United States Patent

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[54] **SELF-STABILIZING SUSPENSION SYSTEM**
12 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **248/17,** 210/364
[51] **Int. Cl.** **F16f 15/00**
[50] **Field of Search** 248/17, 18, 358, 317, 318, 323, 324, 325, 327, 328; 211/113, 115, 116, 117, 118, 119; 210/364

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ABSTRACT: A suspension system particularly adapted for use in an automatic clothes washer is provided for supporting a load member, upon which are mounted the dynamic components of the washer, from a stationary support member such as a tub. At least three bilink elements are provided, each having one end pivotally connected to a separate point on the support member and the other end pivotally connected to a separate point on the load member. Means are provided which pivotally connect with each of the bilink elements at the point of juncture of the links thereof, whereby the center of gravity of the dynamic load will rise under any movement of the load member relative to the support member from the position of equilibrium thereof.

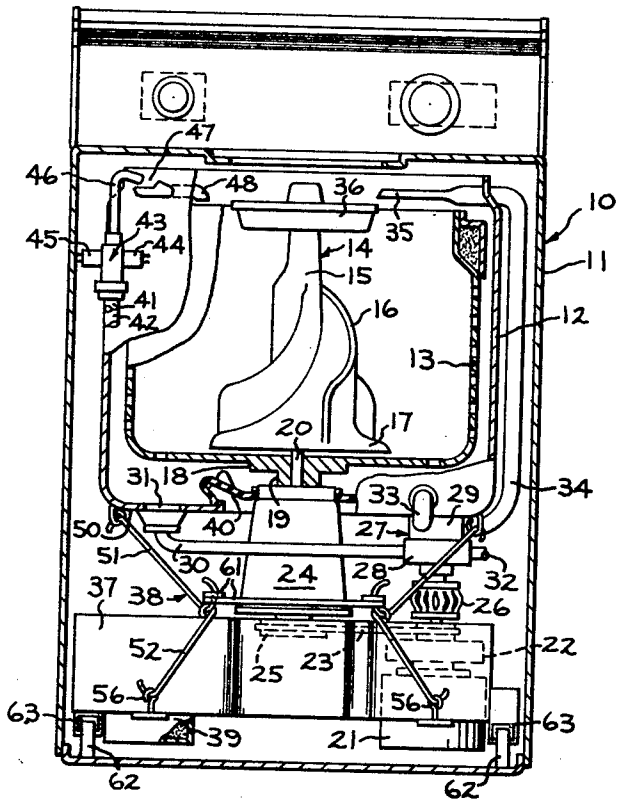


FIG. 1

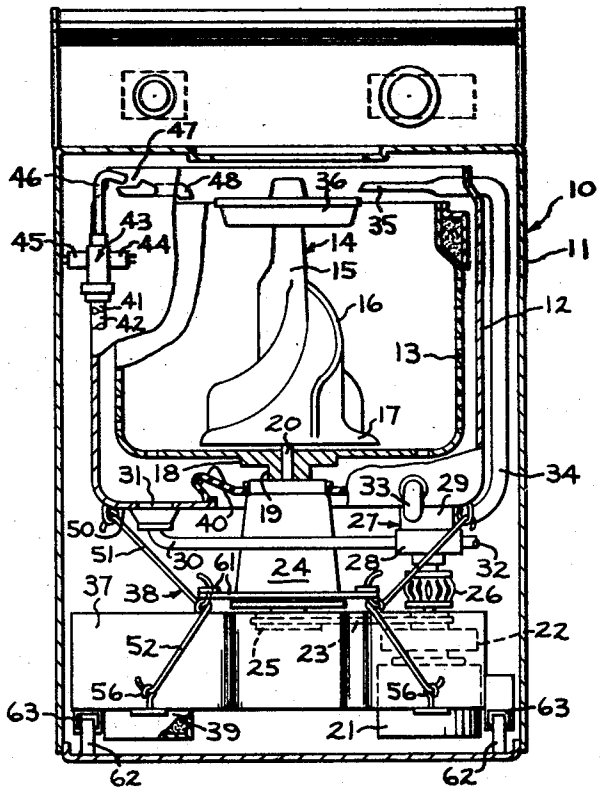
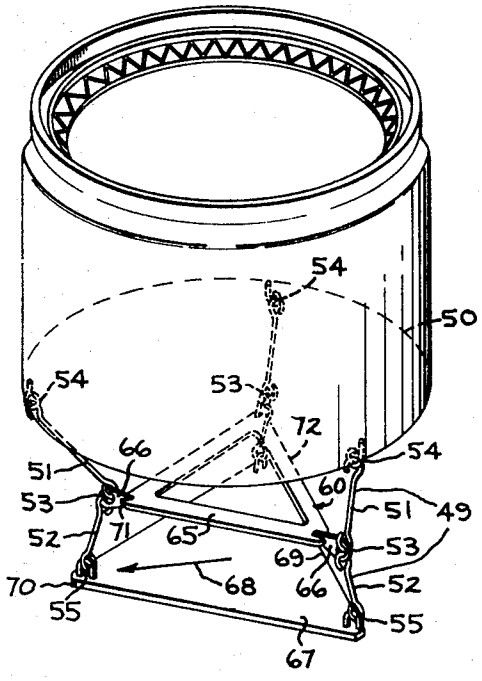


FIG. 3



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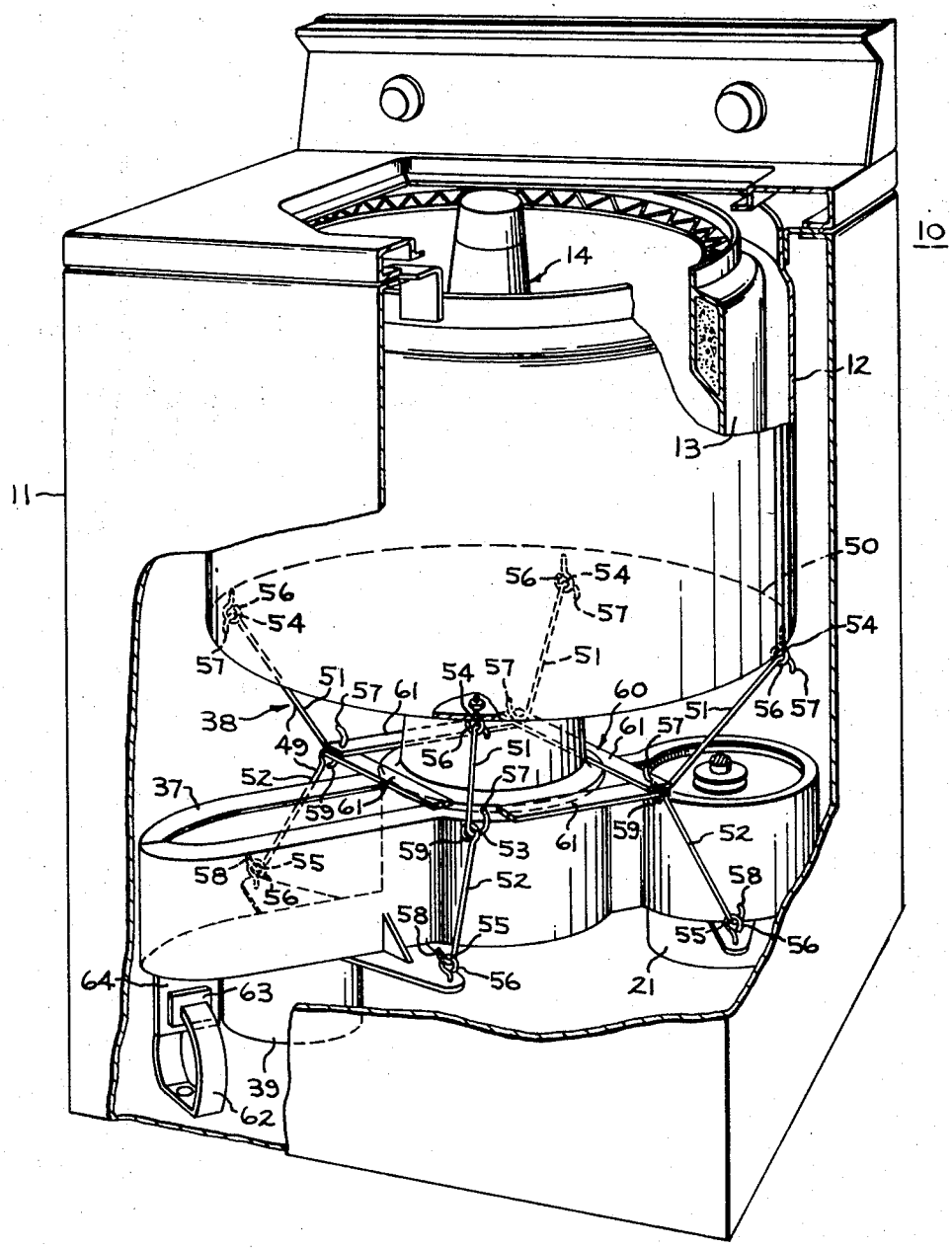

FIG. 2

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SELF-STABILIZING SUSPENSION SYSTEM

This invention relates generally to a suspension system and, more particularly, to such a system adapted to isolate vibrations of the moving components of a vertical-axis automatic clothes washing machine from the stationary supporting structure thereof.

The problem of isolating vibrations of the moving parts of a machine from the stationary parts thereof has long been recognized and many solutions have been proposed therefor. A common example of such movement and vibration isolation problems may be found in automatic clothes washers of the type presently commercially available for domestic use. Such machines usually provide an upwardly opening clothes basket in which clothes are washed and rinsed, the basket being of perforated construction, rotatably mounted within an imperforate stationary tub. When it is desired to remove the liquid therefrom, the basket is rotated about its vertical axis at high speed so as to centrifuge the liquid out of the clothes. Very often the system for effecting the washing and centrifuging operations does not have its weight symmetrically distributed about the axis of rotation so there is inherently an imbalance in the system. In addition, the clothes which are being laundered will seldom distribute themselves in perfectly balanced relation about the inner surface of the cylindrical wall of the basket but will provide an additional degree of unbalance.

While many of the systems which have been evolved have been satisfactory it has been found that it is most difficult to provide an arrangement which is economical and yet capable of isolating vibrations and limiting their amplitudes. Two additional requirements somewhat peculiar to automatic washer suspension systems further complicate the problem to be overcome. Firstly, it frequently occurs that the moving parts of such apparatus must be allowed only a limited degree of freedom. In order for the supporting structure or cabinet of such machines to be small enough to be commercially attractive for home use, and for the proper functioning of the apparatus, vertical freedom should be highly restricted. Secondly, in order to minimize expense and to salvage the space consumed by above-the-tub supports, it is desirable to employ a suspension system which does not structurally extend upwardly beyond the bottom of the tub and which, therefore, is capable of supporting in complete stability a load having a center of gravity which is significantly higher than the highest element of the suspension system.

A number of commonly used suspension systems for automatic washers are of the type wherein a plurality of rigid or flexible elements extend downwardly from a stationary member to support a dynamic system. Such systems are ideal in the respects of inherent strength, simplicity, and dependability. However, it has been extremely difficult to provide a stable suspension system of this character wherein the highest member of the suspension system is positioned a significant distance below the center of gravity of the load to be supported.

It is therefore an object of this invention to provide a new and improved, stable suspension system which is simple in design, economical to manufacture, and yet which will effectively isolate the vibrations or oscillations of a load supported thereby from a position significantly below the center of gravity of the load.

It is a further object of my invention to provide such a suspension system particularly adapted for use to support the dynamic components of an automatic clothes washer.

SUMMARY OF THE INVENTION

Briefly stated, in accordance with one aspect of the present invention, there is provided a suspension system having a support member, a base member disposed beneath the support member, and at least three bilink elements for supporting the base member from the support member. The bilink elements each have one end pivotally connected to a separate point on the support member and the other end pivotally connected to a separate point on the base member. Means are provided for pivotally connecting with each of the bilink elements at The point of juncture of the links thereof whereby the center of gravity of the load will rise under any movement of the load member relative to the support member from the position of equilibrium thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed the invention will be better understood from the following description of the preferred embodiments taken in connection with the accompanying drawings, in which:

FIG. 1 is a sectional view of a washing machine incorporating one embodiment of my invention;

FIG. 2 is a perspective view of the machine of FIG. 1, the view being partially cut away to show details with some parts removed to simplify the illustration; and

FIG. 3 is a perspective view of an alternate embodiment of my system, the view having a substantial number of parts removed to simplify the illustration.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing, and initially to FIG. 1 thereof, there is illustrated an agitator-type vertical-axis automatic clothes washer **10** having a cabinet **11**. The washer may include an imperforate tub **12** rigidly mounted within cabinet **11**. Rotatably supported within tub **12** is a perforate washing basket **13** for washing and rising clothes therein and for centrifugally extracting liquid therefrom. At the center of basket **13** is an agitator **14** which includes a center post **15** having a plurality of curved water circulating vanes **16** joined at their lower end to form an outwardly flared skirt **17**.

Both the clothes basket **13** and the agitator **14** are rotatably mounted. The basket is mounted on a flange **18** of a hub **19** and the agitator **14** is mounted on a shaft **20** which extends upwardly through the hub **19** and through the center post **15** and is secured to the agitator so as to drive it. During one possible cycle of operation of the machine **10**, liquid is introduced into the tub **12** and basket **13**, and the agitator is then oscillated back and forth about its axis to wash the clothes within the basket. After a predetermined period of this washing action, basket **13** is rotated at high speed to centrifugally extract the washing liquid from the fabrics. Following this extraction operation, a supply of clean liquid is introduced into the basket for rinsing the fabrics and the agitator is again oscillated. Finally the basket is once more rotated at high speed to extract the rinse liquid.

The basket **13** and agitator **14** may be driven by any suitable means. By way of example, I have shown them as driven from a reversible motor **21** through a drive mechanism including a clutch **22** mounted on the motor shaft. The motor is tailored so as to be used to its full extent when it accelerates the basket **13** to spin speed. In order to assist the motor during starting, clutch **22** allows the motor to start without a load and then accept the load as it comes up to speed. A suitable belt **23** transmits power from clutch **22** to a transmission assembly **24** through a pulley **25**. Thus, depending upon the direction of motor rotation, the pulley **25** of transmission **24** is driven in opposite directions. The transmission **24** is so arranged that it supports and drives both the agitator drive shaft **20** and the basket mounting hub **19**. When motor **21** is rotated in one direction, the transmission causes agitator **14** to oscillate and, when motor **21** is driven in the opposite direction, the transmission rotates the clothes basket **13** and agitator **14** together at high speed for centrifugal fluid extraction. While the specific type of transmission used does not form a part of the present invention, reference is made to U.S. Pat. No. 2,844,225 issued July 22, 1958 to Mr. James R. Hubbard et al. and assigned to the assignee of the instant invention. That patent discloses in detail the structural characteristics of a transmission assembly suitable for use in the illustrated machine.

In addition to driving the transmission 24 as described, motor 21 directly drives, through a flexible coupling 26, a pump structure 27. Pump structure 27 includes two separate pumping units 28 and 29 which are operated simultaneously in the same direction by motor 21. Pump unit 28 has an inlet connected by conduit 30 to an opening 31 formed in the lowermost part of tub 12 and an outlet connected by a conduit 32 to a suitable drain (not shown). Pump 29 has an inlet connected by a conduit 33 to the interior of tub 12 and an outlet connected by conduit 34 to a nozzle 35 which is positioned to discharge into a suitable perforate bottomed filter pan 36 which may be removably secured to the top portion of agitator 14. With this structure, then, when the motor is operating to provide agitation, pump unit 29 draws liquid in through conduit 33 from tub 12 and discharges it through conduit 34 into filter pan 36, and then down through the small openings provided in the bottom of the filter pan back into the basket. Conversely, when the motor is reversed so as to rotate the basket 13 and agitator 14 together at high speed to centrifugally extract fluid from fabrics in the basket, pump unit 28 will draw liquid in from opening 31 through conduit 30 and discharge it through conduit 32 to drain. Each of the pump units is substantially inoperative in the direction of rotation in which it is not used.

Basket 13, agitator 14, motor 21, clutch 22 and transmission 24 form a suspended washing and centrifuging system which is secured to a load member 37 which may in turn be supported by the stationary structure of the washer to permit isolation of vibrations from the stationary structure. A suspension system for such support and vibration isolation is indicated generally by the numeral 38 and will be described in detail at a later point in the specification.

It will be seen that transmission 24 is mounted on the top of member 37 and that motor 21 is mounted substantially within member 37. A counterweight 39 is mounted on bracket member 37 opposite motor 21 to aid in balancing the weight distribution of the various components of the suspended system.

In order to accommodate the movement which occurs between basket 13 and tub 12 without any danger of fluid leakage between them, the stationary tub 12 is joined to the upper part of transmission 24 by a flexible boot member 40. A member of this type is described and claimed in U.S. Pat. No. 2,959,966 issued Nov. 15, 1960 to Mr. John Bochan and assigned to the assignee of the instant invention.

Hot and cold water may be supplied to the machine through conduits 41 and 42 which are adapted to be connected respectively to sources of hot and cold water (not shown). Conduits 41 and 42 extend into a conventional mixing valve structure 43 having solenoids 44 and 45 and being connected to a hose 46. Hose 46 connects with a vacuum break device 47 as is increasingly required by various plumbing codes to prevent a backup of detergent suds or other impurities into the household water supply. An inlet nozzle 48 directs water into basket 13. In a conventional manner, selective or concurrent energization of solenoids 44 and 45 will provide the passage of hot, cold or warm water from the mixing valve 43 through the inlet nozzle 48. When one or both of solenoids 44 and 45 are energized, water discharges from inlet nozzle 48 and enters basket 13 and tub 12.

It will be understood that, while the description of the machine thus far excludes a substantial amount of detail relating to the drive, and does not show all the valves and particular controls normally provided on modern domestic washing machines, the elimination and simplification of these items is primarily for the purpose of permitting a clear explanation of the inventive concept set forth below. It will be recognized that the omitted details are conventional items included in virtually all domestic washing machines, whose structure and positioning is well known to those skilled in the art.

In accordance with the present invention, as best seen in FIG. 2, suspension system 38 comprises a plurality of bilink elements 49 for supporting load member 37, and the components carried by it, from a support member such as the bottom 50 of stationary tub 12. In one embodiment of my device, four bilink elements 49 are utilized for convenience in mounting generally rectangular members in a four-cornered supporting structure; however, as will be later explained, it is within the scope of my invention to use more or less than four bilink elements.

By "bilink elements" is meant interconnecting linkages of at least two links, each having at least one point of pivotal juncture between links which is adapted for pivotal connection to another means. The interconnected links may be either flexible or rigid and may be made of any suitable material which will withstand the tension created by the weight to be supported without elongating thereunder. In the particular form of my invention shown in FIG. 2, bilink elements 49 each comprise a rigid upper link 51 and a rigid lower link 52 pivotally interconnected at a point of juncture 53. Each upper link 51 is of equal length to all other upper links 51 and is pivotally secured, at its upper end, to a separate point of connection 54 on support member or tub 50. Each lower link 52 is of equal length to all other lower links 52 and is pivotally secured, at its lower end, to a separate point of connection 55 on load member 37. The points of interconnection 54 and 55 are shown as comprising eyebolts 56 secured to support member 50 or load member 37 through holes drilled therethrough. Each upper link 51 has a hook portion 57 formed on each end thereof, while each lower link has a hook portion 58 formed at the lower end thereof and an eye portion 59 formed at the point of juncture 53. The hook portions 57 of one end of upper links 51 pivotally engages a separate eyebolt 56 attached to support member 50 while the hook portions 57 of the other end of links 51 each pivotally engages a separate one of the eye portions 59 of lower links 52. Each hook portion 58 of the lower links 52 pivotally engages a separate one of the eyebolts attached to load member 37.

Pivotally connecting with each of the points of juncture 53 of the bilink elements 49 is a positioning means or members 60 adapted to position points of juncture 53 so as to define a first circle having a first radius. As shown in FIG. 2, means 60 may comprise a plurality of individual links 61 engaging hook portions 57 at points of juncture 53 to interconnect those points of juncture 53 which are adjacent each other on the periphery of the first circle. Links 61 are of equal length so that the points of juncture 53 are equally spaced about the periphery of the first circle. However, it is within the scope of my invention to interconnect these points with a means 60 comprising a single element formed of any suitable flexible material which will withstand tension and not elongate thereunder. To aid in damping vibrations, a number of dual member damping springs 62 may be secured to supporting structure 11. Each of the damping springs 62 have resilient pads 63 thereon to slidably engage a depending portion 64 of load member 37.

The points of connection 55 of the lower links 52 to the load member 37 are so positioned as to define a second circle having a second radius. Similarly, the points of connection 54 of the upper links 51 to the support member 50 are so positioned as to define a third circle having a third radius. It is a feature of the preferred embodiment of my invention that the third or support radius be greater than the second or supported radius which, in turn, is greater than the first radius of the circle defined by the intermediate points of juncture 53. With such a relative arrangement of the link interconnection points my device not only corrects an unbalanced or unstable condition but also substantially limits the vertical freedom of movement of load member 30, as will be explained shortly.

An alternate embodiment of my device is shown in FIG. 3 wherein only three bilink members 49 are employed. The arrangement of the essential components is identical in principle to the arrangement of FIG. 2. The bilink elements each comprise an upper link 51 and a lower link 52 interconnected at a point of juncture 53, the points of juncture being maintained by a means 60 in a first circle having a first radius. Means 60, when employed in a system having only three bilink elements

40 may be made entirely rigid as is shown, because, no matter where the three points of juncture 53 may move, they will always be contained within a single plane. As shown, means 60 here comprises a rigid triangular plate 65 having three juncture portions 66 formed at the corners thereof. The lower links 52 each pivotally connect with a separate point of connection 55 on a load member 67, the points of connection 55 defining a second circle having a second radius which is greater than the first radius. The upper links each pivotally connect with a separate point of connection 54 on the support member 50, the points of connection 54 defining a third circle having a third radius greater than the second radius.

It is within the scope of my invention to employ any number *n* of bilink elements to interconnect a support member and a base member disposed therebeneath, so long as the number *n* is three or greater. It is desirable that the radius of the third circle of the points of connection with the support member be greater than the radius of the second circle of the points of connection with the load member, and that the radius of the second circle be greater than the radius of the first circle of the points of juncture of the upper and lower links. By making the second radius less than the third radius, load member 50 will be given a larger area of displacement when my device is confined within a small cabinet than if the second radius is made equal to or larger than the third radius. By making the first radius somewhat less than the third and second radii it has been found that the range of stable movement of load member 67 relative to support member 50 is increased.

The imbalance forces operating on the moving system supported by load member 37 when basket 13 is spinning at relatively high speed cause, basically, two types of vibration motion. Firstly, there is a generally swinging or pendulous motion of member 37 within a vertical plane. Such pendulous motion causes the link members to pivot at their end portions. Consider, for example, a pendulous motion of load member 67 in the direction of arrow 68 in FIG. 3. When load member 67 is urged leftward relative to plate 65 by vibrational forces, the right side 69 of load member 67 will tend to displace downwardly and the left point 70 of load member 67 will tend to displace upwardly as lower links 52 pivot about their ends. However, such tilting tendency of member 37 is compensated for by a leftward relative movement between plate 65 and support member 50 whereby the left point 71 of plate 65 tends to displace downwardly and the right side of plate 65 tends to displace upwardly thereby applying corrective displacements to load member 67 through lower links 52. By this arrangement, the pendulous movement of the load member 67 tends to become almost a planar horizontal movement with very little tilting and only slight raising thereof. The pendulous movement of load member 67 is thereby seen to be of a self-correcting or self-balancing nature tending to remain substantially horizontal and thereby enabling my device to support a load having a center of gravity substantially higher than the highest point of support of my suspension system. In other words, relative movement of load member 67 relative to support member 50 will tend to raise the center of gravity of the load supported thereby tending to apply a corrective or stabilizing return force to the position of equilibrium.

The second type of motion which may occur is a rocking or oscillating motion about a point wherein the load member 67 tends to rotate relative to support member 50. In a manner similar to that explained in detail for the aforedescribed pendulous motion, my device tends to self-correct or self-balance the tilting tendency of the support member and thereby enables the use of my device with loads having a center of gravity higher than the highest point of connection to a stationary support.

It will thus be seen that the suspension system or may device will accommodate both pendulous and rocking motion. However, almost invariably there is a combination of rocking and pendulous motions. Such a combination of motions, however, poses no additional problem for my device as the components thereof coact in substantially the same manner to self-correct the effects of either motion or a combination thereof.

The four bilink element system of FIG. 2 and systems employing more than four elements may be seen to operate in substantially the same manner as the three element system of FIG. 3 with the exception that the points of juncture 53 do not tend to move in a planar fashion. Therefore means 60, in this system, must be constructed from either a single flexible member or a system of separate links 61 so that means 60 can flex without elongating between adjacent points of juncture 53.

As was previously mentioned, the system of my invention is particularly adapted for use in automatic clothes washers wherein it is desirable to employ a suspension system of the type wherein a plurality of rigid or flexible elements extend downwardly from a stationary member to support a dynamic system, due to its inherent strength, simplicity and stability, yet where it is also desirable to limit the degree of freedom of vertical movement and by a system having the capability to support a load from a position significantly below the center of gravity thereof. From the foregoing description it should now be apparent that the present invention provides a stable suspension system capable of isolating the vibrations of dynamic components while supporting a load having a center of gravity significantly higher than the highest point of connection to a stationary structure.

As will be evident from the foregoing description, certain aspects of the invention are not limited to the particular details of construction of the examples illustrated, and it is contemplated that various other modifications or applications will of occur to those skilled in the art. It is therefore intended that the appended claims shall cover such modifications and applications as do not depart from the true spirit and scope of the invention.

I claim:

1. A suspension system for supporting a load comprising:
a support member and a load member disposed beneath said support member;
at least three substantially inextensible bilink elements for supporting said load member from said support member;
said bilink elements each having one end pivotally connected to a separate point on said support member and the other end pivotally connected to a separate point on said load member; and
means pivotally connecting with each of said bilink elements at the point of juncture of the links thereof, whereby the center of gravity of the load will rise under any movement of said load member relative to said support member from the position of equilibrium thereof to provide a corrective force tending to return the system to equilibrium.

2. The suspension system of claim 1 wherein:
said means positions said points of juncture to define a first circle having a first radius;
said points of connection to said load member define a second circle having a second radius; and
said points of connection to said support member define a third circle having a third radius greater than said first radius.

3. The suspension system of claim 2 wherein said third radius is greater than said second radius, and said second radius is greater than said first radius.

4. The suspension system of claim 2 wherein:
said points of juncture are equally spaced about the periphery of said first circle;
said points of connection to said load member are equally spaced about the periphery of said second circle ; and
said points of connection to said support member are equally spaced about the periphery of said third circle.

5. The suspension system of claim 4 wherein each of said bilink elements comprise an upper link and a lower link pivotally connected thereto, said upper links being of a uniform first length, a said lower links being of a uniform second length.

6. The suspension system of claim 5 wherein said means comprises a single laterally flexible element.

7. The suspension system of claim **5** wherein said means comprises a plurality of individual links interconnecting adjacent points of juncture.

8. A hanging suspension system comprising:

a support member and a load member disposed beneath said support member;

means disposed between said members having a number *n* of juncture points equally spaced about the periphery of a first circle having a first radius, said number *n* being at least three;

a number *n*of equal length lower links, each of said links being substantially inextensible and pivotally connected at one end to a separate one of said juncture points and pivotally connected at its other end to a separate point on said load member, said points of connection to said load member being equally spaced about the periphery of a second circle having a second radius greater than said first radius;

a number *n* of equal length upper links, , each of said links being substantially inextensible and pivotally connected at one end to a separate one of said juncture points and pivotally connected at its other end to a separate point on said support member, said points of connection to said support member being equally spaced about the periphery of a third circle having a third radius greater than said second radius.

9. The suspension system of claim **8** wherein said means comprises a single flexible element.

10. The suspension system of claim **8** wherein said number *n* equals three and said means comprises a rigid element.

11. The suspension system of claim **8** wherein said means comprises a number *n* of equal length links interconnecting adjacent points of juncture.

12. The suspension system of claim **11** wherein the number *n* equals four.