A dynamic balancing apparatus for a rotary member, such as a grinding wheel, supported for rotation on a spindle journaled in a spindle housing. The spindle housing is pivoted on a support for rocking movement under the control of a resilient restraining means. Balancing is effected by the release of self-adjusting weights operating in a raceway on the spindle adjacent the rotary member. After balancing, the housing is clamped tightly to the support.

8 Claims, 5 Drawing Figures
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DYNAMIC BALANCING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a dynamic balancing apparatus of the type in which self-adjusting weights are supported for concentric movement with respect to the geometric axis of the rotary member and assume, during rotation, positions which are such as to correct any out-of-balance condition of the member. This balancing action depends for its operation on a pivotal support for the spindle at a point remote from the rotary member to rotate about its axis of mass rather than about its geometric axis. A balancing device of this type is shown in U.S. Pat. No. 2,507,558 to Dall et al. dated May 16, 1950. In the device shown in the patent, the spindle bearing adjacent the grinding wheel is resiliently supported on spring rods while the bearing adjacent the drive pulley acts as a pivot and permits gyration of the free end of the spindle thereabout. When the grinding wheel is rotated above its critical speed, it will tend to rotate about its center of mass, and the balancing weights, or balls, will distribute themselves about the axis of the spindle in such a way as to reestablish rotation of the spindle-wheel combination about its geometric axis. This mechanism has performed very satisfactorily but is somewhat complicated and expensive to manufacture because of the flexible supporting and clamping arrangement required for the front bearing.

SUMMARY OF THE INVENTION

The present invention has for its object the provision of a dynamic balancing mechanism for a rotary member, such as a grinding wheel, which is just as effective as the mechanism shown in the above-mentioned patent, but which is less complicated and less expensive to construct. To this end, the spindle bearings are fixedly mounted in the spindle housing and the housing itself is arranged to pivot about a point remote from the rotary member. Oscillatory movement of the housing about the pivot, is yieldably restrained by a resilient support means to allow the rotary member to rotate about its axis of mass. Balancing weights of the type disclosed in the afore-mentioned patent are permitted to seek positions in which they correct the out-of-balance condition after which they are clamped. To provide a rigid support for the rotary member, means is provided for clamping the spindle housing to its support so as to render it immobile thereon after the balancing has been effected.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The improved form of dynamic balancing mechanism is shown herein in connection with a grinding machine the details of which are not set forth since they form no part of the present invention. In the mechanism shown, a grinding wheel 10 (FIGS. 1 and 2) is mounted on a flange 11 provided on one end of a spindle 12. The spindle is journaled in a spindle housing 13 by means of front and rear bearings 14 and 15, respectively. Axial movement of the spindle is prevented by a thrust bearing 16 and a collar 17 located on opposite sides of the bearing 14. Power for driving the spindle and the grinding wheel is supplied by a motor (not shown) which drives a pulley 18 on the spindle by means of multiple V-belts 19.

The spindle housing 13 is pivotally mounted on a support 25 by a shaft 26 (FIG. 4) secured to the housing in the vicinity of the rear bearing 15. The shaft is disposed with its axis normal to that of the spindle and permits oscillation of the housing in a plane parallel to the axis of the spindle. The shaft is provided with a flange 27 and a tenon 28 which are received in corresponding bores provided therefor in the housing 13. The shaft 26 is secured to the housing 13 by screws 29 passing through the flange 27 and into the body of the housing. A bore 24 is provided in the support 25 for receiving needle bearings 30 which journal the shaft in the support.

At its forward end, that is, the end adjacent the grinding wheel 10, the housing 13 is provided with a bore for receiving one end of a spring rod 31 which is secured therein by a set screw 32. The rod 31 passes through an aperture 33 in the wall of support 25 and is slidably received in a bushing 34 rigidly mounted in a web 35 formed in the support 25. Thus, pivotal movement of the housing 13 about the pivot shaft 26 is resiliently restrained by flexing of the rod 31. With the end of the housing 13 adjacent the grinding wheel free to oscillate about the axis of the pivot shaft 26 when the wheel is rotated above its critical speed, balance of the wheel may be achieved by releasing a plurality of weights 35 (FIG. 2) riding in a raceway 36 concentrically disposed in the flange 11 of the spindle. After balancing has been effected, the weights 35 may be clamped in their adjusted positions by a flange 37 on the end of plunger 38 which is axially slideable within the spindle 12. This portion of the apparatus may be constructed in the manner described in U.S. Patent No. 2,507,558 wherein the plunger 38 is normally urged into clamping position by a spring and is released by the application of hydraulic pressure applied to the opposite end thereof within the spindle. As described in the patent, the balancing weights may take the form of steel balls there being three such weights in the preferred embodiment.

After balance has been achieved, it is desirable to clamp the housing 13 against movement relative to the support 25 so as to provide a rigid base for the grinding wheel. For this purpose clamp means are provided at each end of the housing, the clamp means at the forward end taking the form of a clamp dog 42 (FIG. 4) having a tail portion 43 rockably supported in a recess formed in a block 44 secured to the support 25. At its opposite end the dog is provided with a beveled clamp
face 45 which is adapted to bear against a corresponding surface provided on the underside of the housing. Situated on the upper side of the housing opposite the dog 42 is a fixed clamp dog 46 which is secured by screws 47 to the support and has a beveled clamp face 48 engaging a corresponding surface on the housing.

Activation of the clamp dog 42 is effected by a piston 49 having a rod 50 connected by a link 51 to the dog 42. The piston is urged toward the right or into clamping position by means of a series of Belleville washers 52 acting between the piston and the end of a guide bushing 53 for the rod 50. Movement of the piston to the left, or to the unclamped position, is effected by hydraulic pressure applied to the piston by a hydraulic intensifier 54. This device consists of a large piston 55 and a small piston 56 which are constructed as a single unit and operate in unison within their respective cylinders. Accordingly, when hydraulic pressure is supplied to the line 57, the piston 55 will move toward the left whereby the small piston 56 will compress the hydraulic fluid contained in the cylinder containing piston 49 and cause the piston to be moved toward the left. Thereby, the dog 42 will be released and the face 48 will move away from the fixed dog 46 due to the unbalanced weight of the forward end of the housing which will turn on the pivot against the bias of the spring rod 31. Make-up fluid for the cylinders is supplied through a line 58 and a check valve 59 as shown in FIG. 4.

The pulley end of the housing 13 is adapted to be clamped to the support 25 by a similar mechanism applied to the pivot shaft 26. Again referring to FIG. 4, the distal end of the pivot shaft is adapted to receive a thrust bearing 62 which is subjected to axial pressure by Belleville washers 63, held in compression by a lock nut 64 threaded on the end of the shaft. Thus the pivot shaft and the housing 13 secured thereto are normally urged toward the right as viewed in FIG. 4 so as to urge the pulley end of the housing into clamping engagement with the support. This pressure or force may be relieved by the selective application of hydraulic fluid under pressure to a line 65 connected to a cylinder containing a piston 66 having a rod 67 adapted to bear against the end of the pivot shaft 26.

To insure free swinging movement of the housing 13 in the vicinity of the spring rod 31, provision is made for selectively moving the rod toward the left, as viewed in FIG. 3, through a small distance sufficient to insure clearance between the housing and the support 25. The mechanism for accomplishing this is best shown in FIG. 2 and includes a lever 67 pivoted on the support at 68 and having one arm thereof bearing against the inner end of the rod 31. The other end of the lever is adapted to be actuated by a piston 69 operating within a cylinder provided therefor in the web 39. When fluid pressure is applied to the cylinder through a line 70, the piston 69 will rock the lever about its pivot and force the rod 31 outwardly to the extent permitted by a limit stop 71. The axial movement of the spring rod 31 within the bushing 34 need only be enough to prevent frictional contact between the adjoining surfaces of the housing 13 and support 25. A rod travel of from 0.003 - 0.005 inches is normally sufficient to accomplish this.

A modified form of spindle drive mechanism is shown in FIG. 5 of the drawings. In this embodiment, a torque coupling 75 is interposed between the belt pulley and the spindle 12 so as to remove the influence of the belt tension from the pivoting action of the spindle housing 13 about the shaft 26 during balancing operations. A driving motor (not shown) drives a pulley 76 by multiple V-belts 77 as before. In this case, however, the pulley 76 is mounted on the outer end of a stub shaft 78 which is journaled in bearings 79 mounted in a bracket 80 secured to the support 25. The stub shaft 78 is secured to the input member of coupling 75 which, as shown, may take the form of the well-known Oldham coupling. The output member of the coupling is connected to the spindle 12 to drive the same as required. Inasmuch as the location of the coupling is closely adjacent the pivot axis of the housing 13 on its support, there will be a minimum of interference by the drive with the pivoting action of the housing.

The balancing apparatus of the present invention operates as follows: Whenever it becomes necessary to balance the rotary member 10, the clamping means are released and the member 10 is driven at a speed such that the period of rotation thereof exceeds the natural frequency of the grinding wheel - spindle housing combination supported on the spring rod 31. The balancing weights 35 are then released to allow them to move to positions in which they serve to correct any imbalance of the rotary member. The weights are then clamped in their adjusted positions by the plunger 38 (FIG. 2) after which the spindle housing 13 is clamped to the support 25 by relieving the pressure applied to the hydraulic fluid in lines 57, 65 and 70. The rotary member 10 is now balanced and the machine is ready to resume operation.

While the apparatus herein shown and described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this particular form of apparatus and that changes may be made therein without departing from the scope of the invention.

What is claimed is:

1. Apparatus for dynamically balancing a rotary member mounted on the end of a spindle comprising a housing; journal means in said housing for supporting said spindle for rotation therein; a support; means to pivot said housing on said support for rotation about an axis which is disposed normal to the axis of said spindle and located at a point remote from said rotary member; resilient means for restraining pivotal movement of said housing about the axis of said pivot means; a circular raceway provided on said spindle adjacent the rotary member; and a plurality of self-adjustable weights adapted to roll in said raceway during rotation of said spindle and to assume such positions therein as to correct any imbalance of the rotary member.

2. The balancing apparatus of claim 1, including selectively operable means for clamping said housing to said support after balance has been effected.

3. The balance device of claim 2, wherein said resilient means comprises a spring rod having one end mounted in said support and the other end mounted in said housing.
4. The balancing device for claim 3 including selectively operable means for producing limited axial movement of said spring rod to move said spindle housing away from said support during balancing operations.

5. The balancing device of claim 2 wherein said pivot means includes an axially movable shaft, and said clamping means includes an actuating mechanism for moving said shaft axially to engage said housing with said support.

6. The balancing device of claim 1 including a power drive means for said spindle, and a torque coupling between said power drive means and said spindle.

7. The balancing device of claim 6 wherein the axis of the pivot for said housing intersects the axis of said spindle.

8. The balancing device of claim 7 wherein said torque coupling is situated adjacent to the point of intersection of the pivot and spindle axes.

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