July 25, 1961 R. L. RICHARDSON 2,993,547

TORSION BALANCE

Filed May 6, 1959 3 Sheets-Sheet 1

FIG.1.

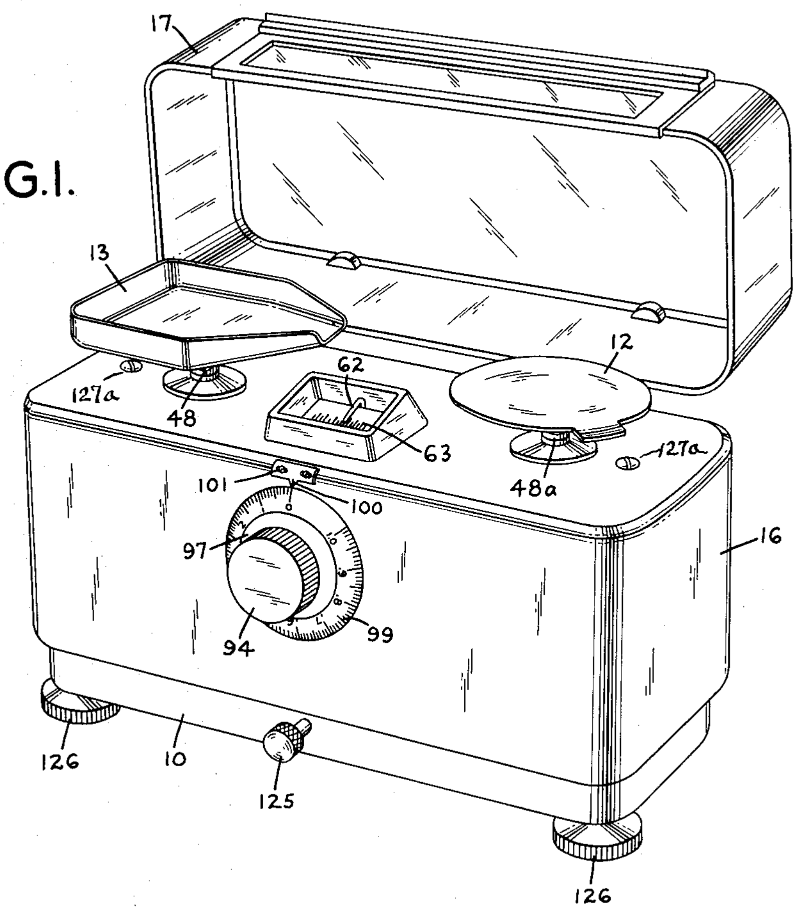
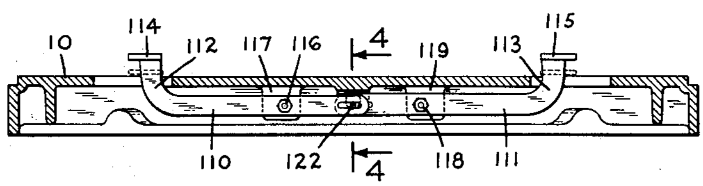


FIG.3.



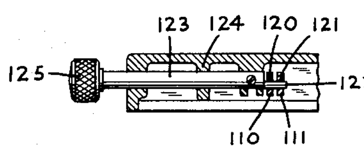


FIG.4.

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TORSION BALANCE

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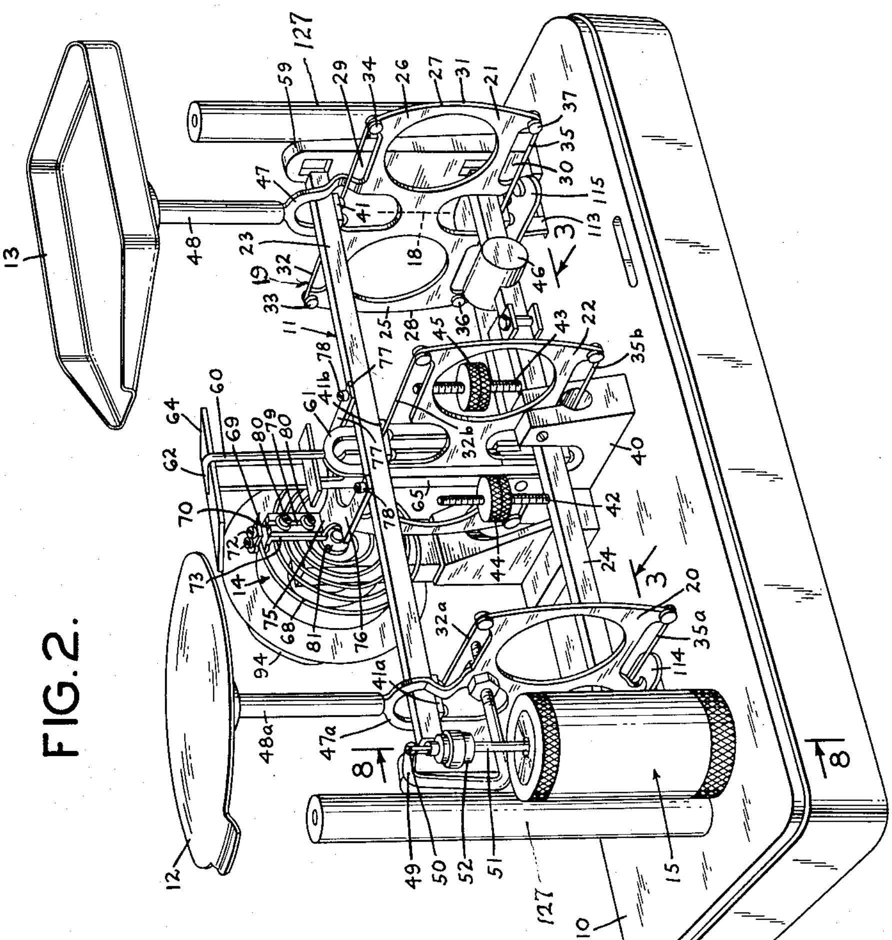


FIG. 2.

FIG.5.

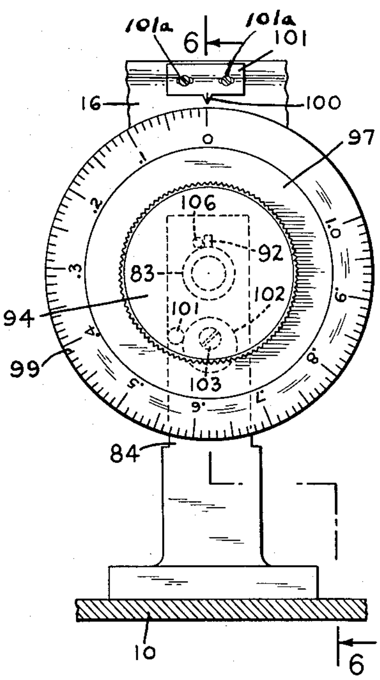


FIG.6.

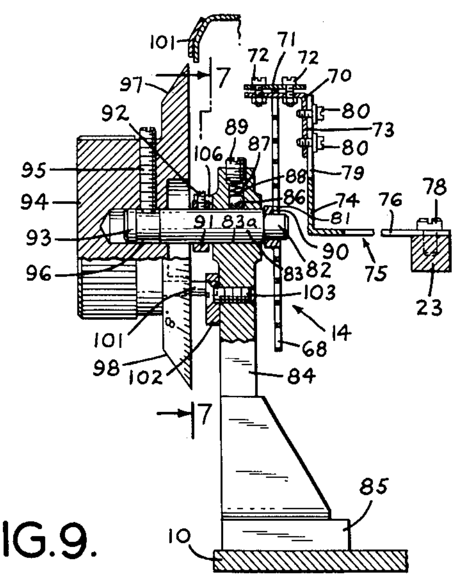


FIG.9.

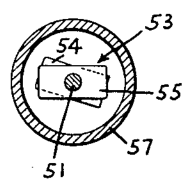


FIG.7.

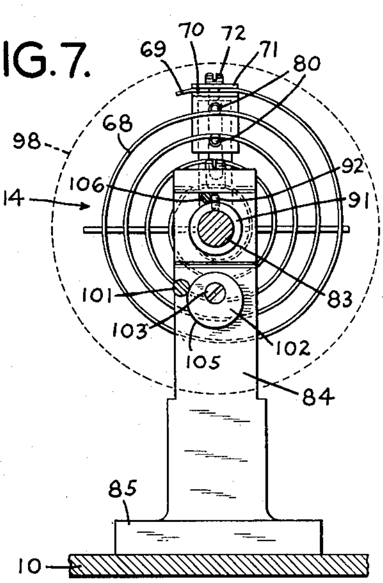
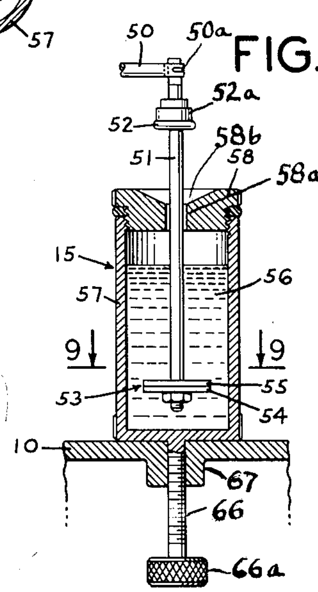


FIG.8.



United States Patent Office

2,993,547

Patented July 25, 1961

2,993,547
TORSION BALANCE

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Filed May 6, 1959, Ser. No. 811,347
10 Claims. (Cl. 177—168)

This invention relates generally to torsion balances and more particularly to a torsion balance having a spring means for supplying a torque component for aiding in balancing the beam and skeleton structure against an unknown weight mass whose weight is to be determined on the balance.

Generally speaking, a torsion balance comprises a skeleton mounted on a base. The skeleton comprises an upper and lower beam, two end truss assemblies, that is, one at each end of the pair of beams, and one center truss assembly. The center truss assembly is fixedly secured to the base and provides a fulcrum for the two beams, which are mounted parallel to each other in a vertical plane. Each end truss assembly comprises a frame on which is tautly mounted a metal band having an upper run or section supported at each end leaving a length of band between the supporting parts of the truss frame and a lower run or section supported at each end leaving an unsupported length between the supported ends. These bands are sometimes referred to as "tension wires" or ribbons. It is to be understood that "band" as used herein is intended to include those other terms. The mounted bands are under tensile stress. The stress of a band whose ends are secured to the truss or to each other, may be adjusted by controlling or adjusting the length of the metal truss. This may be done, for example, by causing deformation of a small center section of the truss. The end trusses are similar to each other and the center truss is substantially similar but is fixedly mounted and supported on the base in a plane perpendicular to the plane of the base and at right angles to the plane through the upper and lower beams. The upper and lower runs or sections of the bands are referred to herein for convenience of description merely as upper and lower bands.

The upper beam is attached at each end to the upper band of the corresponding end truss and the upper beam is attached to the upper band of the fixed center truss; usually, but not necessarily, midway of the length of the beam. The lower beam is attached to the three lower bands in like manner as the upper beam is attached to the upper bands. The end trusses are provided with means for attaching pans or platters at their upper extremities, allowing for the placing of weights or objects to be weighed upon the pans; or, the weights may be hung from the trusses. For convenience of description, the left hand pan is herein referred to as the "unknown weight or weighing pan" and the right hand pan, as the "balancing pan."

When the center truss is fixedly mounted on the base, as mentioned above, the skeleton, comprising upper beam, lower beam, and two end trusses, is free to oscillate about the instant center of the upper and lower truss bands of the center truss. The upper and lower beams will rotate about the upper and lower truss bands, at their centers, without friction. This is in contrast to other types of balances which have a beam or beams supported by conventional pivots, knife edges, and the like, which involve the element of friction to a greater or less degree. When the beams of the torsion balance are rotated about their centers on the center bands as a fulcrum, the end trusses will describe a motion somewhat different from that of the upper and lower beams.

The vertical center line through the end truss will remain vertical when the skeleton is rotated or deflected and will have a small transverse motion away from or toward the center truss depending upon the position with respect to a horizontal condition of either the upper or lower beam.

If a mass is added to the unknown weight pan attached to the end truss, this will cause a torque or twisting force on the bands and a rotation of the beams about their mounting points on the center bands intermediate their ends. To weigh the mass, which may be assumed to be unknown, known weights are placed in the opposite or known weight pan until the two pans are balanced, and then the weight of the unknown mass is determined by the amount of known weight necessary to balance the beams on the fulcrum of the skeleton. That is, there is a balancing of the torque on each of the beams in the weighing operation. It is conventional to mount a pointer on the movable skeleton, usually on the lower beam opposite its fulcrum point and a fixed graduated index scale having a "zero" mark in the center is mounted on the base or on the housing of the balance. The skeleton is balanced when the pointer registers with the zero mark on the scale. Also, it is conventional to connect a dash-pot to the skeleton to dampen the oscillating movement.

In the absence of some sort of mechanical arrangement on the balance for quickly applying a balancing torque of known amount against the torque caused by a mass of unknown amount on the unknown weight pan, the weighing operation may require considerable time because of the necessity oftentimes of changing the weights of known units or fractional denominations of weight units on the balancing pan to bring about the balanced condition which will determine the weight of the unknown mass. Also, in the changing of known weight units or fractional denominations of units on the balancing pan during the weighing operation, it is desirable to arrest the movement of the beams by a device built into the balance for that purpose.

In accordance with this invention a means comprising a yieldable means preferably in the form of a spiral spring is mounted on the balance between the base and movable skeleton, with one end of the spring secured to a mounting means on the base and the other end to one of the beams intermediate its ends; the spring means being secured to a spring adjusting means which is quickly adjustable to change and adjust the spring tension, so that the balancing torque applied against the torque caused by the unknown weight in the weighing pan may be changed in response to the movement or adjustment of the spring. And this change in torque may be brought about quickly without the necessity of applying or using beam arresting means during the weighing operation. Preferably, the spring tension adjusting means is in the form of a rotatable hand knob provided with a graduated index scale and the spring is designed and calibrated so that for a given angular rotation of the knob from a predetermined zero position as measured by the graduations on the knob scale, a given and known torque (corresponding to a predetermined amount of weight in the unknown weight pan) is applied to the skeleton for balancing the skeleton in the weighing operation. Hence, within specified or predetermined limits, the desired change in torque applied to the balance skeleton to balance it against the torque produced by the unknown weight in the weighing pan may be quickly performed by the simple expediency of turning the hand knob.

Although the novel features which are believed to be characteristic of the invention are pointed out in the annexed claims, the invention itself as to its objects and advantages and the manner in which it may be carried out, may be better understood from the following more detailed description taken in connection with the accompanying drawings, forming a part hereof, in which—

FIG. 1 is a front view in perspective of a torsion balance embodying the invention;

FIG. 2 is a rear view in perspective of the balance shown in FIG. 1 with the housing removed;

FIG. 3 is a section in elevation on line 3—3 of FIG. 2, showing an arrester for arresting movement of the skeleton;

FIG. 4 is a view on line 4—4 of FIG. 3;

FIG. 5 is a front view in elevation of the rotatable knob showing the graduated index scale and mounting post;

FIG. 6 is a view on line 6—6 of FIG. 5;

FIG. 7 is a view on line 7—7 of FIG. 6;

FIG. 8 is a vertical view in section through the dash-pot which dampens the oscillation of the beams; and

FIG. 9 is a horizontal view in section on line 9—9 of FIG. 8.

Referring now to the drawings, in which like reference characters designate similar parts throughout the several views, the torsion balance, as shown, comprises a base **10**, a skeleton designated generally by reference character **11**, a known weight or balancing pan **12**, an unknown weight or weighing pan **13** and the torque changing or adjusting mechanism **14**, and a dash-pot **15** connected to the skeleton. The major part of the working mechanism is mounted in a housing **16** mounted on the base **10**. The housing has a hinged cover lid **17**.

The skeleton comprises two end trusses, **20**, **21**, a center truss **22**, having attached thereto an upper beam **23**, and a lower beam **24**. A typical truss **21** comprises a plate-like member having wings **25**, **26**; the wings being symmetrical with reference to a vertical center line **18** through the truss plate and the wings have rim portions **27**, **28**. Between the tips of the wings are cut-out portions **29**, **30** at top and bottom. A ribbon or band **19** of steel, or other suitable material, is mounted taut around the truss, thus providing an upper band **32** extending from wing tip **33** to wing tip **34** and a lower band **35** extending from wing tip **36** to wing tip **37**.

The middle truss **22** and end truss **20** are constructed substantially the same way as truss **21**; end truss **20** having an upper band **32*a*** and lower band **35*a***; and middle truss having an upper band **32*b*** and lower band **35*b***. The center truss **22** is fixedly mounted on a foot **40** secured to the base **10** and is clamped at its lower portion to the foot so that the truss lies in a plane perpendicular to the base and at right angles to the upper beam **23** and lower beam **24** which lie in a vertical plane through the vertical center lines through the three trusses **20**, **21**, **22**.

The upper beam **23** is secured at one end to the upper band **32** of truss **21**, and at its other end to the upper band **32*a*** of truss **20** and at its center to upper band **32*b*** of middle truss **22**, by clamps **41**, **41*a***, **41*b***, which are removably secured to the beams by means of threaded screws. The lower beam **24** is likewise attached to lower bands **35**, **35*a*** by similar end clamps and midway of its length to lower band **35*b*** by a similar center clamp.

The lower beam **24** has at each side of center truss **22** an upwardly extending threaded shank **42**, **43** upon which are mounted, for vertical adjustment, female threaded counterpoise weights **44**, **45**. A further adjusting weight **46** is mounted for adjustment along the lower beam **24**.

Now it will be seen that the beams **23**, **24** may rotate about the center lines of upper and lower bands **32*b***, **35*b*** of the fixed center truss **22**, since the two end trusses are free to move up and down in response to movement of the beams because the end trusses are not fixed to the base but are carried by the bands secured to the trusses.

Mounted on upstanding brackets **47**, and **47*a*** on the end trusses are vertically extending platter mounting posts **48**, **48*a*** which in turn mount weighing pan **13** and balancing platter **12**, respectively. A dash-pot arm **49** is secured to the end truss **20**. Its outer end **50** is pivotally secured by means of a U-pin **50*a*** to the outer end of a piston rod **51**, which has a collar-shaped sealing plug **52*a*** secured thereto, as by soldering. The lower end of the sealing plug has mounted thereon an O-ring **52**, of resilient material such as neoprene or the like. The lower end of piston rod has connected thereto a piston **53** comprising two plates **54**, **55**, which are rotatably adjustable with respect to each other to change the effective restraining area of the piston **53**, which is movable vertically in an oil bath **56** in cylinder **57** of dash-pot **15**, mounted on base **10**. The piston rod is movable in an apertured cap **58** in the upper end of the dash-pot cylinder **57**. The aperture **58*a*** flares outwardly at the top thus providing an annular seat **58*b*** in the cap **58**. The lower end of cylinder **57** has secured thereto a downwardly extending, threaded screw **66**, which is rotatable in a female threaded boss **67** by means of milled handle **66*a***. Hence, when the screw **66** is turned to move it upwardly, the cylinder **57** is raised. It can be raised a sufficient distance to cause the seat **58*b*** in cap **58** to engage sealing O-ring **52** to seal the cylinder and prevent leakage of liquid **56** from the cylinder; for example, during transportation of the balance. A beam arresting post **59** is provided but is used only to clamp the skeleton in locked position when the balance is shipped or transported. A pointer rod **60** is mounted on a bracket **61** secured on the beam **23** midway of its length. The pointer rod extends upwardly and has a horizontally extending pointer finger **62**, which moves over a fixed graduated index scale **63**. The scale **63** is mounted on a flat plate **64** carried on the upper end of a post **65** secured at its bottom end to base **10**. When the skeleton is balanced, the pointer finger **62** registers with the center or zero division of graduated index scale.

The mechanism for applying torque to the known weight, or balancing, side of the beams is an important feature of the invention. It comprises a spring having one end secured to the skeleton and the other end to means mounted on the base adapted to change the tension on the spring whereby the spring may be caused to apply a torque to the skeleton. The torque may be varied within limits and the spring is calibrated to apply a predetermined torque for a predetermined adjustment whereby to facilitate the determination of the weight of an unknown mass being weighed.

As shown in the drawings a spiral spring **68**, sometimes referred to as a hair spring, has its outer end **69** clamped to an angle bracket **70** by means of a plate **71** clamped in place by screws **72**. Leg **73** of the bracket **70** is secured to the upstanding leg **74** of a right angle bracket **75** the horizontal part of which is bifurcated to form two arms **76**, **77**, which are secured to beam **23** by means of screws **78**. The bracket **75** is mounted midway of the length of beam **23**. It will be observed that the upstanding leg **74** is provided with a vertical slot **79** so that the bracket **70** may be adjusted vertically within limits by loosening the clamping screws **80** and tightening them in any desired adjusted position.

The inner end **81** of hair spring **68** is anchored to the inner end **82** of a hub shaft **83** (see FIG. 6). The shaft **83** is horizontally mounted for rotation in a journal bearing **83*a*** in the upper end portion of a mounting post **84**, the base **85** of which is fixedly secured to base **10** of the balance. To provide frictional resistance to unwanted rotation of shaft **83**, a ball **86** is mounted in a threaded bore **87**; the ball being yieldably pressed against shaft **83** by a compression spring **88** held in adjusted position by a set screw **89**. This arrangement permits manual rotation of shaft **83** but prevents unwanted self-rotation of the shaft. Axial movement of the shaft **83** is prevented by a collar **90** and a ring **91**, the latter being held in place by a set screw **92**.

Mounted on the outer end **93** of shaft **83** is a hand knob **94** which is held in clamped position on shaft **83** by means of a set screw **95** extending through a threaded bore. The inner end of the set screw **95** engages an annular groove **96** in the shaft. Hence, the knob **94** is angularly adjustable on shaft **83** and may be clamped in any desired angular position on the shaft. The hand knob has an annular flange **97** extending outwardly from the knob head **94**. The flange has a beveled face portion **98**, upon which is a circumferential graduated index scale **99** which lies adjacent to and moves relatively to a fixed index mark **100** on a plate **101** adjustably mounted on housing **16** (see FIGS. 1 and 5), by means of slots and screws **101***a*.

The graduated scale **99**, as shown, is divided into ten main divisions marked "0" to "10." Each main division is subdivided into ten subdivisions. Hence, the whole scale **99** from "0 to 10" may be related to the spring **68** to represent, for example, a weight of from 0 to 1 gram, in which case each main division represents one-tenth gram and a subdivision would represent one one-hundredth of a gram. As will be described in further detail later on, the knob **94** may be rotated together with shaft **83** to any desired angular position and the division of scale **99** which registers with fixed index mark **100** will be proportional to the torque (and hence corresponds to weight as though placed on platter **12**) applied against the torque caused by an unknown weight on the weighing pan **13**. For example, if the unknown mass on weighing pan weighs between ten and eleven grams, as determined by placing a known ten gram weight on weighing platter **12** and then, in addition, a one gram weight on platter **12**. Then the one gram weight is removed and the knob **94** turned from zero on scale **99** until it provides a torque which balances the skeleton. Assuming this would be "8.3" which is on subdivision three between main division "8" and "9" on the scale opposite fixed index marker **100**, then the weight of the unknown mass is 10.83 grams, because of the ten gram weight on the platter and the equivalent of 0.83 gram provided by the additional torque of spring **68** against the torque set up by the unknown mass on pan **13**.

It will be seen from the foregoing description that turning knob **94** is clockwise direction will wind up spring **68**, inasmuch as the outer end of spring **68** is clamped to bracket **70**, which in turn is clamped to bracket **74**, which is secured to beam **23** and the inner end of spring **68** is anchored to rotatable hub **82**. The more the hub is rotated clockwise to rotate scale **99** from zero reading to a higher reading the more tension is placed on spring **68**. The amount of torque resulting on the outer end of spring **68** (connected through brackets **70**, **74** to beam **23**), and hence on beam **23**, opposing the torque caused by a mass on weighing pan **13**, is proportional to the amount of angular rotation of hub **94** as indicated on graduated scale **99**.

In operating the balance, the unknown weight (the mass to be weighed) is placed on the left hand weighing pan **13**, with graduated scale **99** at zero position. Known weights are placed on the right hand balancing pan **12** until the weight is approximated to within the capacity of the spiral spring **68**. Turning the hub **94** rotates scale **99**, and shaft **83** on which the inner end of the spring **68** is anchored. Hub **82** retains the inner end of spring **68**. This produces a torque at the outer end of the spring which is transmitted to the beam **23** of skeleton **11** because this outer end is attached to the skeleton assembly through brackets **70**, **74**. This torque being applied to the beam **23** produces a torque opposite in direction to that produced by the as yet unbalanced part of the unknown mass. When the dial scale **99** is rotated so that the developed torque balances the skeleton assembly as indicated when the pointer finger **62** registers with the zero mark on fixed index scale **63**, then the amount of rotation which is directly proportional to the change in torque produced can be read from the calibrated dial index scale **99** in terms of mass on the left hand weighing pan **13**. Therefore the summation of known weights on the right hand balancing pan **12** plus the weight increment counterbalanced and read on dial scale **99** constitute the total weight of the unknown mass.

Some variation in spiral springs as manufactured may be found to exist. However, springs of this type may be and are manufactured to develop a predetermined required torque in inch grams for a given rotation in degrees. In manufactured springs this nominal value may vary a little from spring to spring. Deviation from the specified torque characteristics must be compensated in order to use a standard dial scale in which the same standard scale is used on dials on different balances. In other words, instead of varying the scale **99** from balance to balance, means are provided to adjust the hair spring from balance to balance, so that two or more balances of the same type and capacity will weigh accurately.

The equation which describes the torque produced by such a spiral spring device involves the length of wire or band used to make up the spiral spring; that is, the effective wire length from the point of attachment at the hub **82** to the outer end of the spring which is attached to the bracket **70**. A reduction in this length produces a given torque with a smaller angle of rotation of shaft hub **82** and conversely, an increase in the length produces the same given torque with a greater angle of rotation of shaft hub **82**. Consequently, in order to provide adjustment for accuracy in weighing, the bracket **70** is provided with a clamp plate **71** so that the free or outer end portion of spring **68** may be drawn through and clamped in such a way as to effectively change the effective length of the spring. Shortening or lengthening of the effective length changes the geometry of the configuration so a second adjustment may be desirable. Means for this adjustment, also, are provided. The bracket **70** is adjustable up and down by means of slot **79** and screws **80** so that the configuration of the spring may be adjusted so as to prevent adjacent coils of the spiral spring from contacting each other when the hub **82** is rotated in a direction which winds up the spring or when the hub is rotated to relax the spring.

The knob **94** has a stop pin **101** extending outwardly from its inner face and toward the post **84**. Cooperating with the stop pin **101** is a circular plate stop member **102**. This circular or disc stop plate **102** is mounted on a screw **103** mounted off center of plate **102** and threaded into a threaded bore **104** in post **84**. It will be seen that the stop plate **102** is located in the circular path described by the pin **101** when the knob **94** is rotated on the axis of shaft **83**. The angular position of knob **94** at which the pin **101** will engage the cam face **105** of disc stop **102** and thereby stop further rotation counterclockwise or clockwise may be changed within limits because the aperture in the plate **102** through which the screw **104** extends, is off center. Hence, the disc **102** may be rotated and then clamped in desired position by tightening screw **103**. As the disc is rotated clockwise (as viewed in FIG. 7) the cam face **105** when the pin **101** engages the disc **102** is moved to the left. Rotation counterclockwise of stop plate **102** will move its cam face **105** to the right. Hence, by angular adjustment of the stop disc **102** on screw **103**, the knob will be stopped against further rotation at the desired angular position of the knob. This adjustment is made so that the knob **94** when returning the dial scale **99** to zero ("0") position opposite fixed index **100** will be positively stopped at zero, which is an advantage in beginning a weighing operation. Also, the plate will serve as a positive stop when the knob is turned clockwise so that the spring cannot be wound up too tightly or unduly beyond the end of the dial scale **99**. Also, this stop arrangement prevents the knob from being turned in either direction sufficiently to unwind or wind up the spring beyond its effective capacity.

Another stop arrangement for adjustment of the shaft **83** and knob **94** with relation to hair spring **68** is provided. A pin **106** extends outwardly from post **84**. This pin is engaged by set screw **92** which extends through a threaded bore in ring **91**. This ring **91** may be angularly adjusted on shaft **83** and clamped by screw **92** so that the screw **92** will engage the stop pin **106**. This stop allows for setting the hair spring at its nearly relaxed position when the dial scale **99** reads "zero." However, this pin **106** and ring **91** as a stop arrangement is secondary to the pin **101** and disc **102**, the latter mentioned stop arrangement being sufficiently sturdy to take the stresses. Otherwise, the secondary stop pin **106** might be thrown out of adjustment by careless handling or use of the knob. Consequently the arrangement is such that instantly upon engagement of pin **106** by screw **92**, the more sturdy pin **101** engages the more sturdy stop **102**, to transmit any undue shock or stress to the more sturdy and positive stop.

Although a particular embodiment has been illustrated in the drawings, it is contemplated that other arrangements or devices which can be used to determine angle of rotation can be used to indicate or present the weight data which is a function of the spiral spring. For example, any device which digitally shows the degree of rotation of a shaft might be used for indicating the applied torque. Also, the graduated index scale **99** might take other forms and subdivisions so that other weight ranges could be had. And a gearing between the shaft **83** and knob and dial scale **99** might be provided to change the ratio of angular rotation of the spring hub to angular rotation of the graduated scale. Moreover, the dial scale **99** which is used in the illustrative embodiment to indicate weight need not be located in the position on the housing as illustrated in the drawings; but by use of flexible shaft or appropriate gear train, might be located elsewhere on the balance case. Since the spiral spring can be calibrated and a variety of wire sizes are available, it is contemplated that the capability of the spiral spring to produce a variety of torques is possible. Furthermore, a spiral spring of proper construction can be used to indicate torques accurately and linearly over a range of one part in ten to one part in a thousand. Hence, a torsion balance of great sensitivity may be produced in accordance with the invention. Also, it may be mentioned here that the rotation of the dial scale or knob is not necessarily limited to one turn or less since the amount of rotation is a function of the design of the spiral spring.

Although the use of an arresting device is not necessary during a weighing operation, a beam arresting device is provided. It is recommended that it be used when the balance is not in use, merely to protect the moving parts. The arrester comprises a pair of levers **110**, **111** having upwardly turned arms **112**, **113**, supporting cross arms **114**, **115** which are positioned under the end portions of the lower beam **24**. Lever **110** is pivoted at **116** on a bracket **117** depending from base **10**. Lever **111** is pivoted at **118** on bracket **119** depending from base **110** the inner ends of the levers having slots **120**, **121** through which extends the eccentric pin **122** of a shaft **123** mounted crosswise of the levers for rotation in brackets **124**, in the casing. The outer extremity of the shaft **123** has a hand knob **125** fixed thereto for manual rotation of the shaft. When the shaft **123** is rotated through approximately 180° the pin **122** causes the levers **110**, **111** to rotate on pivots **116**, **118** which in turn causes the cross arms **114** and **115** to move upwardly and engage the bottoms of trusses **20**, **21** thus in effect locking the skeleton against rotation and also taking the stress from the bands of the skeleton in the event of placing undue weights on the balance pans.

The base of the balance is also provided with three feet, one of which is stationary and the other two of which are vertically adjustable. The two vertically adjustable feet **126** are at the two front corners of the base and the other (not seen in the drawings) is located at the rear edge of the base midway between the corner feet. This provides for such leveling of the balance as may be needed when it is placed on a non-level or rough surface.

Posts **127** mounted vertically on the base provides means for mounting the housing case **16** on the base, over the skeleton, by means of screws **127***a*.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. In a torsion balance, a base, a pair of parallel beams consisting of an upper beam and a lower beam, a fulcrum truss fixedly mounted on said base and having on each of two opposite sides a torsion band consisting of an upper fulcrum band and a lower fulcrum band, said upper and lower beams being connected intermediate their ends to said upper and lower fulcrum bands respectively, a pair of end trusses each having an upper and a lower torsion band to which the ends of said beams are secured, a shaft, means secured to said base mounting said shaft for rotation, a spiral spring having its outer end connected to a given one of said beams and its inner end connected to said shaft to exert a torque on said given beam in a direction tending to rotate said given beam about its fulcrum band, said rotatable shaft providing one spring tension adjusting means mounted on said base, said shaft being operative upon rotation to change the tension on said spring and thereby change the torque everted on said given beam by said spring and another spring adjusting means engaging said spring for adjusting the effective length of said spring.

2. A torsion balance, which comprises a base, and a skeleton comprising a pair of parallel beams consisting of an upper beam and a lower beam, a fulcrum truss fixedly mounted on said base and having on each of two opposite sides a tension band consisting of an upper fulcrum band and a lower fulcrum band, said upper and lower beams being connected intermediate their ends to said upper and lower fulcrum bands respectively, a pair of end trusses each having an upper and a lower tension band to which the ends of said beams are secured, a shaft mounting member secured to said base, a shaft mounted for rotation on said member and a spiral spring having its outer end connected to said skeleton and its inner end connected to said shaft to exert a torque on said skeleton in a direction tending to rotate said skeleton about said fulcrum bands, said rotatable shaft providing spring tension adjusting means, said shaft being operative upon rotation to change the tension on said spring and thereby change the torque exerted on said skeleton by said spring, and means engaging said spring to adjust the effective length of said spring to insure that the torque exerted by said spring is proportional to the angular rotation of said shaft.

3. A torsion balance constructed according to claim 2 in which said upper and lower beams are connected to said upper and lower bands midway of the length of the beams, and in which said skeleton has a bracket mounted on one of said beams adjacent its fulcrum, and in which the outer end of said spiral spring is secured to said bracket for exerting a torque on said skeleton.

4. A torsion balance constructed in accordance with claim 3 in which adjustable clamping means are secured to said bracket clamping said outer end of said spring to said bracket, said clamping means permitting the effective length of said spiral spring to be changed and adjusted.

5. A torsion balance constructed according to claim 4 in which said bracket means include adjustable means for adjusting the spring clamping means toward and away from the inner anchored end of said spring anchored to said shaft.

6. A torsion balance constructed according to claim 2 in which said spring tension adjusting means comprises shaft mounting means secured to said base, a shaft mount-

ed on said shaft mounting means for rotation, means anchoring the inner end of said spring to said shaft, a manually rotatable knob fixed to said shaft for rotating said shaft, a graduated index scale on said knob, movable with said knob over a fixed index connected to said base, said spring being calibrated so that upon equal increments of angular rotation in a given direction within predetermined limits, of said shaft from zero position as indicated on said graduated scale, the torque exerted by said spring on said skeleton is increased by equal increments.

7. A torsion balance constructed according to claim 6 in which said shaft mounting means is a post fixed to said base and in which said knob carries a stop pin and said post carries an adjustable stop member; said stop member being adjustable to a position in which said pin engages said stop member when said knob is rotated to zero position as indicated when the zero division of said graduated scale registers with said fixed index.

8. In a torsion balance having a base and torsion balance skeleton, said skeleton comprising end trusses having end truss tension bands, a middle truss fixedly mounted on said base and having middle truss tension bands, and a pair of parallel beams mounted on said middle truss bands intermediate the ends of said beams for rotation about said middle truss bands as a fulcrum, and said beams being connected at their ends to said end truss bands, bracket means mounted on one of said beams intermediate its ends, shaft mounting means fixedly secured to said base, a shaft mounted for rotation on said shaft mounting means, a spiral spring secured at its outer end to said bracket and at its inner end to said shaft, said shaft upon rotation in one angular direction acting to wind up said spring thereby to increase the torque exerted by said spring on said skeleton and upon rotation in the opposite angular direction unwinding said spring thereby to decrease said torque and adjustable means secured to said spring to adjust the effective length of said spring between its point of attachment to said shaft and its point of attachment to said bracket.

9. Construction according to claim 8 in which said means for adjusting the effective length of said spiral spring comprises clamp means secured to said bracket.

10. Construction according to claim 9 in which said bracket includes means for adjustably changing the radial distance from the center of said shaft to the point of attachment of the outer end of said spring.

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