Feb. 23, 1960 D. H. MacDONALD 2,925,728

DEAD-WEIGHT MACHINE

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Fig. 1.

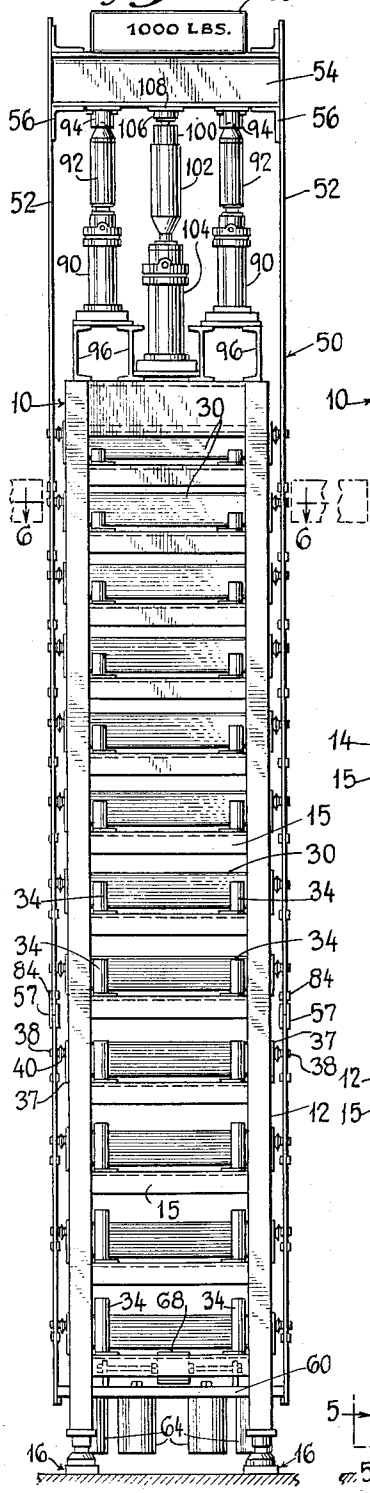


Fig. 2.

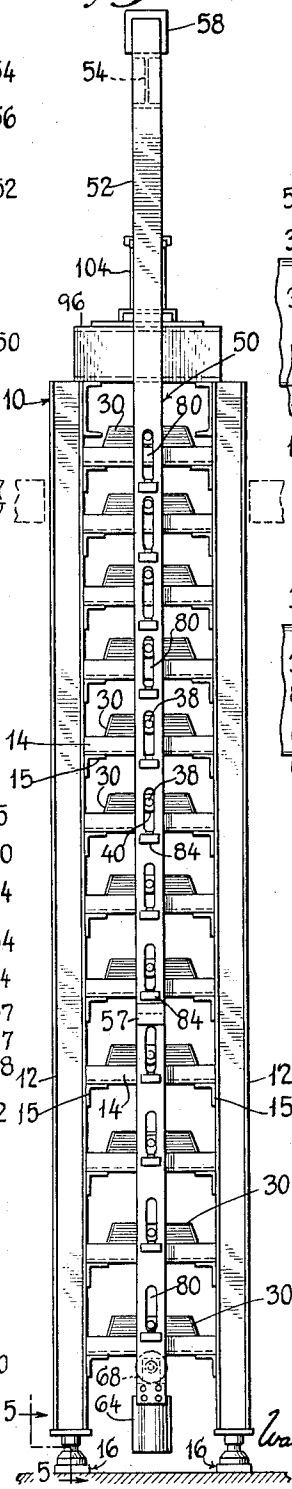


Fig. 3.

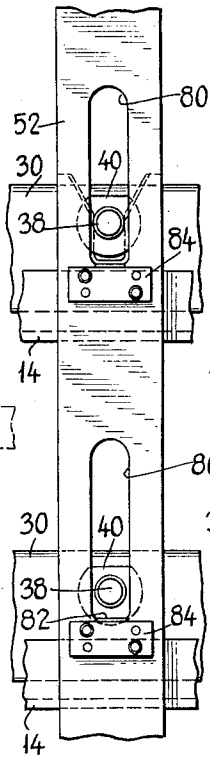


Fig. 4.

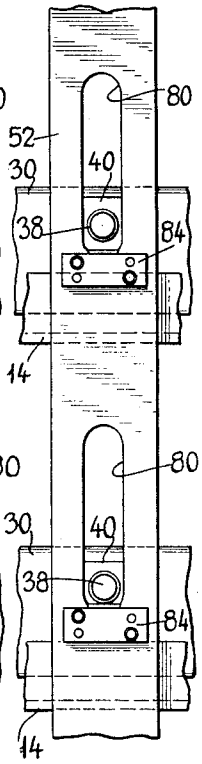
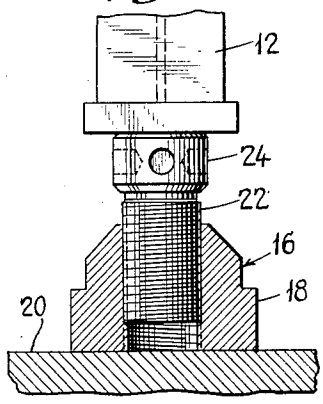


Fig. 5.



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Fig. 6.

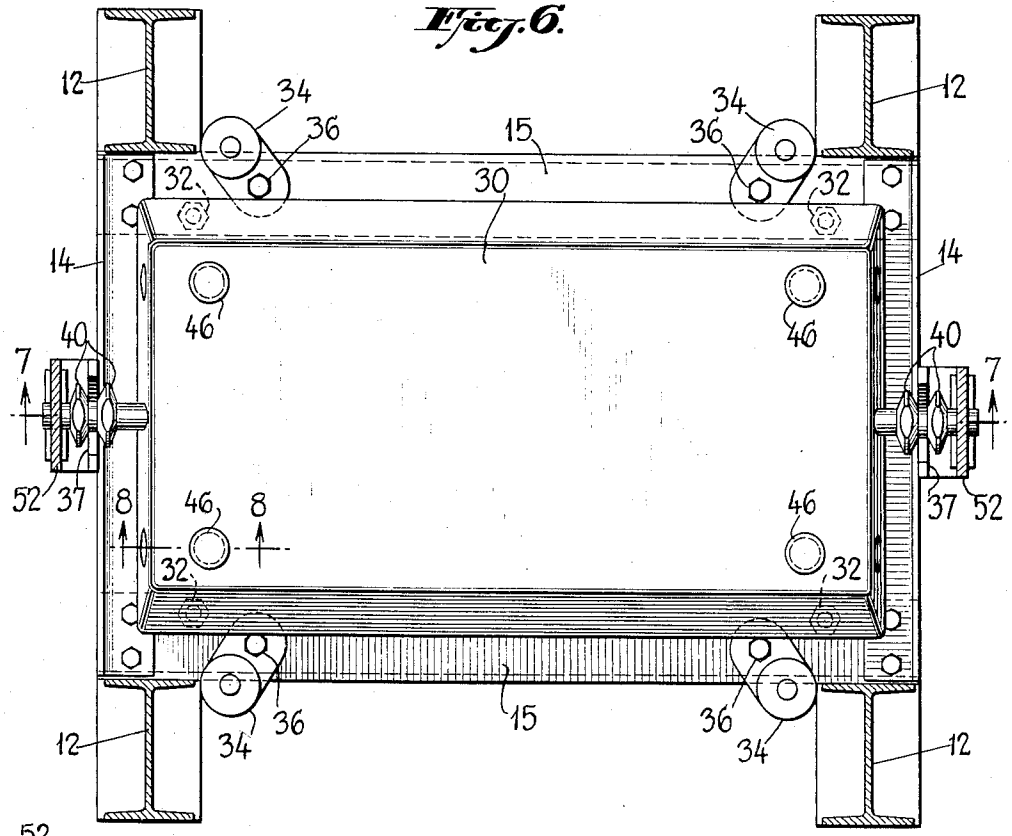


Fig. 7.

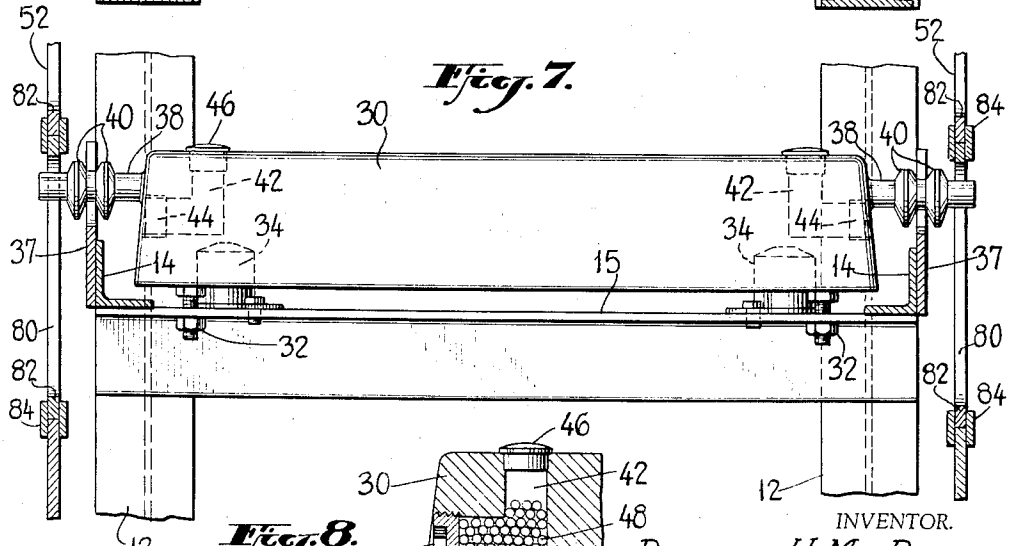


Fig. 8.

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DEAD-WEIGHT MACHINE

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Fig. 9.

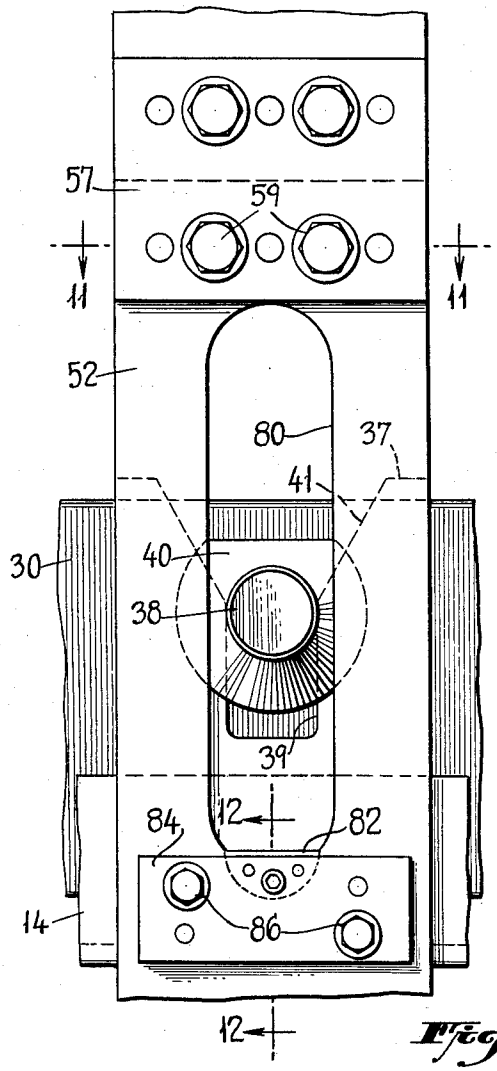


Fig. 10.

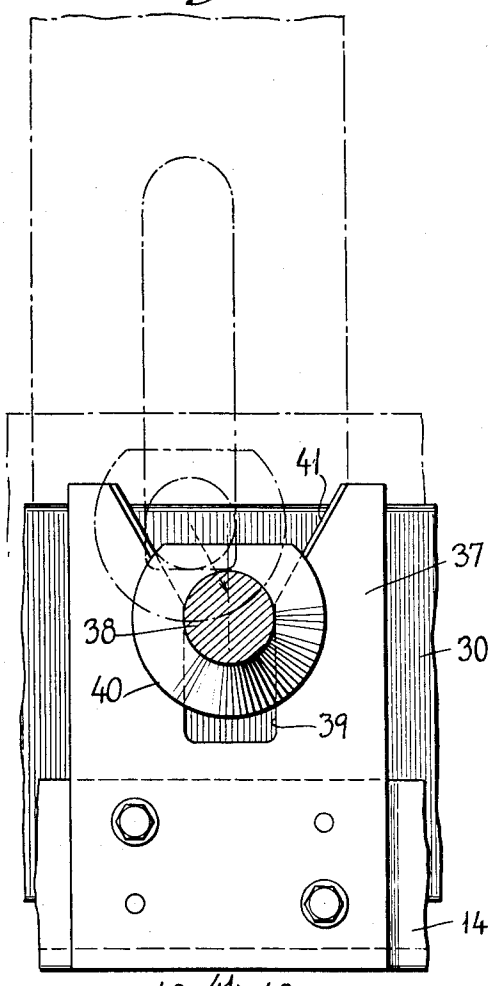


Fig. 12.

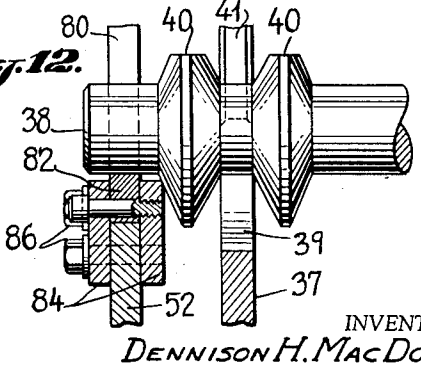
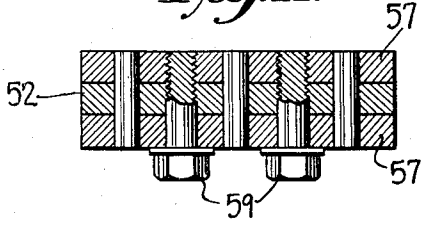


Fig. 11.



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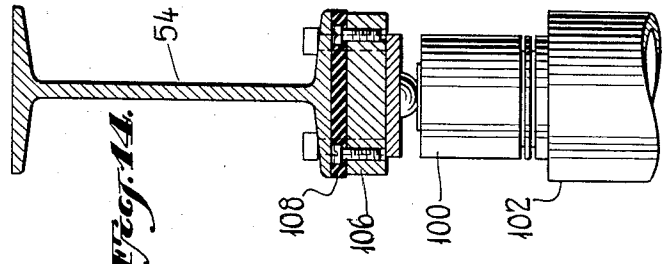


Fig. 14.

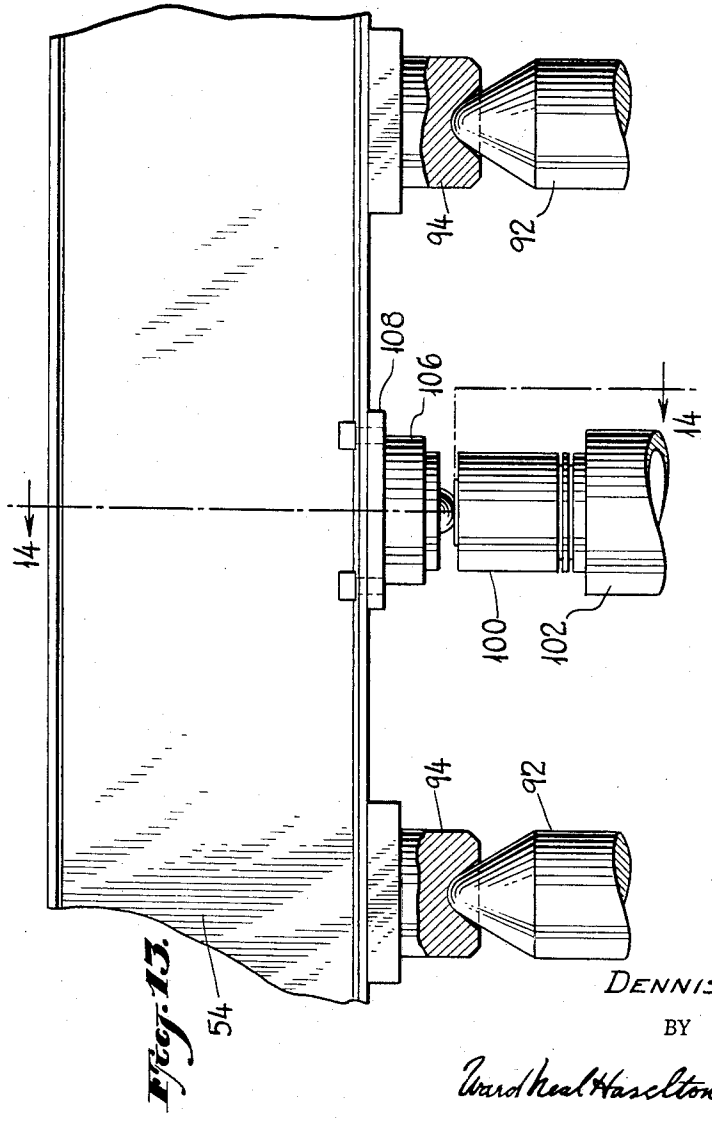


Fig. 13.

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DEAD-WEIGHT MACHINE

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Fig. 15.

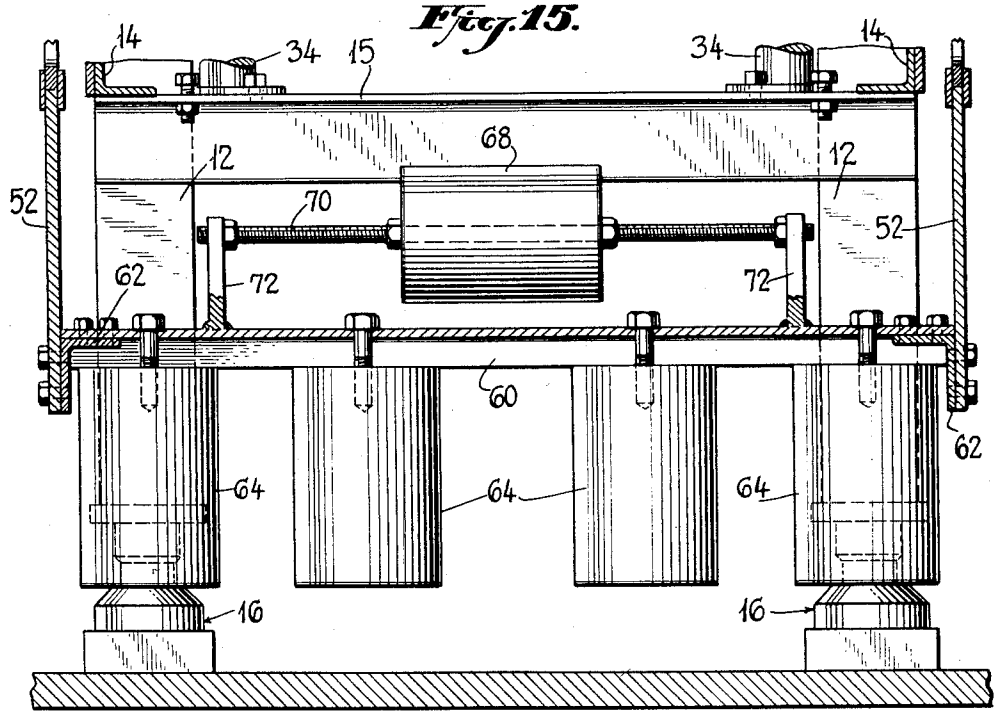
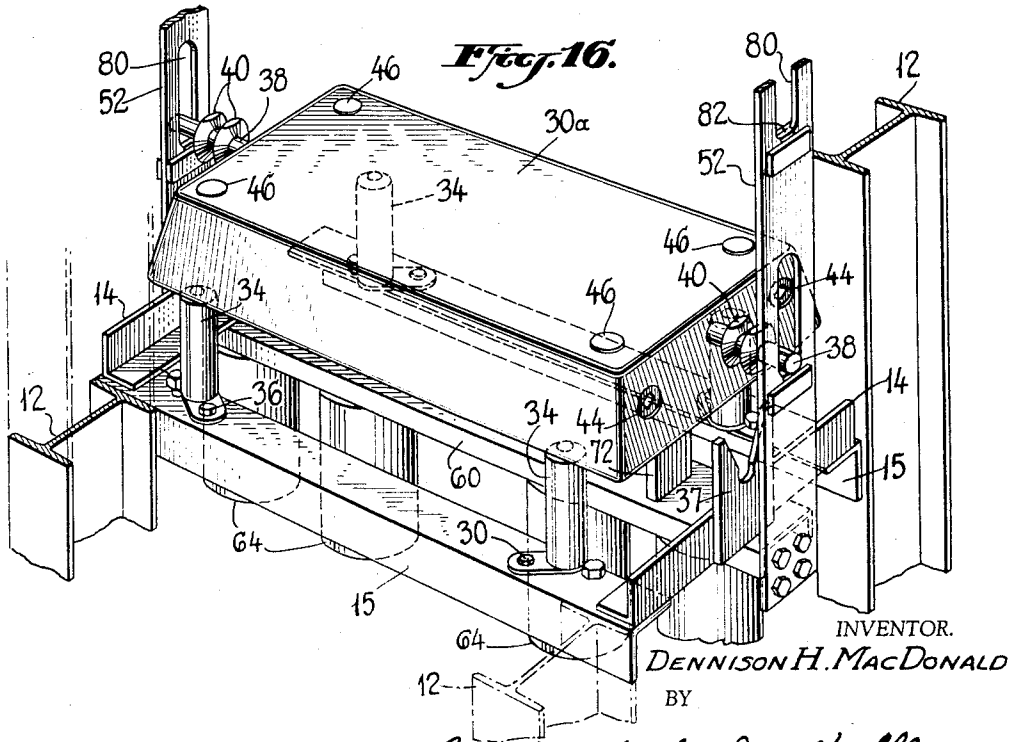


Fig. 16.



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United States Patent Office 2,925,728 Patented Feb. 23, 1960

2,925,728

DEAD-WEIGHT MACHINE

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Application June 26, 1957, Serial No. 668,086

7 Claims. (Cl. 73—1)

This invention relates to so-called "dead-weight" machines; that is, apparatus adapted for subjecting any desired element or type of device to the effect of various stationary weights arranged to apply various corresponding pressures or forces to such devices or elements, thereby to enable testing, calibrating or appropriate adjustment of the device or element.

The National Bureau of Standards, Washington, D.C., has constructed a dead-weight machine in which there are arranged a plurality of superposed heavy weights of disc shape. A central suspending rod extends down through central apertures in such weights, such rod having mounted thereon a succession of flanges, protuberances, or the like, so positioned that as the rod is elevated, the various weights will become successively suspended thereby, so that, for example, a total weight varying from 1000 pounds up to 10,000 pounds may be applied in stepwise increments to the rod, the rod being arranged with other parts to apply these various weights to an element such as a weighing cell or other device, the responses of which are to be tested and calibrated.

While the particular machine referred to above is reliable for its intended purposes, it has various inherent disadvantages. For example, the arrangement is such that it will act to pick up and suspend the weights in succession to provide step-by-step increasing loads, yet in some cases it is important to be able to test a weighing cell or other pressure sensitive equipment by initially applying thereto a selected, predetermined, very heavy load to determine the response of the device to such a heavy load immediately applied, as distinguished from the response which would occur if the load, starting at a low value, were increased step by step. The National Bureau of Standards machine is not adaptable for thus starting a test with a heavy load as distinguished from loading step by step, starting with a light load. Also, the construction of that machine is such that in practice it becomes necessary accurately to machine the surfaces of all of the numerous heavy disc-like weights in the manufacture thereof to obtain accurate weight values, which fact adds excessively to the cost of the equipment.

In accordance with the present invention, a dead-weight machine is provided which avoids the above-described difficulties and which also is of a construction making possible a high degree of flexibility in its operation, for various testing and calibrating purposes. That is, the apparatus according to the present invention is adapted to subject a test cell to either a heavy initial load or an incremental load, and each of the weights used therein may be accurately tested, adjusted and balanced by arrangements permitting the adding of small weighted particles to the weights which may be originally cast inexpensively in relatively rough form.

The apparatus of the present invention is adapted for various uses, including the testing and calibration of pressure-responsive load weighing cells, as well as various

other types and varieties of apparatus which are responsive or may be made responsive to various dead weights.

Various further and more specific objects, features and advantages of the invention will appear from the description given below, taken in connection with the accompanying drawings illustrating by way of example, a preferred form of the invention.

In the drawings:

Fig. 1 is a side elevation of the apparatus embodying the present invention;

Fig. 2 is an end elevation of the apparatus shown in Fig. 1;

Fig. 3 is a detailed partial end elevation showing the starting position of the hanger frame and two typical weights before either of same is supported by the hanger;

Fig. 4 is a partial end elevation similar to Fig. 3 after the hanger frame has been raised a slight distance, thereby engaging and lifting the lower weight shown;

Fig. 5 is a detailed partial sectional view taken along lines 5—5 of Fig. 2, showing an adjustable foot on the platform stand;

Fig. 6 is a sectional plan view taken along section lines 6—6 of Fig. 1;

Fig. 7 is a side sectional view taken along lines 7—7 of Fig. 6;

Fig. 8 is a detailed sectional view of a portion of one of the weights, taken along lines 8—8 of Fig. 6;

Fig. 9 is an enlarged end elevational view showing the hanger strap and a typical guide bracket for one of the weights, and also a weight-supporting insert piece;

Fig. 10 is a detailed, enlarged and elevational view similar to Fig. 9, but showing the operation of the weight guide bracket;

Fig. 11 is a detailed, sectional view taken along lines 11—11 of Fig. 9, showing means for attaching two sections of the hanger strap together;

Fig. 12 is a detailed sectional view taken along lines 12—12 of Fig. 9, showing the weight-supporting insert in the hanger strap, as well as certain adjacent parts;

Fig. 13 is a detailed view showing the lifting and supporting means for the hanger assembly;

Fig. 14 is a partial sectional view taken along lines 14—14 of Fig. 13;

Fig. 15 is a detailed partial sectional view of the bottom portion of the hanger assembly and the supporting stand; and

Fig. 16 is a perspective view of one of the weights supported by movable supporting pins therefor, and various other adjacent parts.

Referring to the drawings, the dead weight apparatus of the prevent invention has a stand member **10** consisting preferably of four upright supporting columns **12** to which are attached horizontal supports **14** at various elevations. These horizontal supports function as shelves **15** for initially supporting the weights. Means may be provided for adjusting the upright supports of the stand member, such as adjustable feet on each of the upright members. A detail of an adjustable foot **16** is shown in Fig. 5 wherein a supporting nut **18** rests on a suitable base or floor **20**. The lower end of the upright support carries a rotatable screw member **22** with its lower end in threaded engagement with the nut **18** and having a plurality of holes **24** therein for the purpose of turning the member and thereby adjusting the height of the support above the floor. Of course if the floor or other supporting surface for the apparatus is originally constructed in level condition, such adjustable foot means will be unnecessary.

A relatively heavy weight **30** may be positioned on each of the horizontal shelves **15** and supported thereon by means of screw and nut devices as at **32** (Fig. 7) which can be used to level the weight with the shelf or

adjust, within narrow limits, the vertical position of the weight. Each shelf 15 also carries other weight-supporting members consisting of upright pin supports 34 which are swingable about pivot points 36 into and out of weight-supporting position (Fig. 6). When the pins are all in weight-supporting position the weight placed thereon is held a predetermined vertical distance above the platform and this distance is usually different for each shelf. As shown in Fig. 1, the lowermost pins are the tallest and they decrease in height in incremental steps to the top shelf which has the shortest pins.

Each weight 30 has a lifting arm or pivotal support 38 rigidly attached to each end thereof (Figs. 6 and 7). Two guiding collars 40 are formed integral with the lifting arm and spaced apart axially thereon. These collars are formed as shown to provide a V-shaped circumferential groove therebetween for engaging guide brackets. Such guide brackets shown at 37 are attached to each of the shelves at each end thereof for the purpose of engaging the lifting arms 38 of the weights 30 when the weights are being lowered and guiding the weights back to their original position on the shelves. Each guide bracket 37 includes a vertical slot 39 having a diverging mouth 41 for guiding a descending weight as stated above and as shown in Fig. 10.

As shown in Fig. 8, each weight has a plurality of cavities 42 therein, preferably located respectively adjacent the four corners of the weight and each cavity is closed by a threaded cap 44 and a plug 46. These cavities may be filled or partially filled with small weighted particles 48 such as small metal balls or shot for the purpose of accurately adjusting the effective total amount of each weight, and also permitting the even balancing of the two opposite ends as well as the two opposite sides of each weight. Thus the weights may be roughly and inexpensively cast of lead for example and later adjusted and balanced so that they will hang properly in the apparatus as explained below.

A hanger frame assembly, generally indicated at 50, includes two hanger straps 52 positioned at each side of the stand member. These straps are connected at the top by a connecting beam 54 and suitable brackets 56. The top of the hanger structure provides a suitable support for a removable standard test weight 58. The elongated hanger straps 52 may be made from two or more pieces of strap and fastened butt to butt by lap plates 57 suitably attached by screw means 59, as shown in Fig. 11. The hanger frame assembly with the weights 30 thereon is suspended from the top of the apparatus as an assembled unit normally hanging in a vertical position, but free to swing at least slightly in any direction without engaging or incurring any frictional resistance with any part of the stand, except at the point or points of support at the top, and the various weights 30, after they have been balanced as above described, will be suspended when lifted by the hanger normally in horizontal positions, but each will be free to tilt sideways to become truly balanced horizontally as they are raised or lowered. But if, due to slight tilting movements of the weights upon being raised and lowered, they should become displaced gradually or otherwise, either endwise or sidewise, then as they are lowered again by the hanger, the above-described guide collars 40, in conjunction with the guide brackets 37, will cause the weights to be restored accurately to a predetermined position, thus preventing them from progressively "crawling" out of place as the rsult of repeated lifting and lowering by the hanger. Thus even though the weights are left free to balance themselves in horizontal positions when suspended, they will be guided back into proper place when lowered each time and thereby any danger of causing the whole hanger assembly to be put out of balance and to swing sideways to any objectionable degree will be avoided and yet the assembly will be left normally free of frictional or other engagement with the stand at any place.

Details of the bottom arrangements of the hanger assembly 50 are shown in Fig. 15 wherein a bottom connecting member 60 is secured to the hanger straps 52 by brackets 62 and suitable weights 64 may be supported from this bottom connecting member by screw bolts as shown. A horizontally adjustable weight 68 is supported on a threaded rod 70, which in turn is carried by brackets 72 attached to the bottom connecting member 60. When the weight 68 is rotated, it will be moved toward one side or the other and thereby balance the hanger frame assembly in sidewise directions.

The hanger straps 52 are provided with a plurality of elongated openings 80 adjacent the end edges of each of the shelves 15 for the purpose of engaging the lifting arms 38 on the weights 30. The positions of the bottoms of these slots is determinative of when the weights will be lifted upon raising of the hanger assembly. That is, if the points of engagement between the hanger strap and the weights were initially a common distance apart, the weights would of course all be lifted at once, and if they are a variable distance apart, the weights will be lifted at various times. Fig. 12 shows details of one of the hanger straps as it engages the lifting arm of one of the weights. A weight-supporting insert 82 may be rigidly attached at the bottom of each slot 80 by means of straps 84 and suitable screws 86.

The mechanism for lifting the hanger assembly 50 includes two jacks 90 engaging lifting columns or spacers 92, the upper ends of which fit in sockets 94 attached to the top connecting beam. The jacks are supported on beams 96 attached to the top of the stand member 10, and they may be of the hydraulic type arranged for simultaneous operation.

A weight-measuring device 100, which may be for example a weighing cell utilizing electrical strain gauges, is attached to or mounted on the top of spacer column 102 and is likewise vertically positioned by a jack member 104 which is operable independently of jacks 90. The top of the weight-measuring device 100 is engaged by a load-applying member 106 attached to the top beam 54 preferably through an interposed and somewhat resilient member 108, thereby cushioning the load applied to the device 100.

The dead-weight apparatus as described above may be used for various purposes such as the testing and calibration of pressure responsive weighing cells and the calibration of accurate weights. To first accurately calibrate the frame and associated weights, a suitable procedure may be as follows:

A weighing device 100, such as a weighing cell, is arranged to wholly support a heavy reference weight, such as a standard 1000-lb. weight. This is accomplished when the weighing device is not in the dead weight apparatus, by means of a suitable yoke or the like arranged to support the weight on the cell, and the reading indicated by the cell is noted. This heavy-reference weight is next placed on top of the hanger frame 50, as indicated by reference numeral 58, and different bottom weights 64 are attached to the hanger frame assembly until the entire weight of the hanger assembly 50, together with the weight 58 produce an indication on the weighing device of a value double that produced by weight 58 alone; i.e., an indication equal to 2000 lbs. At this time, of course, the hanger assembly is supported solely by the jack 104, and the spacer 102 and cell resting thereon. Weight 58 is then removed and the entire weight of the hanger frame assembly 50 with weights 64 should produce an indication on the weighing device 100 identical to the indication produced by the accurately calibrated reference weight when it alone was weighed by the cell as described above. Then the hanger frame assembly 50 is raised by the two outside jacks 90 until the bottom weight 30*a* is supported by the bottom slots 80. The center jack 104 is raised to apply pressure to the cell 100 until it supports the entire weight of the

hanger frame assembly **50** and the bottom weight **30***a*. Then the cell should indicate a weight of approximately 2000 lbs. Then the bottom weight **30***a* is calibrated and balanced by means of adjusting the amount of weighted particles **48** in each of the cavities **42** until the cell **100** indicates a weight double the weight of the reference weight—i.e., 2000 lbs. The bottom weight **30***a* may then be raised by the use of jacks **90** and set on the swingable pin supports **34** to support the weight on the stand **10** rather than by the hanger frame assembly **50**. Subsequently, the frame **50** may be raised further to engage and support the next-to-the-bottom weight **30***b* and this weight is calibrated and balanced in the same manner as weight **30***a*. All the other weights on higher shelves may also be accurately calibrated and balanced in this manner.

To test or calibrate other weighing devices, or cells, they are placed in the position of weighing device **100** and are subjected to the weight of the hanger frame assembly **50** plus various of the weights **30**. As the jacks raise the hanger frame assembly, the weights **30** which are supported on screw and nut devices **32** will be lifted, one more at each time, since the bottoms of slots **80** are step-by-step at varying distances from the arms **38**, as shown in Fig. 2. Hence, accurately calibrated 1000-lb. weights may be applied in increments to the weighing cell or device, and the cell may be calibrated or tested accordingly. To support the entire load on the load-measuring device, the jack **104** may be raised to a small distance above the effective height of jacks **90**, thereby relieving these jacks of the load.

The swingable supporting pins **34** are of different heights for supporting weights at different elevations according to the shelf on which the weight is placed and each of these different elevations preferably is a common distance from the bottom of the corresponding slots **80** in the hanger straps **52**; hence, the incremental effect of the slots **80** in the hanger straps are offset when such supporting pins are swung into place. Thus any weights which have been positioned on top of the supporting pins **34** may be picked up on a vertical upward movement of the hanger straps, all at the same time, thereby applying an initial very heavy load to the weighing device **100**. This same effect of applying loads by steps, or any desired number thereof at one time, also may be carried out in reverse; that is, the weights may be set down on the supports either more than one at a time or in increments, or steps, one at a time. When the weights are descending toward the supports, they are guided back to their original positions on the supports by means of the guide brackets **37** which engage the lifting arms **38** of the weights **30** between the guiding collars **40**, as shown particularly in Figs. 10 and 12.

The hanger assembly **50** need only be lifted a distance slightly greater than the length of the top slot **80** in the hanger strap **52** to pick up all the weights in incremental steps or all the weights at the same time, and then the weights may be again restored to their supports by a corresponding downward vertical movement of the hanger straps.

The weights **30** and the slots **80** may be positioned relative to each other in different ways to obtain the same result; that is, the slots **80** could be at a common distance apart and the weights could be supported at different distances apart for step-by-step loads, and a common distance apart for applying the effects of various weights together.

Although a certain particular embodiment of the invention is herein disclosed for purposes of explanation, further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. In a dead-weight machine, the combination comprising: an upright supporting stand; a series of superposed weights and means for normally supporting same in vertically spaced relation on said stand; a hanger having a top portion and other portions suspended therefrom and extending down past said weights; means on each of said weights for supporting same respectively for free pivotal movement about substantially horizontal axes passing through the mid portions of each; means at predetermined spaced points along the suspended portions of the hanger means for engaging said pivotal supports respectively in a predetermined order as the hanger means is raised to thus raise the weights from said normal supporting means therefor; and elevating means for raising the hanger means while a device to be tested or calibrated is interposed betwen the elevating means and the hanger means in a position to be subjected to the weight of the hanger means and the weights raised thereby.

2. In a dead-weight machine, the combination comprising: an upright supporting stand; a series of superposed weights and means for normally supporting same in predetermined vertically spaced relation on said stand; a hanger having a top portion and other portions suspended therefrom and extending down past said weights; arms protruding from each side of each of said weights for pivotally supporting same respectively about substantially a central horizontal axis passing through each; means at predetermined spaced points along the suspended portions of the hanger means for engaging said arms respectively in a predetermined order as the hanger means is raised and thus raising the weights; elevating means for raising the hanger means while a device to be tested or calibrated is interposed between the elevating means and the hanger means in a position to be subjected to the weight of the hanger means and the weights raised thereby; and interengaging means on said arms and on the stand for guiding said weights back to predetermined positions with respect to the stand when the hanger is lowered again.

3. A machine in accordance with the foregoing claim 2 and in which the said interengaging means comprises portions forming circumferential V-shaped grooves on said arms, and brackets mounted on said stand and formed with slots having upwardly diverging sides adapted to engage said grooves.

4. An apparatus for testing and calibrating weighing cells and the like comprising: an upright stand; a plurality of horizontal support members affixed to said stand for supporting heavy weights in predetermined vertically spaced positions; a hanger assembly having hanger straps with means thereon corresponding respectively to each of the weights to engage and lift said weights upon upward movement of said assembly, each of said means prior to such upward movement being normally spaced vertically with respect to its point of engagement with its corresponding weight by a different distance, whereby during such upward movement said assembly lifts said weights, one weight in addition at a time; and shiftable means carried by said support members for selectively supporting each of said weights at different predetermined positions above said support members respectively such that said lifting assembly upon upward movement then engages and lifts all of said weights so positioned simultaneously.

5. A dead-weight apparatus comprising: a stand; a plurality of horizontal shelves mounted on said stand; a plurality of weights adapted to be supported respectively by each of the said shelves; supporting means carried by each of said shelves and movable into positions for supporting each of the said weights at predetermined stepwise variable distances above said shelves respectively; a hanger having means for engaging each of said weights on each of said shelves when said hanger is moved up-

ward, said engaging means being normally spaced respectively at different vertical distances from their points of engagement with the weights when said weights are resting on said shelves, whereby said hanger member will lift the weights one additional at a time, when said hanger member is moved upward, and when said weights are resting on said supporting means at stepwise varying distances apart, said varying distances being such that said hanger member will lift all of said weights on said supports simultaneously upon upward movement; and jack means adapted to support thereon a weight measuring device to thrust such device up against a portion of the hanger thereby to lift the hanger.

6. A weight structure adapted for use in a dead-weight machine and to be supported on a suspended hanger and to be balanced about an axis extending substantially horizontally through the middle portion thereof, said weight structure being formed with shaft-like supporting arms extending along such axis and to opposite sides thereof, two cavities formed in the weight structure respectively at spaced positions at opposite sides of one of said arms, two other cavities also formed respectively at spaced positions at opposite sides of the other of said arms, said cavities having removable closure means and each being adapted to contain numerous and variable numbers of small weights or weight particles to enable adjustment of the balance of the weight structure with respect to said axis and with respect to another axis passing through the approximate center of gravity of the weight structure at right angles to said first-mentioned axis.

7. Machine in accordance with the foregoing claim 1 and in which the weights are generally flat and of a generally rectangular outline and substantially balanced in horizontal positions with respect to said axes thereof, and in which machine the normal supporting means for the weights respectively include elements of various different heights located beneath the corner areas of the weights.

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