March 29, 1960 A. MOHRENSTEIN 2,930,169

DEVICE FOR BALANCING GRINDING WHEELS DURING THEIR ROTATION

Filed April 29, 1958 2 Sheets-Sheet 1

FIG. 1

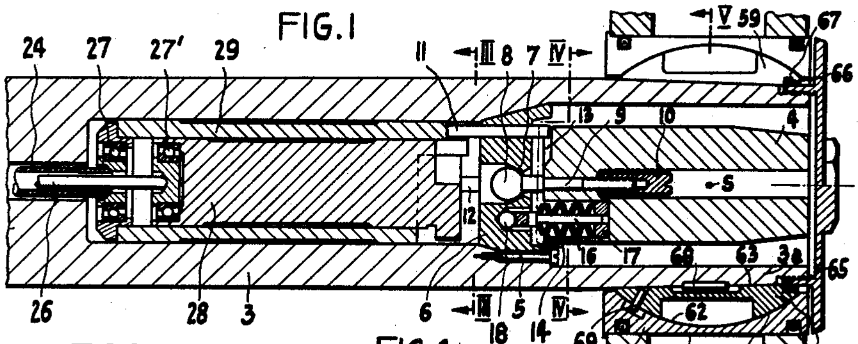
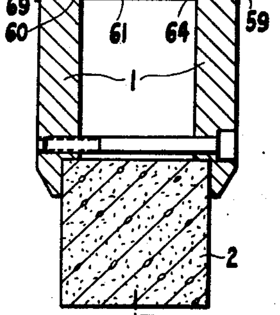



FIG. 3

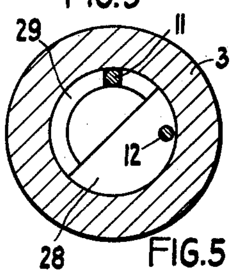


FIG. 4

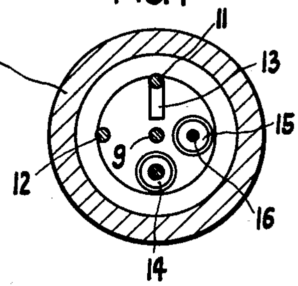


FIG. 5

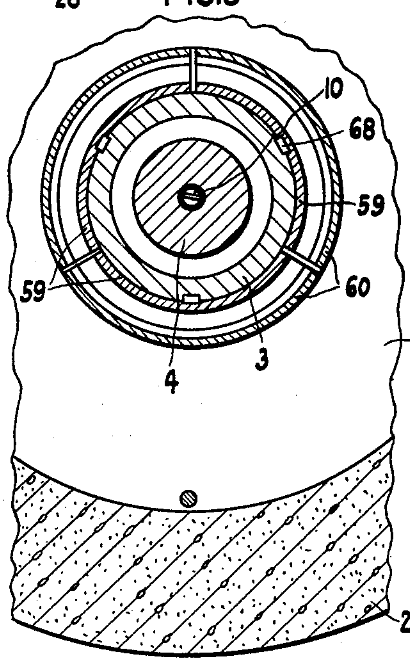
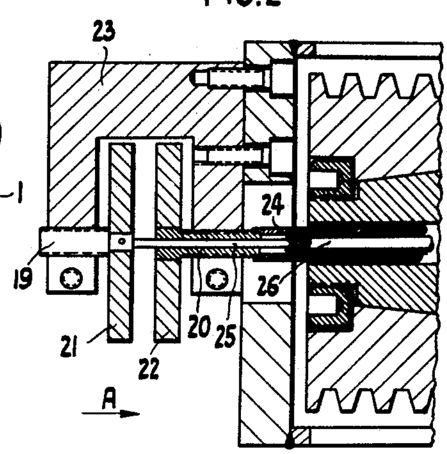


FIG. 2



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DEVICE FOR BALANCING GRINDING WHEELS DURING THEIR ROTATION

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FIG. 6

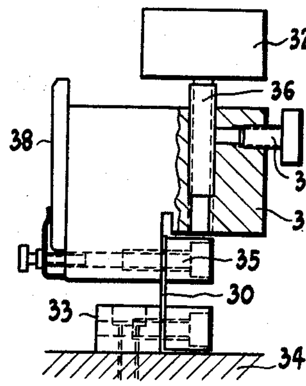
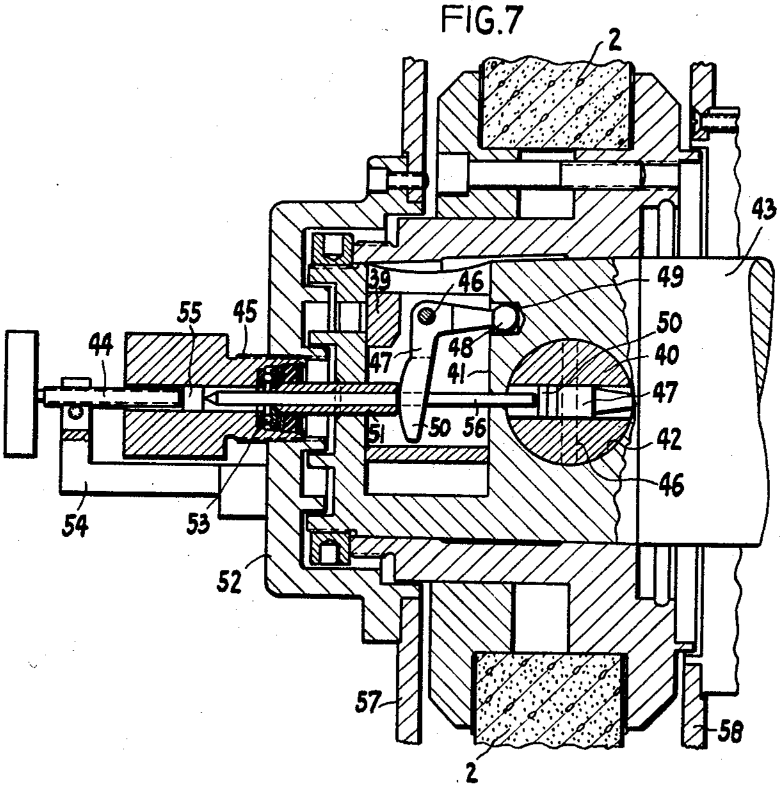


FIG. 7



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DEVICE FOR BALANCING GRINDING WHEELS DURING THEIR ROTATION

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13 Claims. (Cl. 51—169)

The invention relates to device for balancing grinding wheels during their rotation by means of balance weights movable on the grinding spindle. The known balancing devices of this kind, in which the balance weights are moved either by manual operation or even automatically, do not permit satisfactory balancing of the grinding wheel, especially complete and accurate balancing.

It is the object of the invention to provide a simple balancing device for grinding wheels which permits, in a convenient manner during the rotation of the wheel, a sensitive and above all also a very accurate balancing. For this purpose, in the balancing device according to the invention, a balance weight is arranged within the hollow spindle—with its centre of gravity lying in the axis of the spindle—and is adapted to move in two directions perpendicular to each other and to the spindle axis, and furthermore, outside the spindle, two fixed adjusting members are provided, lying in the direction of the spindle axis and axially adjustable, and said adjusting members are connected independently of each other, by means of intermediate members which rotate with the spindle, to the balance weight in such a manner that each adjusting member moves the balance weight only in one of the two aforesaid directions. Advantageously, the balance weight is arranged so that its centre of gravity coincides with the centre of the grinding wheel.

The details and advantages of the invention are explained more fully in what follows with reference to constructional examples represented in the drawing, wherein

Figure 1 shows a longitudinal section through the right-hand part of a grinding spindle together with the grinding wheel and balancing device,

Figure 2 is the longitudinal section through the left-hand end of said grinding spindle,

Figures 3, 4 and 5 show cross-sections through the grinding spindle on lines III—III, IV—IV and V—V of Figure 1,

Figure 6 is a resonator for measuring the degree of balance, partly in section,

Figure 7 a longitudinal section through a grinding spindle with grinding wheel and balancing device in another construction.

The grinding wheel shown in Figure 1 consists of a grinding ring **2** carried by the two discs **1**. This grinding wheel is mounted on a grinding spindle **3**, which is made hollow for receiving a balancing device. Arranged within this spindle is a balance weight **4**, which consists for example of hard lead and normally lies with its centre of gravity S in the spindle axis. This balance weight **4** is furthermore adapted to move in two directions perpendicular to each other and to the spindle axis. For this purpose, fixed in the hollow spindle by means of screws **5** is a bearing disc **6**, on the central bearing position **7** of which is supported a swivel ball **8**. This swivel ball is mounted on a shaft **9**, which is secured to the balance weight **4** by means of a nut **10**. Furthermore, slidably mounted in the bearing disc **6** and offset at a right-angle to each other are two thrust pins **11** and **12** lying parallel

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to the spindle axis. These thrust pins **11** and **12** engage at the right-hand end radial slots **13** of the balance weight **4** and bear against the latter. Furthermore, diametrically opposite the thrust pins **11** and **12** are pressure springs **14** and **15** arranged between bearing disc **6** and balance weight **4**. The pressure springs **14** and **15**, formed for example as plate springs, are each mounted on a shaft **16**. The plate springs which, on the one hand bear via a ring **17** against the balance weight **4**, press on the other hand the shaft **16** against a ball **18** arranged in a bore in the bearing disc **6**. The pressure springs **14** and **15** respectively, thus constantly press the balance weight **4**, which can swivel about the ball joint **8**, against the thrust pin **11** or **12**.

In the advantageous constructional example shown in Figures 1 and 2, the adjusting members are provided in the form of concentric adjusting screws **19** and **20**, adapted to be screwed by means of the discs **21** and **22** independently of each other in a stationary housing part **23**.

As will be seen from Figure 2, the hollow adjusting screw **20** presses on a tubular intermediate member **24**, whilst the pin **25** of the screw **19** projecting through the hollow screw **20** moves a rod-formed intermediate member **26**. Said intermediate members **24** and **26**, as will be seen in Figure 1, bear with the interposition of axial bearings, preferably shoulder ball bearing **27** and **27'**, against a thrust sleeve **29** and a thrust cylinder **28**, respectively, the latter being surrounded by the sleeve **29**. The two parts **28** and **29** rotate with the spindle **3** and are axially slidable in the latter.

As follows from Figure 1, the thrust cylinder **28** and thrust sleeve **29** bear with their right-hand end faces respectively against the thrust pins **12** and **11**. By means of the parts described in the foregoing, therefore, the axial movement of the adjusting screws **19** and **20**, which are preferably provided with fine screwthreads, is transmitted to the balance weight **4**. In the event of an axial movement of the adjusting screw **20** in the direction A, the thrust pin **11** will be shifted in the same direction, and hence the balance weight **4** will be swung down in the plane of the drawing about the ball joint **8**, the centre of gravity will therefore be displaced downward somewhat. In a similar manner, in the event of a movement of the adjusting screw **19** in the direction A, the thrust pin **12** will be moved in the same direction, and hence the balance weight **4** will be moved about the joint **8** in a plane perpendicular to the plane of the drawing.

The manipulation is as follows:

If there is an unbalance in the grinding wheel, first of all the one screw **19** will be turned in one or other direction so as to reduce the unbalance. Screw **20** will then be turned in one direction or the other until the unbalance disappears completely. The balancing device described in the foregoing thus enables in a very simple manner complete static balancing of a grinding wheel to be effected during its rotation. In order to measure the degree of balance attained, advantageously a resonator is used, which is mounted on the grinding machine in very close proximity to the grinding wheel, and the frequency of which corresponds to the spindle speed. Advantageously, for this purpose, use will be made of a resonator shown for example in Figure 6, consisting of a weight **31** fixed to a leaf spring **30**, together with adjustable additional weight **32**. This resonator is fixed by its base **33** to the support (housing) **34** in such a manner that its leaf spring **30** is directed transversely to the direction of vibration of the support. By means of a screw **35**, coarse adjustment of the weight **31** can be effected at first, so that the frequency of the resonator agrees approximately with the grinding spindle speed. A fine adjustment can then be made by means of the additional weight **32**, which forms the head of an adjusting screw 36, adapted to be clamped by means of a screw 37. A mirror 38 can be fixed to the resonator for making the degree of balancing visible. Any unbalance still existing can also be perceived by touching the resonator. It is, however, also possible to mount a gauge or electric vibrometer on the resonator. In this case, the measurement is very accurate, so that by means of this measurement, very accurate balancing can be accomplished.

The balancing device according to the invention can if desired also be constructed in accordance with Figure 7. Whereas in the example according to Figure 1 the balance weight 4 is in one piece, according to Figure 7, the balance weight may be divided into two cylindrical parts 39 and 40, adapted to slide radially in two radial bores 41 and 42 of the grinding wheel spindle 43, said bores being offset relatively to each other at a right angle. In this case, each adjusting member 44 and 45 is connected via intermediate members with only one cylinder part 40 and 39, respectively. As shown in Figure 7. a bell crank 47 is pivoted at 46 in each balance weight 39 and 40 respectively, one arm of which bell crank is supported by means of a ball joint 48 in a transverse bore 49 of the spindle 43, whilst an axially slidable thrust sleeve 51 acts upon the other arm 50 of the bell crank. The adjusting nut 45, mounted stationary or screwable in the housing part 52 acts on the thrust sleeve 51 via an axial ball bearing 53.

In a similar manner, the other balance weight 40 is shifted radially in its bore 42, by means of the adjusting screw 44 adapted to be screwed in a stationary bearing bracket 54. Said adjusting screw 44 acts through the medium of a hard steel block 55, slidable in the nut 45, on the tip of a steel pin 56, axially slidable in the sleeve 51, which pin bears against the lever arm 50 of the bell crank 47 pivoted in the cylinder part 40. In Figure 7, 2 denotes the grinding wheel and 57 and 58 the grinding wheel guard.

In the particularly advantageous construction shown in Figures 1 to 5, it is possible to eliminate not only static unbalance, but also dynamic unbalance (unbalance moments with respect to point S). For this purpose, the grinding wheel 1, 2 is prevented from rotating relatively to the grinding spindle 3, but is mounted to swivel freely on spherical segments 59 about the centre S of the grinding wheel, and an expanding and clamping device is provided which, during rotation of the grinding wheel, permits radial outward pressing of the spherical segments 59 and thus clamping of the grinding wheel on the spindle after dynamic balancing has been effected. As will be seen from the drawing, the discs 1 carrying the grinding ring 2 serve for receiving segments 60, the outer side 61 of which is cylindrical and the inner side 62 is spherical. Axially slidable on the tapered spindle end 3*a* are the thrust segments 59, which internally at 63 are correspondingly tapered and externally at 64 are correspondingly spherical.

Furthermore, a nut 65 adapted to be screwed on the spindle end 3*a* is provided and engages by means of a collar 66 in a corresponding annular groove 67 in the thrust segments 59. This nut 65 thus permits axial displacement of the thrust segments 59 in both directions. The thrust segments 59 are prevented from rotating on the spindle 3 by means of keys 68. In the same way, the segments 59, 60 are prevented from mutual rotation by means of pins 69.

Dynamic unbalance is eliminated as follows:

First of all, the nut 65 is slackened so that the then rotating grinding wheel can adjust itself (wobble) freely on the spherical segments 59, 60. Its unbalance moment with respect to the plane V—V in Figure 1, which passes through the spherical centre S, will then be equal to zero. The nut 65 is then slowly tightened with the spindle running, this being best done by lightly tapping the edge of nut 65 with a rubber hammer. After stopping of the spindle, the nut 65 can be tightened fast with a spanner.

I claim:

1. Device for balancing a grinding wheel during rotation, said device comprising a frame, a hollow spindle rotatably mounted in the frame and serving for the support of a grinding wheel, a balance weight arranged within the hollow spindle and mounted for movement, from a central position in which the center of gravity of the weight lies in the spindle axis, in two directions perpendicular to each other and to the spindle axis, two adjusting members mounted on the frame and operatively connected to the balance weight by intermediate members mounted within the spindle for rotation therewith, each of said adjusting members being independently adjustable axially of the spindle to move the balance weight only in a seperate one of the two said directions; a bearing disc fixed in the hollow spindle and having a central bearing; a swivel ball rigidly connected to the balance weight and supported on said central bearing; two slidable thrust pins mounted in the bearing disc, offset at a right angle to each other and parallel to the spindle axis, the said balance weight having radial slots for engagement with the pins which bear against the balance weight; and pressure springs situated diametrically opposite to the pins and arranged between bearing disc and balance weight.

2. Device for balancing a grinding wheel during rotation, said device comprising a frame; a hollow spindle rotatably mounted in the frame and serving for the support of a grinding wheel; a balance weight arranged within the hollow spindle and mounted for movement from a central position in which the center of gravity of the weight lies in the spindle axis in two directions perpendicular to each other and to the spindle axis; two adjusting members mounted on the frame and operatively connected to the balance weight by intermediate members mounted within the spindle for rotation therewith, each of said adjusting members being independently adjustable axially of the spindle to move the balance weight only in a separate one of the two said directions; spherical thrust segments mounted on said grinding spindle and secured against rotation relatively to said grinding spindle, said grinding wheel being mounted to swivel freely on said spherical thrust segments about the center of the grinding wheel; and an expanding and clamping device which during rotation of the grinding wheel permits radial outward pressing of the thrust segments and hence clamping of the grinding wheel on the spindle in its position of equilibrium.

3. Device according to claim 2 and suitable for use with a grinding wheel comprising a grinding ring mounted on two spaced discs, the device including outer segments adapted to be mounted on said discs, each of said outer segments having a cylindrical outer side and a spherical inner side, characterised in that said thrust segments are axially slidable on a tapered end portion of the spindle, each of the thrust segments having a tapered inner side provided with a transverse slot and arranged to engage the tapered end portion of the spindle and a spherical outer side arranged to engage the inner side of an outer segment, and said expanding and clamping device comprises a nut having a collar engaging in the slots in the thrust segments, the nut being screwed in the spindle and adjustable to effect axial movement of the thrust segments in both axial directions of the spindle.

4. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said

center of gravity is radially spaced from said axis in a predetermined direction; and second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction.

5. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direct or substantially perpendicular to said predetermined direction; and actuating means mounted on said support and movable relative to said spindle for actuating said moving means.

6. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a directon substantially perpendicular to said predetermined direction; and actuating means mounted on said support substantially coaxial with said spindle and movable relative to said spindle for actuating said moving means.

7. A device for balancing a machine tool during rotation thereof, comprising, in combination, a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means mounted on said spindle and secured against rotation relative thereto for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; and second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction.

8. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means mounted on said spindle and secured against rotation relative thereto for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction; actuating means mounted on said support and movable relative to said spindle for actuating said moving means; and thrust bearing means having two members rotatable relative to each other, one of said members being secured to said actuating means, and the other member being secured to said moving means.

9. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means for moving said weight means relative to said spindle between a position in which the center of gravity is located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction; and actuating means mounted on said support and axially movable relative to said spindle for actuating said moving means.

10. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means movably mounted in said spindle and having a center of gravity; first moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said center of gravvty is radially spaced from said axis in a predetermined direction; second moving means for moving said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction; and actuating means threadedly mounted on said support and axially movable relative to said spindle for actuating said moving means.

11. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; balancing weight means pivotally mounted in said spindle and having a center of gravity, said weight means being pivotable in two planes substantially perpendicular to each other and intersecting each other in a line parallel to the axis of said spindle; first moving means for pivoting said weight means relative to said spindle between a position in which said center of gravity is located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; and second moving means for pivoting said weight means relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction.

12. A device for balancing a machine tool during rotation thereof, comprising, in combination, a support; a hollow spindle mounted on said support for carrying said machine tool and rotatable about an axis; two balancing weights movably mounted in said spindle and having a common center of gravity; first moving means for moving one of said weights relative to said spindle between a position in which said center of gravity is

located in said axis of said spindle and a position in which said center of gravity is radially spaced from said axis in a predetermined direction; and second moving means for moving the other one of said weights relative to said spindle between a position in which said center of gravity is located in said axis and a position in which said center of gravity is radially spaced from said axis in a direction substantially perpendicular to said predetermined direction.

13. A device as set forth in claim 12, said spindle being formed with two radial bores offset at right angles to each other, and said balancing weights being respectively slidable in said bores.

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