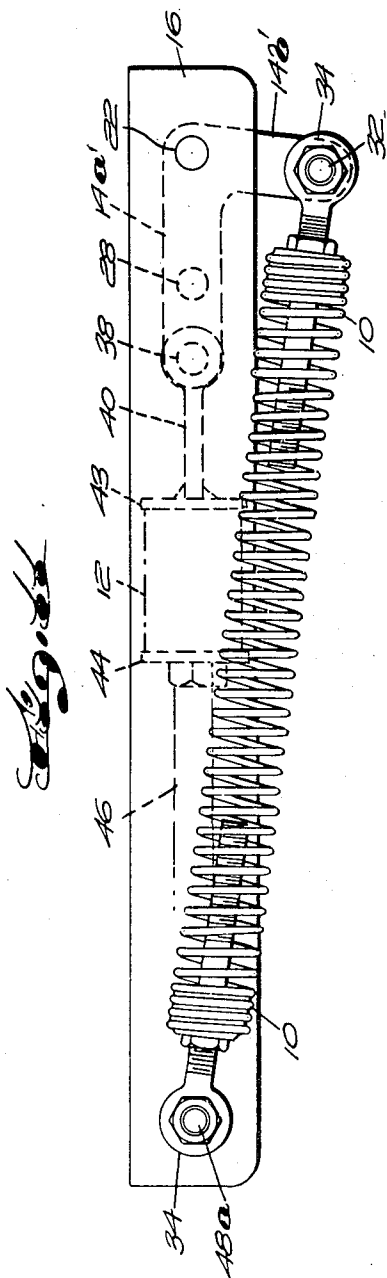
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2,480,864

SPRING SUPPORT

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,480,864

SPRING SUPPORT

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Application April 30, 1947, Serial No. 744,852

11 Claims. (Cl. 248—54)

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This invention relates to improvements in spring supports. More especially it has to do with a spring support which within the limits of its range permits a known load to move without being subjected to any substantial change in the lifting effect afforded by the support.

The present support is generally of the same type and for the same purpose as that disclosed in my Letters Patent No. 2,391,467, granted December 25, 1945, but whereas in that patented support the primary lifting effect was supplied by direct acting main spring means and the variations in that effect were compensated for by a component of the force of auxiliary spring means, here both the supporting effect and the compensating effect of the spring means act through a lever system in accordance with the principle of moments.

Illustrative of a known load with which the improved support is usable is a piping system for conducting a fluid subject to wide variations in temperature. When the temperature rises the pipes in the system elongate and their elongation may reach several inches. This change in length of the vertically disposed portions of the piping system causes the horizontal portions to move upward or downward as well. The upper limit of the displacement is commonly called the "hot" position and the lower limit the "cold" position of the system. These positions may of course be reversed if the piping moves downward as its temperature increases.

Except for relatively inconsequential changes the weight of the piping system remains substantially constant. It is therefore important that the lifting effect of the supporting means likewise remain substantially constant regardless of the movement of the piping because if the load is not properly supported at all times its movement may impose unsafe stresses and reactive forces upon the piping itself or the fittings or apparatus to which it is connected, or upon both.

Therefore, the principal object of this invention, like that of my aforesaid Letters Patent No. 2,391,467, is to provide a spring support capable of exerting a substantially constant lifting effect on a load throughout its anticipated range of movement and to do this by combining with main spring means, whose supporting effect necessarily changes as such means are elongated or contracted in accordance with the load movements, auxiliary spring means which compensates for the variation in the supporting effect of the main spring means. It is also among the objects of the invention to provide apparatus

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which is simple in construction, requires but little space of vertical extent, can be readily adjusted, and which follows the law of moments in its operation.

The best modes in which it has been contemplated applying the principles of these improvements are shown in the accompanying drawings but these are to be deemed merely illustrative because it is intended that the patent shall cover by suitable expression in the appended claims whatever features of patentable novelty exist in the invention disclosed.

In the drawings:

Fig. 1 is a top plan view of a spring support embodying my improvements and showing the positions of the parts when the load is preferably at the mid-point of its range of travel;

Fig. 2 is a side elevation of the same;

Figs. 3, 4 and 5 are elevations of certain of the elements to show variations in some of the moments involved;

Fig. 6 is a plan in section taken as on line 6—6 of Fig. 2;

Fig. 7 is an elevation looking from the left in Fig. 2, the piping being omitted;

Fig. 8 is another elevation looking from the right in Fig. 2, again with the piping omitted;

Fig. 9 is a side elevation showing the relative positions of parts of the support when the load has moved upward from its preferred mid-position;

Fig. 10 is another side elevation showing the relative positions of parts when the load has moved downward from its preferred mid-position;

Fig. 11 is another elevation, similar to Fig. 2, but showing a modified arrangement of the lever and the main spring means;

Fig. 12 is a left end elevation of the support shown in Fig. 11; and

Fig. 13 is a right end elevation of the same.

In the embodiment of the invention shown in the drawings, the main spring means is a pair of tension springs 10, 10' and the auxiliary spring means is a compression spring 12. These spring elements and a rotatable element 14 are mounted on a rigid frame 16 which can be secured to some fixed structural member (not shown) such as an I-beam or the like.

The frame 16 comprises a pair of side plates 16a and 16b held in parallel spaced relation by horizontal top plates 16c and 16d, which may be integral with or secured to the side plates along their upper edges near the ends thereof, and by a vertical plate 16e interposed between the side

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plates close by one end of the frame. Near this same end of the frame a U-shaped yoke piece 18 has its legs secured to the side plates, preferably by welding, and to the cross bar of this yoke is attached a tie rod 20 which in turn may be connected to some overhead structural member. If desired, a reinforcing plate 18a (see Fig. 7) may be inserted under the cross bar of the yoke.

An axle 22 extends through the side plates and is clamped thereto by nuts 24 threaded onto the projecting ends. This axle is positioned between the vertical spacer plate 16e and the U-shaped yoke piece 18 and on it is mounted the rotatable element, here shown as a simple bell crank lever 14 whose arms 14a and 14b, as seen in Figs. 1 to 10 inclusive, are disposed at right angles to one another. Other forms of lever and indeed several levers could be used instead of the simple bell crank, provided only that whatever lever system is employed the principle of moments herein disclosed should be applied to the lever or system of levers incorporated in the support. As here shown the upper or what may be called the horizontal arm 14a extends toward the opposite end of the frame and is bifurcated (see Fig. 6) to permit the eye 26a of a hanger rod 26 to be positioned between the separated parts 14a' and 14a'' of the arm 14a about an axle pin 28 extending across the separated parts and held in place by cotter pins inserted through holes of the pin outside the arm parts. The load, here represented by a pipe 30 secured to the lower hanger rod 26 by any suitable means such as a pipe clamp 31, hangs vertically downward from the horizontal arm 14a of the bell crank.

The main spring means preferably consists of the two main tension springs 10, 10' which act upon the depending arm 14b of the bell crank. This arm carries an axle 32 on each end of which is an eye bolt 34. Suitable washers are provided on both sides of each eye bolt and a pair of nuts 36 are threaded on each end of the axle to provide for proper adjustment and for locking. On each eye bolt 34 is threaded the usual end plug 35 for engaging a spring, the plug having external helical grooves along which several turns of the springs are wound and having a central threaded bore through which the shank 34a of the eye bolt is screwed. This same arrangement is provided at the opposite end of each main spring (the corresponding parts having the same reference numerals), where the main springs are pivotally attached to another axle 42 carried in depending portions 16f of the frame side plates. This axle 42, as shown in Figs. 1 to 10, is welded to the side plates and has reduced portions for the eye bolts 34 and threaded end sections to receive the adjusting and locking nuts 36.

The parts thus far described are shown in Figs. 1 and 2 when the upper arm 14a of the bell crank is horizontal. The same position of the bell crank is reproduced in Fig. 3. The load hangs vertically from the axle pin 28 and therefore the moment exerted on the bell crank by the load is the weight W of the load times its moment arm, the latter being the perpendicular distance w from the axis of axle 22 to the line of force of the load. The moment exerted on the bell crank by the main spring means is the force S of the two main springs times the moment arm of this spring force. This moment arm is the perpendicular distance s from the axis of axle 22 to the line of force of the main springs.

As shown in the drawings the two moment

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arms w and s are equal. While this is the preferred relation of these arms they could be of different lengths if desired and this would make no difference in the principle of operation but would only change the spring force proportionally to the difference between the lengths of the moment arms. With the moment arms w and s equal, the main springs are chosen or adjusted so that when the load is at a position corresponding to the horizontal position of the bell crank arm 14a the spring force S equals the weight W of the load. Expressed as an equation $W \times w = S \times s$.

If now the load moves upward so that the bell crank assumes the position shown in Fig. 4, (which might be deemed the "hot" position of a piping system), the load moment changes because, although the weight W remains the same, the new moment arm w' is less than was the moment arm w . The new moment arm s' of the main springs is also less than was the moment arm s , but is substantially the same as the moment arm w' . The spring force S' exerted by the springs is now less than was the force S because the main springs have contracted. The change in spring force is the product of the spring constant times the reduction in length of the springs. Accordingly, the new moments can be expressed as $W \times w' > S' \times s'$ and since, as noted above, w' and s' are substantially equal it follows that the spring force S' is now less than the load W .

Conversely, if the load moves downward to bring the bell crank to the position shown in Fig. 5 (which could be the "cold" position of a piping system), the load W remains unchanged but its moment arm w'' is less than was the moment arm w . The moment arm s'' is substantially equal to the moment arm w'' but less than was the moment arm s . The spring force S'' is now greater than was the spring force S because the main springs have been elongated. Accordingly, the new moments can be expressed as $W \times w'' < S'' \times s''$ and since w'' equals s'' , the spring force S'' is now greater than the load W . And here again the change in the spring force is the product of the spring constant times the change in the length of the springs.

For purposes of illustration, the upward position of the load shown in Fig. 4 is as far above the position shown in Fig. 3 as the position shown in Fig. 5 is below the position shown in Fig. 3. Accordingly, the spring moment at the position shown in Fig. 4 is as much less than the load moment at that position as the spring moment at the position shown in Fig. 5 is greater than the load moment at that position.

It is clear from the above that except when the bell crank is in the position shown in Figs. 2 and 3, the supporting effect of the main springs is different from the load being supported, and that the change in supporting effect varies solely in accordance with the movement of the load and the change in the force of the main springs. In other words, the moment exerted on the bell crank by the main spring means increases or decreases as the main spring force increases or decreases, respectively. This variation in the supporting effect supplied by the main springs is not desirable because it is precisely the same as though the load were hanging from a spring in tension or resting on a spring in compression with no intervening bell crank or other leverage mechanism interposed between them. As the main springs are contracted the

supporting effect decreases and as these springs are elongated the supporting effect increases. In one case undesired stresses are imposed on the remainder of the piping system by the unsupported portion of the weight of the load and in the other case other such stresses are imposed by the excess supporting effect of the main spring means. Both of these dangerous results are avoided by the compensating feature of the improved support.

This compensating feature is provided by having an auxiliary spring interposed and so disposed between the frame and the bell crank that it will exert a turning moment on the bell crank except when the main spring moment alone counterbalances the load moment.

Beyond the load axle pin 28, in direction away from the main axle 22, a second axle pin 38 extends between the bifurcated parts 14a' and 14a'' of the upper arm of the bell crank. (See Fig. 6.) To this second pin is connected an extended rod 40 which has secured to it a plate 43 having on its surface remote from the eye of the rod a ring 43a constituting a flange for retaining one end of the auxiliary spring 12 on the plate surface. The other end of this spring is retained by a similar flange ring 44a on the surface of a second plate 44 threaded on a rod 46 and backed up by a locking nut 45. The rod 46 extends to near the end of the frame side plates 16a and 16b where its hub 46a bears on an axle 48 extending between the side plates and being secured thereto by nuts 50 on its projecting ends. Suitable spacer sleeves 52 maintain the hub 46a at the middle of the axle pin 48 and thus keep the rod 46 in alignment with the rod 40 pivoted on the bell crank. Indeed, the rod 46 has a bore 46b to receive the rod 40 as shown in Fig. 6. With the rods 40 and 46 in direct alignment with the upper arm 14a of the bell crank, as seen in Fig. 2, it is evident that the auxiliary spring 12 has no effect whatever on the lifting effect afforded by the support because the line of force of the auxiliary spring extends through the axis of the axle 22, which axis may also be called the pivot of the rotatable element, and hence its moment arm is zero.

The compensating action of the auxiliary spring can best be described by reference to Figs. 9 and 10. In Fig. 9, the bell crank 14 is in the same position as is shown in Fig. 4 and, as previously described, the load moment is not counterbalanced by the main spring moment because with the main springs contracted the main spring moment is less than the load moment. However, the clockwise swing of the bell crank has caused the rods 40 and 46, associated with the auxiliary spring 12, to assume a position where now the auxiliary spring exerts a turning moment on the bell crank. The moment arm a' of the auxiliary spring force A' is the perpendicular distance from the axis of the axle 22 to the axis line of the rods 40 and 46, which is the direction of the force A' exerted by the auxiliary spring. Since this moment arm can readily be determined, it only remains to choose an auxiliary spring of the proper force and then adjust the plate 44 by screwing it along the rod 46 until the auxiliary spring exerts a moment on the bell crank equal to the difference between the load moment and the main spring moment. By adding this auxiliary spring moment to the main spring moment, since both moments are being exerted clockwise on the bell crank, the two together will counterbalance the load moment which

is always acting counterclockwise on the bell crank. Thus the net lifting effect of the support will be the same when the bell crank is in the position shown in Figs. 4 and 9 as it was when the bell crank was in the position shown in Figs. 2 and 3 and hence there will be no material change in supporting effect on the piping system despite its upward movement. Expressed in the form of an equation, $W \times w' = S' \times s' + A' \times a'$.

A like counterbalance occurs if the load moves downward so that the bell crank assumes the position shown in Fig. 10, which is the same position as shown in Fig. 5. In this instance the lifting effect of the main springs has increased due to the elongation of these springs. But now the swing of the bell crank has caused the auxiliary spring 12 and the rods 40 and 46 to move to a position where the auxiliary spring exerts a moment in the counterclockwise direction. This moment is the product of the moment arm a'' times the force A'' of the auxiliary spring. If, as shown for purposes of illustration, the downward movement of the load in Fig. 10 is the same as the upward movement indicated in Fig. 9, then the moment of the auxiliary spring is the same in both positions except that in the upper position it is acting in a clockwise direction whereas in the lower position it is acting counterclockwise. Accordingly, since the main spring moment at the lower position of Figs. 5 and 10 is as much greater than the load moment as it was less than the load moment at the upper position of Figs. 4 and 9, it follows that the net spring moment is the same at both the upper and lower positions and is equal to the spring moment at the positions of Figs. 2 and 3. Expressed as an equation for the lower position, $W \times w'' = S'' \times s'' - A'' \times a''$. Thus again the system is in balance and the lifting effect on the piping is the same as when the load was supported solely by the lifting effect exerted by the main springs alone.

By suitable selection of springs, both main and auxiliary, together with the adjustments provided for all the springs, the support will afford a substantially constant lifting effect on the load throughout its anticipated range of movement. When the direction of the line of force of the auxiliary spring passes through the axis of the main axle 22, as shown in Fig. 2, the auxiliary spring exerts no turning moment whatever and the load moment is then counterbalanced solely by the moment of the main springs. As the bell crank swings in either direction, there is established a moment arm for the force of the auxiliary spring, small at first as the bell crank begins to swing and the force of the auxiliary spring is greatest. Then as this spring force lessens due to the elongation of the auxiliary spring its moment arm becomes appreciably greater and at a greater rate than the force of the auxiliary spring diminishes. As a result the moment of the auxiliary spring keeps pace with the change in the moment of the main springs and in sufficiently close step therewith to provide substantially a constant supporting effect on the load throughout its anticipated movement.

It is to be noted that although the preferred use of the improved support contemplates that the load shall be at the mid-position of its travel when the arm 14a of the bell crank is horizontal, this is not a requirement. The position of the load with the arm 14a horizontal may be either at the top of its anticipated displacement or at the bottom thereof, and, indeed, the limits of

travel of the load may be with the arm 14a either wholly above or below its horizontal position. For any one size of support such an arrangement would necessarily reduce the range of travel of the load and so it is preferred to have the load at its mid-position of its displacement when the arm 14a of the bell crank is horizontal as shown in Fig. 2.

The modification disclosed in Figs. 11 to 13 performs in precisely the same manner as already described. In this arrangement the main springs are mounted on the same axle 48a on which the rod 46 of the auxiliary spring is pivoted. In this arrangement the bell crank arms 14a' and 14b' are so disposed that when the upper arm 14a' is horizontal, the axial line of the lower arm 14b' (being the axial line between the axis of the main axle 22 and the axis of the spring axle 32) is perpendicular to the longitudinal axes of the main springs. If the moment arms of the load and the main spring force are equal when in the positions just described, then they will vary in the same amount upon movement of the load either upward or downward and thus the change in supporting effect provided by the main springs will vary as these springs are elongated or contracted. As before, the lifting effect of the main springs on the load varies just as it would if there were no bell crank and the load were hanging directly from the main springs. But this variation is compensated for by the action of the auxiliary spring because its moment will be either added to or subtracted from that of the main springs as the load moves upward or downward respectively.

Although I have shown in the drawings main spring means employing tension springs and auxiliary spring means using compression springs, this particular arrangement is only illustrative because the spring means as a whole may comprise various combinations of compression and/or tension springs. Regardless of the kind of springs used the essence of my improvements is to so apply the force of these springs that the moment arm of the weight of the load and the moment arm of the force of the main spring means remain substantially equal, or in substantially the same proportional relation or ratio to each other as the load is displaced and the moment exerted by the main spring varies from the load moment in accordance with the change in the main spring force. And the moment exerted by the auxiliary spring means varies as the load is displaced to compensate for the aforesaid variation in the moment of the main spring means. Thus the net supporting effect exerted by both spring means on the load remains substantially constant throughout the range of travel of the load.

I claim:

1. A spring support for a load of known value subject to displacement within a predetermined range, comprising a fixed element; a rotatable element to which the load is connected and on which the load exerts a turning moment in one direction; main spring means connected to said fixed element and to said rotatable element and exerting a turning moment on the latter element in direction opposite to that exerted by the load, the said main spring means and the said load operating on the said rotatable element in such manner that throughout the said range of displacement the moment arms of the said turning forces have substantially the same proportional relation and the moment exerted by said main spring means increases or decreases as the main

spring force increases or decreases, respectively; and auxiliary spring means interposed between said fixed element and said rotatable element and effective upon movement of the load to exert a turning moment on the rotatable element which compensates for the variation in the turning moment exerted by the main spring means; the moments of said load and said main spring means being in balance when the line of force of said auxiliary spring means passes through the pivot of the said rotatable element.

2. A spring support for a load of known value subject to displacement within a predetermined range, comprising a fixed element; a rotatable element to which the load is connected and on which the load exerts a turning moment in one direction; main spring means connected to said fixed element and to said rotatable element and exerting a turning moment on the latter element in direction opposite to that exerted by the load, the said main spring means and the said load operating on the said rotatable element in such manner that throughout the said range of displacement the moment arms of the weight of the load and of the force exerted by the main spring means maintain substantially the same ratio to each other; the said main spring exerted moment being equal to the load moment at one position of the load and varying therefrom substantially in accordance with the change in the force of the main spring means as the load is displaced from the said position; and auxiliary spring means interposed between said fixed element and said rotatable element in such manner that the force of the auxiliary spring means is wholly exerted on the pivot of the said rotatable element when the load is at the said position and upon movement of the load from said position exerts a turning moment on the rotatable element which compensates for the variation in the turning moment exerted by the main spring means, whereby the net turning moment exerted by both said spring means remains substantially equal to the turning moment exerted by the load.

3. A spring support for a load of known value subject to displacement within a predetermined range, comprising a fixed element; a lever system rotatable on said fixed element and having connection with the load; main spring means connected to the fixed element and to the said system; the said main spring means and the said load operating on the said system in such manner that as the system is rotated by displacement of the load the proportional relation between the moment arm of the weight of the load and the moment arm of the force of said main spring means remains substantially constant, and the moment exerted by the main spring means on said system is in balance with the load moment at one position of said system and varies substantially in accordance with the change in the main spring force as the load is displaced; and auxiliary spring means connected to said fixed element and to the said system for exerting a turning moment thereon to compensate for the said variation between the load moment and the moment exerted by the main spring means; the force of said auxiliary spring means passing through the pivot of said system when the said load and main spring moments are in balance.

4. A spring support for a load of known value subject to displacement within a predetermined range, comprising a fixed element; a lever rotatable on said fixed element and having connection with the load; main spring means connected

to the fixed element and to the said lever; the said load and the said main springs operating on the said lever in such manner that as the lever is rotated by displacement of the load the turning moment exerted on the lever by the main spring means increases or decreases as the force of the main spring means increases or decreases, respectively; and auxiliary spring means connected to said fixed element and to the lever for exerting a turning moment thereon to compensate for the variation in the turning moment exerted by the main spring means; the force of said auxiliary spring means acting along a line on one side of the pivot of said lever when the load moment exceeds the moment of the main spring means and acting along a line on the opposite side of the pivot of said lever when the load moment is less than the moment of the main spring means.

5. A spring support for a load of known value subject to displacement within a predetermined range, comprising a fixed element; a lever rotatable on said fixed element and having an arm connected to the load; main spring means connected to the fixed element and to another arm of said lever; the load and said main spring means operating on the said lever in such manner that as the lever is rotated by displacement of the load the relation between the moment arm of the weight of the load and the moment arm of the force of said main spring means remains substantially constant and the moment exerted by the main spring means on said lever varies substantially in accordance with the change in the main spring force as the load is displaced; and auxiliary spring means connected to said fixed element and to an arm of the lever for exerting a turning moment thereon to compensate for the said variation between the load moment and the moment exerted by the main spring means; the moments of the said load and of the said main spring means being in balance when the line of force of the auxiliary spring means is in alignment with one arm of the lever.

6. A spring support for a load of known value subject to displacement within a predetermined range, comprising a frame; a lever pivoted on said frame with one arm thereof connected with the load; main spring springs connected with the frame and with the other arm of the lever; the said load and the said main spring means operating on the said lever in such manner as to tend to rotate it in opposite directions of rotation; and auxiliary spring means connected with the frame and with the arm of the lever which is connected with the load; the force of said auxiliary spring means exerting a turning moment in the same direction of rotation as does the load when the load moment is less than the moment exerted by the main spring means, and exerting a turning moment in the same direction as does the main spring means when the load moment is greater than the moment exerted by the main spring means; the main and auxiliary springs means together providing a net supporting effect substantially equal to the load throughout the displacement thereof.

7. A spring support for a load of known value subject to displacement within a predetermined range comprising a frame having depending side members; an axle journaled in said side members near one end thereof; a lever rotatable on said axle having an arm thereof connected to the load; main spring means connected to the frame

near the opposite end thereof and to another arm of said lever; the load and the main spring means operating on the lever in such manner that as the lever is rotated by displacement of the load the turning moments exerted by the load and main spring means are in opposite directions of rotation and the moment arms of the load and of the main spring means maintain substantially the same proportional relation to one another; and auxiliary spring means connected to the frame near said opposite end thereof and to the lever for exerting a turning moment thereon to compensate for the variation in the turning moment exerted by the main spring means; the force of said auxiliary spring means acting along a line on one side of the said axle when the moment exerted by the main spring means exceeds the load moment and acting along a line on the other side of the said axle when the load moment exceeds the moment exerted by the main spring means.

8. A spring support for a load of known value subject to displacement within a predetermined range, comprising a frame; a lever pivoted on said frame with one arm thereof connected with the load; main spring means connected with the frame and with the other arm of the lever; the said load and said main spring means operating on said lever in such manner that they exert turning moments about the pivot of said lever in opposite directions of rotation; and auxiliary spring means connected with the frame and with the arm of the lever which is connected with the load; the said spring means together providing a net supporting effect substantially equal to the load throughout the displacement thereof; the said lever arms being so disposed and arranged in such manner that when the line of force of the load is at right angles to the axis of the lever arm connected with the load, the line of force of the main spring means is perpendicular to the axis of the lever arm connected with said spring means.

9. A spring support for a load of known value subject to displacement within a predetermined range, comprising a frame; a lever pivotally mounted on said frame with one arm thereof connected with the load so that the weight of the load exerts a turning moment on said lever in one direction; main spring means connected between said frame and the other arm of said lever so that the force of said main spring means exerts a turning moment on said lever in the reverse direction; the load and main spring means operating on the lever in such manner that when the load is at one position of the said range of displacement the moment exerted by its weight is equal to the moment exerted by the force of said main spring means and when the load moves either way from said position the moment exerted by the force of the main spring means increases as the said force increases and decreases as the said force decreases; and auxiliary spring means connected with the frame and said lever for exerting a turning moment in the same direction as that of the moment exerted by the main spring means when the load moves in one direction from said position and for exerting a turning moment in the same direction as that of the moment exerted by the weight of the load when the load moves in the opposite direction from said position; the net moment exerted by said main spring means and said auxiliary spring means being substantially equal to

the moment exerted by the weight of the load throughout its movement.

10. A spring support for a known load subject to displacement within a limited range, comprising a frame; a lever pivoted on said frame and having one arm connected with the load and so disposed that when the load is at one position of said predetermined range the arm is horizontal and perpendicular to the line of pull of the load; main spring means connected to the frame and to another arm of said lever, the said other arm being so disposed that when the load is at the said position the said other arm is perpendicular to the line of the force exerted by said main spring means; and auxiliary spring means connected to said frame and to one of the lever arms and being so disposed that when the load is at the said position the line of the force exerted by said auxiliary means passes through the pivot of the lever whereby the force of said auxiliary means exerts no turning moment at the said position of the load.

11. A spring support for a load of known value subject to displacement within a predetermined range, comprising a fixed element; an element pivoted on said fixed element and rotatable about said pivot; the load being connected to said rotatable element and exerting a turning moment in one direction about said pivot; main spring means connected to said fixed element and to said rotatable element and exerting a turning moment on the latter element in the opposite direction about said pivot; the said main spring means and the said load operating on the said rotatable element in such manner

that throughout the said range of displacement the moment arms of the said turning forces have substantially the same proportional relation and the moment exerted by the said main spring means increases or decreases as the main spring force increases or decreases, respectively; and auxiliary spring means interposed between said fixed element and said rotatable element and effective upon movement of the load to exert a turning moment on the rotatable element which compensates for the variation in the turning moment exerted by the said main spring means; the force of said auxiliary spring means when acting along a line on one side of said pivot exerts a turning moment on the rotatable element in the same direction of rotation as does the force exerted by the main spring means, and the force of said auxiliary spring means when acting along a line on the opposite side of said pivot exerts a turning moment on the rotatable element opposite in direction of rotation to that of the moment exerted by the force of the main spring means.

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