March 31, 1942. W. G. HOELSCHER 2,278,262

COUNTERWEIGHT MECHANISM FOR DRILL SPINDLES

Filed Oct. 3, 1939 4 Sheets-Sheet 1

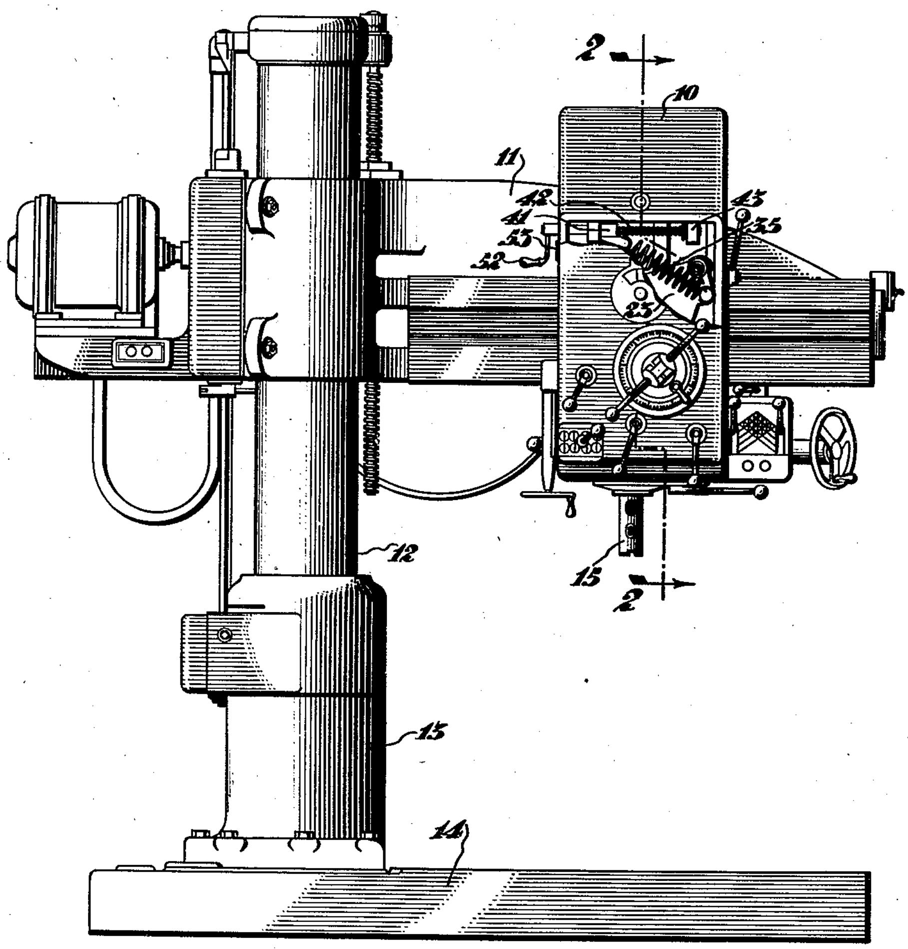


Fig.1

INVENTOR.

BY William G. Hoelscher

Wood & Wood ATTORNEYS

March 31, 1942. W. G. HOELSCHER 2,278,262

COUNTERWEIGHT MECHANISM FOR DRILL SPINDLES

Filed Oct. 3, 1939 4 Sheets-Sheet 2

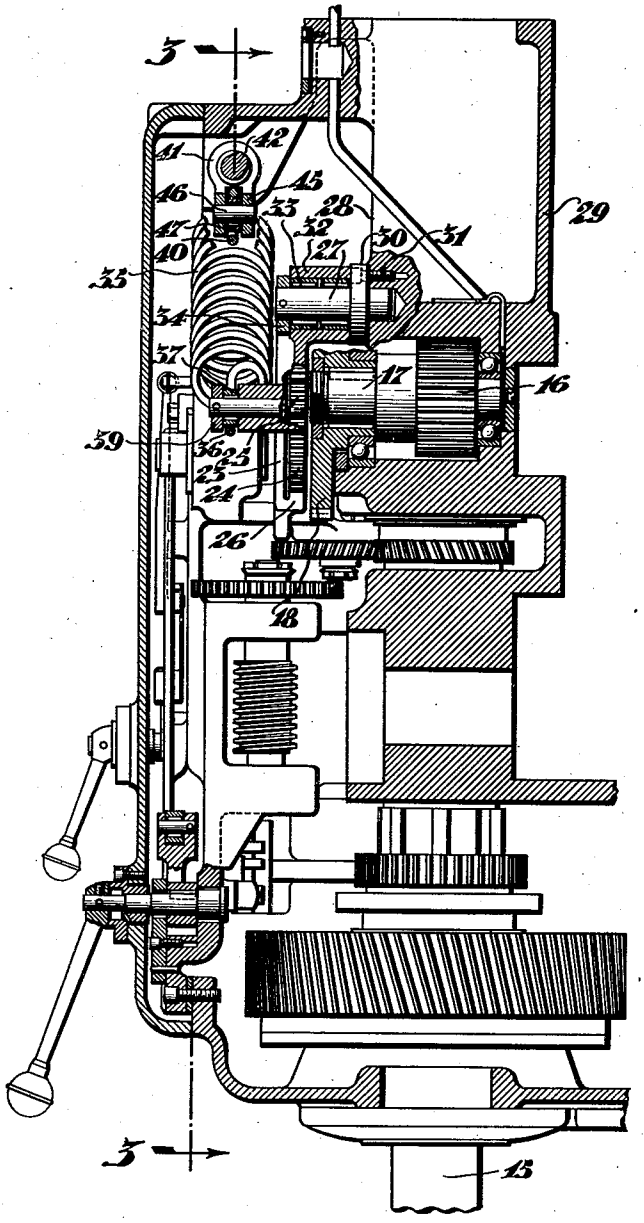


Fig. 2

INVENTOR.

BY William G. Hoelscher

Wood & Wood ATTORNEYS

March 31, 1942. W. G. HOELSCHER 2,278,262

COUNTERWEIGHT MECHANISM FOR DRILL SPINDLES

Filed Oct. 3, 1939 4 Sheets-Sheet 3

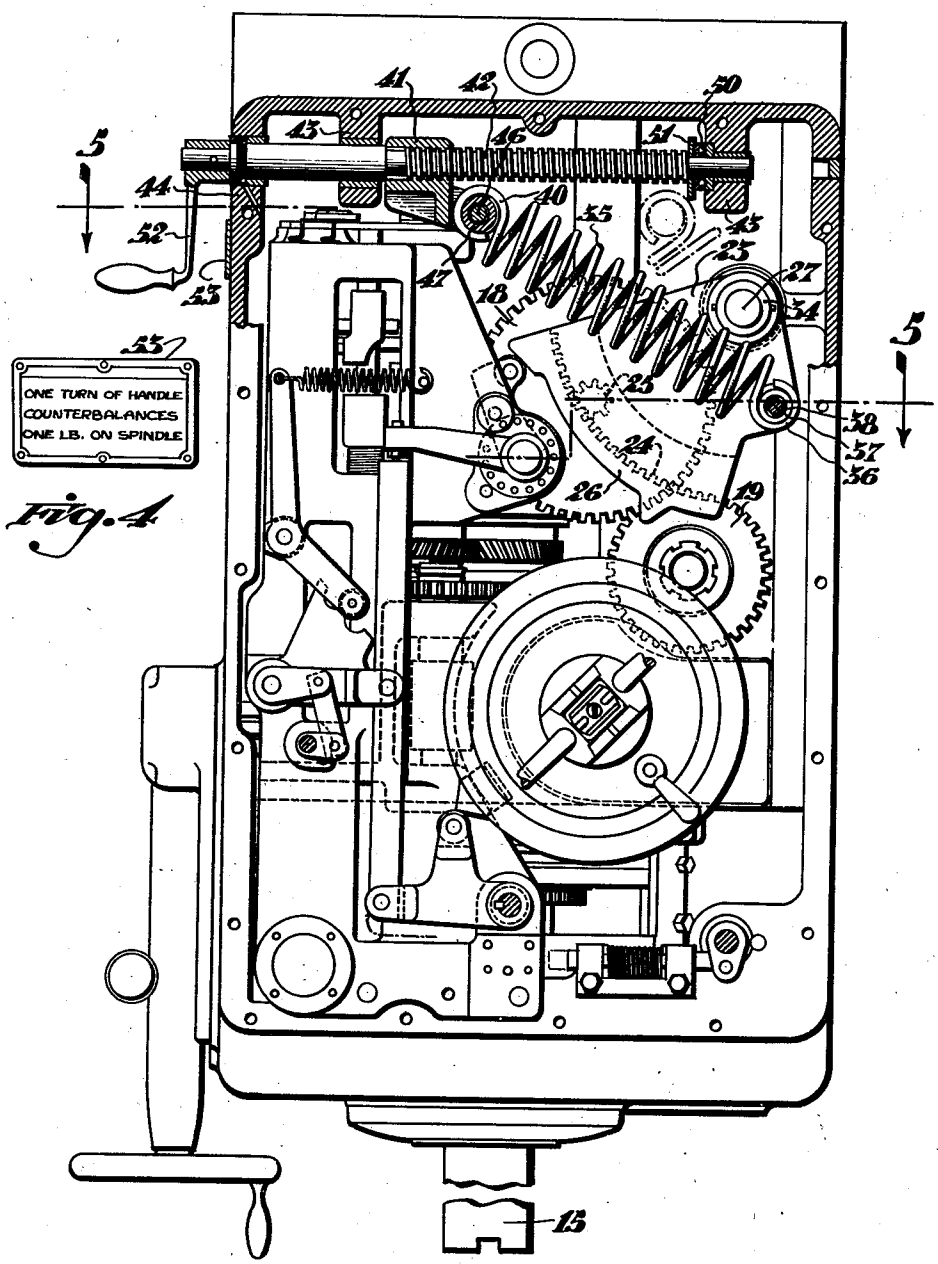


Fig. 4

Fig. 5

INVENTOR.
BY William G. Hoelscher
Wood & Wood
ATTORNEYS

March 31, 1942. W. G. HOELSCHER 2,278,262

COUNTERWEIGHT MECHANISM FOR DRILL SPINDLES

Filed Oct. 3, 1939 4 Sheets-Sheet 4

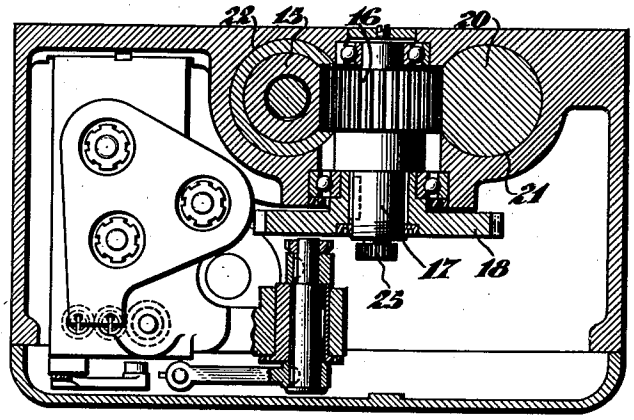


Fig. 5

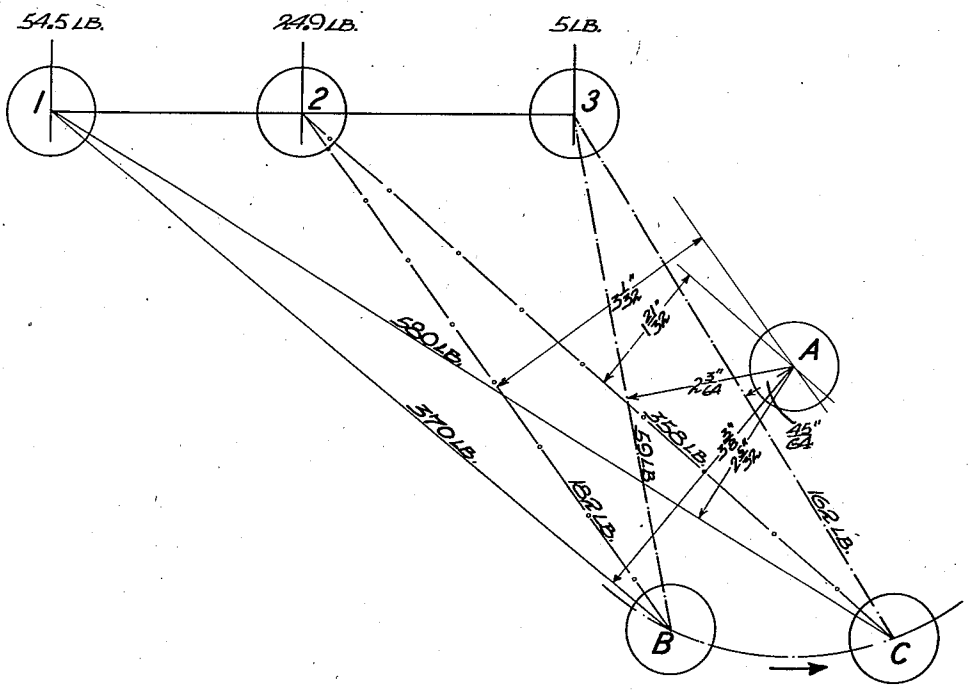


Fig. 6

INVENTOR.

BY William G. Hoelscher

Word. Word ATTORNEYS

Patented Mar. 31, 1942 2,278,262

UNITED STATES PATENT OFFICE

2,278,262

COUNTERWEIGHT MECHANISM FOR DRILL SPINDLES

William G. Hoelscher, Cincinnati, Ohio, assignor to The American Tool Works, Cincinnati, Ohio, a corporation of Ohio

Application October 3, 1939, Serial No. 297,722

9 Claims. (Cl. 77—36)

This invention relates to drilling machines and is particularly directed to improvement of the counterbalance means employed in connection with the drill spindle. It is usual to employ some counterweight or balance means for the spindle and the parts associated therewith, whereby the operations, that is, the feeding and elevating of the spindle, are more easily accomplished, since the weight of the spindle is not imposed upon the mechanism.

The usual means employed for this purpose is a counterweight disposed alongside of and connected to the spindle, the weight of the counterweight being calculated to equal or approximate the weight of the spindle.

If an unusually heavy boring tool is inserted in the chuck of the spindle, the effect is to disturb the balance so that the counterweight is only partially effective. It has been the object of the present inventor to overcome this condition by the provision of a supplemental counterbalance means, which means may be adjusted through a simple expedient to add an additional counterbalancing force to the spindle, equal to the added weight. This objective has resulted in a mechanism which provides perfect balance in any position of the spindle, when set to compensate for any particular additional weight on the spindle.

A concrete embodiment of the invention may employ a spring having one end attached to a lever swung by means of the raising and lowering movement of the spindle. The other end of the spring may be attached to an adjustable means primarily adapted to vary the normal tension of the spring for a given weight on the spindle. By virtue of this arrangement, it is provided that, as the spring tension decreases due to movement of the spindle, the leverage increases in direct proportion, so that the actual effective counterbalance force is uniform at any position of the spindle.

More specifically described, the effective leverage decreases as the lever tends to move toward parallelism with the line of pull of the spring, whereas the spring tension increases. Accordingly, the improved construction constitutes an interposed or supplemental counterbalance means for offsetting unbalance of the normally balanced counterweight and spindle.

It will readily be seen that the spring used in this device or the leverage may be increased, whereby the spring may either take the place of the normal counterweight, or supplement it. Accordingly, it has been the further object of the present inventor to provide a device of this character which may be used either in conjunction with the counterweight for compensating for additional weight, or used without the counterweight, that is to say, providing sufficient spring tension to balance the normal weight of the spindle, and with the adjustment means, as shown, to accommodate or compensate for the added weight of boring tools carried by the spindle.

Other objects and certain advantages will be more fully set forth in the description of the accompanying drawings in which:

Figure 1 is a general front view of a radial drill incorporating the improved counterweighting mechanism of this invention, the portion of the head stock being broken away for elevating the location of the device.

Figure 2 is a sectional view taken on line 2—2, Figure 1, showing details of the compensating counterweighting mechanism.

Figure 3 is a sectional view taken on line 3—3, Figure 2, illustrating more details of the mechanism.

Figure 4 is a face view of the indicator plate for the adjustment means of the mechanism.

Figure 5 is a sectional view taken on line 5—5, Figure 3, illustrating the spindle feeding means and the normal counterweight.

Figure 6 is a diagrammatic view adapted to be considered with the chart illustrating various positions of the compensating counterforce applying means, showing the relationship of spring tension and leverage throughout the positions.

The invention is principled upon the concept of maintaining or obtaining a predetermined counterbalancing force by relating the tension or pull of the counterbalancing spring to the moment or lever arm through which this force is exerted on the part being counterbalanced.

If the lever arm through which the spring operates is of constant value, then, of course, the spring stretches as the spindle is lowered, and the counterbalancing force increases in substantially direct proportion to the distance through which the spindle is lowered, or vice versa. However, in accordance with the present invention, the lever arm or moment through which the spring is operating is decreased as the spring is stretched, as during lowering of the spindle, and, conversely, the lever arm is increased as the tension of the spring is lessened, as when the spindle is raised. In this manner, the parts are related so that the product of the tension of the spring, for instance in pounds, times the lever arm or moment through which it is operating,

for any given position of the spindle, equals or approximately equals the product of the tension of the spring times the moment or lever arm through which it is operating for any other given position of the spindle, within the normal limits of the spindle travel.

From the mechanical point of view, the preferred mechanism for providing this relationship comprises a coupling of the spindle to a mechanical lever through which the spring exerts its counterbalancing force upon the spindle. The lever is pivoted for rotation about a given axis. The spring at its one end is connected to this lever and at its other end is connected to a point which is relatively fixed (this latter point however, is adjustable, as explained later in the specification, to compensate for variation in tool weight).

As the spindle is raised and lowered the lever is rotated about its axis and consequently the effective mechanical lever or mechanical moment is varied. The moment is the defined length of a line drawn perpendicularly from the axis of the spring or from the line of force through which the spring operates upon the lever, to the axis of rotation of the lever. It will be understood, of course, that the fixed point of attachment of the spring is on the same side of the axis of rotation of the lever as the point of attachment of the spring to the lever. The relationship may be expressed mathematically as follows: $T_1 \times L_1 = T_2 \times L_2$ in which T_1 and T_2 are the spring tensions and L_1 and L_2 are the moment arms corresponding to the respective positions of the spring at which the spring provides the tensions T_1 and T_2.

Now, with the points of connection established in this relationship, an adjustment of the fixed point of connection of the spring relatively toward and away from the axis of rotation of the lever will provide a decreasing or increasing tension upon the spring itself. This latter adjustment, therefore, is employed for compensations in the variations of the weights of the tools carried by the spindle.

Referring to the drawings it will be observed that the device is incorporated in a radial drill. It is disposed in the head stock **10**, mounted on the arm **11**, supported on the column **12**, mounted on the stump **13**, fixed to the base **14**. The spindle **15** (Figures 1 and 5) is raised and lowered by means of the gear **16**. This feed gear **16**, meshing with the rack teeth of the spindle, is fixed to a shaft **17** to which a gear **18** (Figures 4 and 5) is fixed. The gear **18** is driven by a gear **19**, driven by a feed transmission which is undisclosed. The gear **16** also meshes with the rack teeth of the counterweight **20** slidably mounted in a bore **21** parallel to the bore **22** containing the spindle.

Now the compensating counterforce means is effective upon the shaft **17** and, therefore, the gear **16** and the spindle **15**. The lever **23** of the compensating mechanism is constituted by a gear segment providing internal teeth **24** in mesh with a spur gear **25**, fixed to the shaft **17**. The gear segment includes a circumferential flange **26** carrying the internal gear teeth **24**. It is mounted on a fixed stud **27** attached to the internal wall **28** of the head stock casing **29** including for this purpose a circular flange **30** traversed by screws **31**. The bearing hub **32** of the lever **23** carries roller bearings **33**. A collar **34** holds the lever or the gear segment on the stub **27**.

The spring **35** exerting the force on the spindle is a heavy coil spring having one terminal loop **36** engaged upon a roller bearing **37** disposed on a pin **38** fixed in the lever **23**. A collar **39** holds the roller bearing **37** in position. The other terminal loop **40** is attached to a bracket **41** normally fixed for any given weight of tool but adjustable to compensate for tools of different weights.

This bracket is mounted upon a screw rod **42** journaled in lugs **43** of the casing and in the side wall **44** thereof. The bracket includes a bifurcated lug **45** carrying a cross pin **46**. A roller bearing **47** is disposed on the cross pin and the terminal loop **40** is looped upon the bearing. The attachment of the spring to the lever is at a point intermediate the length of the effective lever arm and can be disposed more toward the end of the lever, that is the swinging end, if the manufacturer decides to support the normal weight of the spindle by means of it. This pin is always disposed on that side of a line, drawn between the center of the shaft **17** and the center of the stub **27**, which is opposite that upon which the other end of the spring is attached.

Now referring again to the screw rod, an end thrust bearing **50** is disposed between a washer **51** engaged against a shoulder of the rod and one of the lugs **43** with the lug **43** taking the end thrust of the rod as imposed by the spring. Otherwise the rod bearings are plain. A crank handle **52** is pinned to the extended end of the rod and is adapted for rotating the rod to change the tension of the spring. Each turn of the crank, as indicated by the plate **53**, is effective for changing the tension in the spring by the amount of one pound. As shown in Figure 3, the spring is set to support the maximum additional weight which in this case amounts to 54½ pounds. In Figure 6 the applicant shows a diagram disclosing the spring pressures in pounds and the leverages in inches. It will be noted from this diagram that, for any one of the fixed positions of the adjustable spring terminal, the spindle may be moved through its complete range, say from B to C, with virtually no variation in the applied force. The diagram and the formulae show that the force ultimately applied remains virtually the same.

In the position indicated at **1** (which is the position of greatest tension for supporting the heaviest tool) when the spindle is up, the spring tension is 370 pounds and the leverage is 3⅜ inches. When the spindle is down, the tension is 530 pounds and the leverage is $2\frac{5}{32}$ inches. When these figures are converted into inch pounds, they are equal to 1250. When converted into pounds of force on the spindle, they are equal to 54½ pounds.

In the intermediate position (indicated at **2**) when the spindle is up, the tension is 182 pounds and the leverage is $3\frac{1}{32}$ inches. When the spindle is down, the tension is 358 pounds and the leverage is $1\frac{21}{32}$ inches. It will be observed from these equations that the force exerted on the spindle when up is 24.1 pounds and when down is 24.9 pounds.

In the third position, when the spindle is up, the tension is 59 pounds and the leverage $2\frac{3}{64}$ inches. When the spindle is down, the tension is 162 pounds and the leverage is $\frac{45}{64}$ inch. As is apparent from these equations, the force exerted on the spindle in the upper position is 5.3 pounds, and in the lower position, 5 pounds.

Thus it will be apparent that, as the spring

pull tension decreases, the leverage increases in direct proportion, so that the actual effective counterbalance force is uniform in any position of the spindle, regardless of the tension.

Having described my invention I claim:

1. A counterbalancing mechanism in a machine tool having an axially movable spindle, which comprises, a lever rotatable about an axis and coupled for rotation to the spindle to which a counterforce is to be applied, and a tension spring connected to the lever for exerting a restraining force thereon, the point of connection of the spring to the lever being so related to the axis of rotation of the lever that the tension of the spring times the mechanical lever arm distance between the axis of rotation and the axis and line of force of the spring, when the lever is in one position, is substantially equal to the tension of the spring times the mechanical lever arm distance from the axis of rotation to the axis and line of force of the spring, when the lever is in another position within the limits of travel of the said spindle.

2. A counterbalancing mechanism for use in machine tools, having an axially movable spindle, which comprises, a lever rotatable about an axis and coupled for rotation to the spindle to which a counterforce is to be applied, and a tension spring connected to the lever for exerting a restraining force thereon, the point of connection of the spring to the lever being so related to the axis of rotation of the lever within the limits of travel of the spindle, that the tension of the spring times the mechanical lever arm distance between the axis of rotation and the axis and line of force of the spring, when the lever is in one position, is substantially equal to the tension of the spring times the mechanical lever arm distance from the axis of rotation to the axis and line of force of the spring, when the lever is in another position, substantially in accordance with the equation $T_1 \times L_1 = T_2 \times L_2$, T_1 and T_2 being the tensions exerted by the spring in respective given positions, and L_1 and L_2 being the perpendicular distances between the lines of force exerted by the spring and the axis of rotation of the lever arm in those respective given positions.

3. A counterbalancing mechanism for use in machine tools having an axially movable spindle, which comprises, a lever rotatable about an axis and coupled for rotation to the spindle to which a counterforce is to be applied, a tension spring connected to the lever for exerting a restraining force thereon, the point of connection of the spring to the lever being so related to the axis of rotation of the lever that the tension of the spring times the mechanical lever arm distance between the axis of rotation and the axis and line of force of the spring, when the lever is in one position, is substantially equal to the tension of the spring times the mechanical lever arm distance from the axis of rotation to the axis and line of force of the spring, when the lever is in another position, and means for manually adjusting the tension and the angularity of the spring at any position of the lever.

4. In combination with a drill spindle and a counterweight, mechanism for applying a counterforce to compensate for the added weight of a tool mounted on a spindle comprising, a lever swung by raising and lowering movement of the spindle, a tension spring attached at one end to a point on the lever outwardly of the pivot of the lever, adjustable means anchoring the other end of the spring, said spring tending to swing the lever and connected to the lever in such manner that as the spring pull tension decreases, the leverage increases in direct proportion so that the actual effective counterbalance force is uniform at any position of the spindle.

5. In combination with a drill spindle a counterforce mechanism, comprising a lever swung by raising and lowering movement of the spindle, a tension coil spring attached at one end to an intermediate point on the lever, said coil spring having its axis disposed angularly relative to said lever, means anchoring the other end of the spring, said spring tending to swing the lever and connected to the lever in such manner that as the spring pull tension decreases, the leverage increases in direct proportion so that the actual effective counterbalance force is uniform at any position of the spindle.

6. A counterbalancing mechanism for use in machine tools, having an axially movable spindle, which comprises, a lever rotatable about an axis and coupled for rotation to the spindle to which a counterforce is to be applied, and a tension spring connected between a point of adjustment and the lever for exerting a restraining force on the lever, the point of connection of the spring to the lever being so related to the axis of rotation of the lever, that the tension of the spring times the mechanical lever arm distance between the axis of rotation and the axis and line of pull of the spring, when the lever is in one position, is substantially equal to the tension of the spring times the mechanical lever arm distance from the axis of rotation to the axis and line of pull of the spring, when the lever is in another position, substantially in accordance with the equation $T_1 \times L_1 = T_2 \times L_2$, T_1 and T_2 being the tensions exerted by the spring in respective given positions, and L_1 and L_2 being the perpendicular distances between the spring and the axis of rotation of the lever arm in those respective given positions.

7. In combination with a drill spindle, a lever swung by raising and lowering movement of the spindle, a coil spring attached at one end to said lever, said coil spring having its axis extended crosswise relative to said lever, adjustable means for varying the normal tension of the spring, said spring tending to swing the lever, and connected to the lever in such manner that, as the spring pull tension decreases, the leverage increases in direct proportion, so that the actual effective counterbalance force is uniform at any position of the spindle.

8. A counterbalancing mechanism for the spindle of a drilling machine including the spindle; comprising, a lever having its outer end coupled to the spindle and its other end mounted on an axis of rotation, a coil spring disposed under tension and having its axis extending between an intermediate point on the lever and a normally fixed point, said spring extending angularly with respect to a line extending from the axis of rotation of the lever to its coupled outer end, whereby as the spring pull tension decreases, the leverage increases in direct proportion so that the counterbalance force is equal at all positions of the spindle.

9. A counterbalancing mechanism for the spindle of a drilling machine including the spindle; comprising, a lever having its outer end coupled to the spindle and its other end mounted on an axis of rotation, a coil spring disposed

under tension between an intermediate point on the lever and a normally fixed point, said spring extending angularly with respect to a line extended between the axis of rotation of the lever and the coupled end thereof, whereby the tension of the spring times the mechanical lever arm distance between the axis of rotation and the axis and line of pull of the spring when the lever is in one position is substantially equal to the tension of the spring times the mechanical lever arm distance from the axis of rotation and the axis and line of pull of the spring when the lever is in another position within the normal limits of travel of the drill spindle, and means for adjusting the normally fixed point of attachment of the spring so as to change the angularity of the axis and line of pull of the spring relative to said line between the axis of rotation of the lever and its coupled end.

WILLIAM G. HOELSCHER.