

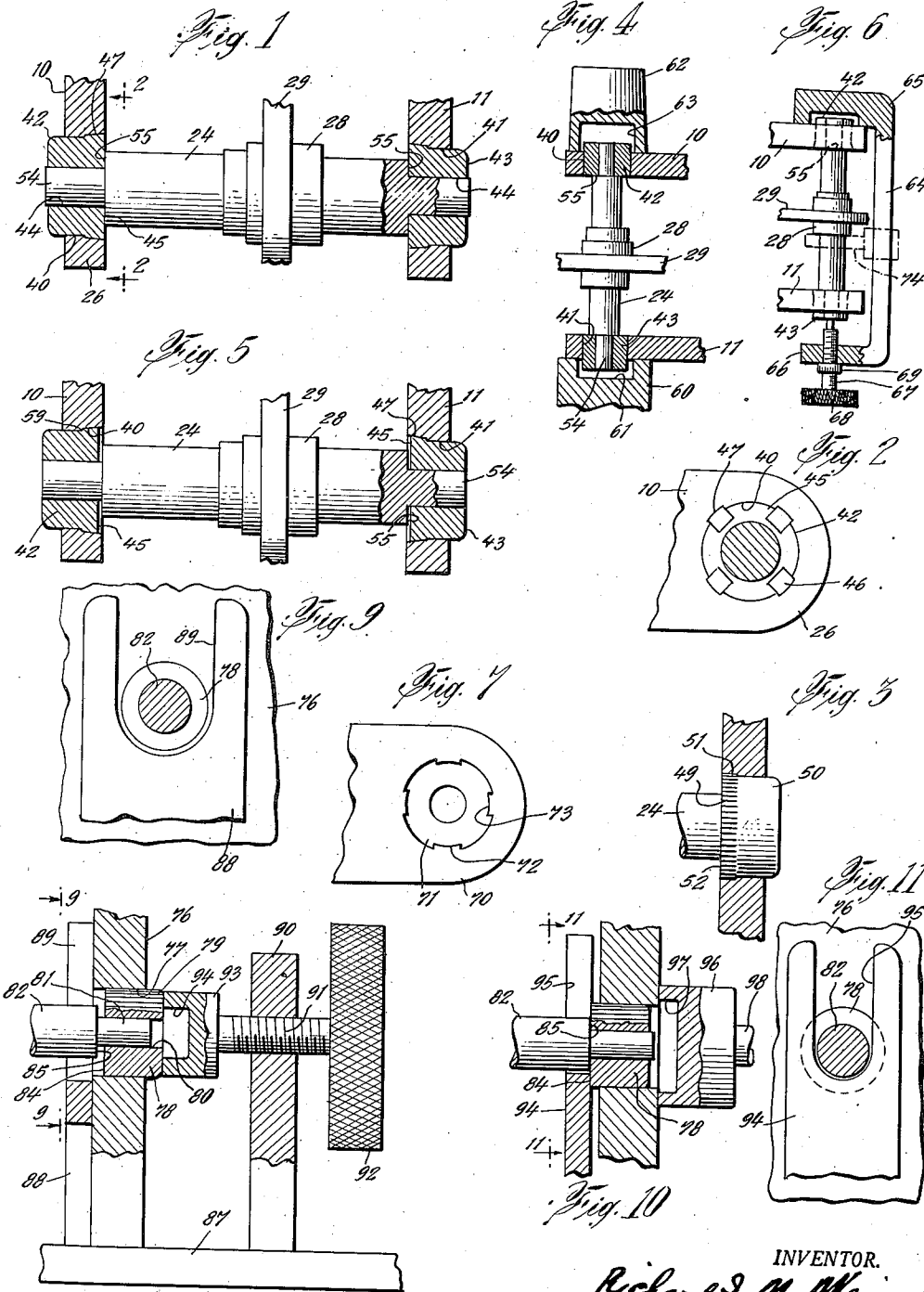
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METHOD OF FORMING BEARING STRUCTURES

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METHOD OF FORMING BEARING STRUCTURES

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Continuation of application Serial No. 549,238, August 12, 1944, which is a division of application Serial No. 475,692, February 12, 1943. This application March 24, 1945, Serial No. 584,719

5 Claims. (Cl. 29—149.5)

1

This invention relates to an improved method of forming a novel bearing structure designed primarily, though not exclusively, for shafts in measuring instruments, horological instruments, and the like, and has for its principal object the provision of means for forming a novel bearing element wherein end play of the shaft can, at the time of manufacture of the instrument, be reduced to a predetermined and desired minimum. The present application constitutes a continuation of my copending application Serial No. 549,238, filed August 12, 1944, now abandoned, which constitutes a division of my co-pending application Serial No. 475,692, filed February 12, 1943, now Patent No. 2,376,406.

End play of shafts in any instrument or apparatus can be reduced by increased accuracy in construction of the parts. This greatly increases the cost, however. In any given instance, if the tolerances are decreased by one-half, the cost may increase four or five times, and this results in prohibitive cost of the instrument. Measuring instruments generally are subjected to considerable vibration. These instruments normally have a plurality of shafts, including a driving shaft and a driven shaft. This continuous vibration causes continuous endwise shifting of the shaft, which, in turn, causes the driving and driven gears to cut into each other in a short time, and thus greatly reduces the accuracy of the measurement.

An important object of the present invention resides in the provision of means and a method for reducing this endwise play, in the case of measuring instruments such as pressure gauges, speed indicators, and the like, from $\pm .003$ or $.004$, to $\pm .0003$ or $.0004$, without requiring a reduction of the tolerances of the individual parts, and without increasing the final cost of the instrument.

Another object of the present invention is the provision of an improved method of forming a novel thrust-bearing element which is simple and inexpensive to manufacture, and which provides a flat, polished thrust-bearing surface, thus greatly reducing friction in the shaft.

In the drawing:

Fig. 1 is a transverse section taken through an instrument frame showing a bearing formed in accordance with the method of the present invention before the shaft has been freed for rotation.

Fig. 2 is a section taken on line 2—2 of Fig. 1.

Fig. 3 is a broken sectional view showing a modified form of the bearing structure constructed in accordance with the method of the present invention.

Fig. 4 is a broken sectional view illustrating one

2

method of carrying out the method of the present invention for obtaining a predetermined amount of end play in the shaft.

Fig. 5 is a sectional view similar to Fig. 1, but showing the relation of the parts after the shaft has been freed for rotation, the amount of end play, however, being shown in exaggerated form.

Fig. 6 shows an alternative method of carrying out the present invention.

Fig. 7 shows another method of forming the bearing structure where the bearing frame rather than the bearing bushing is staked.

Figs. 8 and 10 illustrate an alternative form of the method of the present invention.

Figs. 9 and 11, respectively, are sections taken on lines 9—9 of Fig. 8, and 11—11 of Fig. 10.

Referring now more particularly to the drawing, Fig. 1 illustrates a fragmentary view of a movement for a measuring instrument including spaced frame members 10 and 11, which may be maintained in such spaced relationship by means of spacing bushings (not shown). It will be assumed that a shaft 24, which carries a bushing 28, to which is secured a driving member 29 such as a sector gear, is to be journaled between the frame members 10 and 11. These frame members are provided with aligned apertures 40 and 41 which receive bearing bushings 42 and 43, which are similarly formed and are provided with bearing apertures 44. In many instances, the bearing bushings should be of harder metal than the metal forming the frame members. The external diameter of bearing bushings 42 and 43 is such as to be received snugly with a force fit within apertures 40 and 41 in the frame members.

Before each bearing bushing is inserted within its aperture, its inner surface 45 is "staked" at a plurality of points adjacent to the periphery, as illustrated at 46 in Fig. 2. This staking or upsetting may be done with a die or punch formed with a plurality of spaced punching points or flat surfaces adapted to engage this inner surface 45 adjacent to its periphery. When the die is in engagement with this surface, it is struck a forceful blow which displaces some of the metal outwardly, as shown at 47. This step of moving the metal outwardly at a plurality of spaced points on the inner surface of the bearing bushing adjacent to its periphery may also be accomplished by a slow application of pressure, although the upsetting method possibly is preferable. Whichever method is used, however, the result will be generally that shown in Fig. 1.

An equally satisfactory result may be obtained by knurling the periphery of the bushing 50, as

shown in Fig. 3, adjacent to this inner surface 52. This knurled surface is shown at 49, and the forming of the closely-spaced indentations causes the metal between the indentations to move outwardly, thus forming a plurality of closely-spaced splines 51 in such outer periphery. Another way of accomplishing the result is to cut actual splines by removing the metal, all as is well known in the art. For convenience in description, these projections, which lie outside the periphery of the bearing bushing in its initial state, will be referred to hereinafter as splines. The initial diameter of the bushing may be such as to have a close fit in the frame aperture, but not necessarily a force fit.

When the bushing is inserted within the aperture in the frame, it may, in one form of carrying out the invention, be inserted from the inner end of such frame aperture. The bushing is moved outwardly, and in the course of this outward movement, when the splines eventually reach the metal in the frame, they begin to cut slots or keyways in the aperture. Each bushing may thus be moved outwardly through the frame aperture to a point wherein its inner surface is substantially plane with the inner surface of the frame members, as shown in Figs. 1 and 3. By providing a fairly snug fit between the unsplined portion of the bushing and its supporting aperture, the bearing bushing aligns itself in the aperture before the keyways are cut. This subsequent cutting does not disturb this alignment.

The shaft 24 is formed with the usual reduced terminal portions 54, thus forming shoulders 55 which engage the inner surface 45 of the bearing bushings. The dimensions of the spacer bushings in this instance, relative to the length of the shaft between opposed shoulders 55, is such as to cause the inner surfaces of bearing bushings 42 and 43 to engage such shoulders with even a fair degree of pressure when the frame members are initially assembled. The tolerances, however, need not be too fine in view of the subsequent operation. In other words, when the frame members are initially assembled, the bearing bushings engage the shoulders 55 of the shaft with sufficient pressure to freeze the shaft against rotation.

The next step in the method is illustrated in Fig. 4. One frame member 11 is rested on a stationary die 60 having an aperture 61 of slightly greater diameter than that of bushing 43. In other words, when frame member 11 is positioned on the stationary die, such die does not engage the bushing. An upper die 62 having a similarly-shaped aperture 63 is placed on the outer surface of the opposite frame member 10, also not engaging bushing 42. Die 62 is then struck a light blow with a hammer, and since bushing 42 which is carried in frame member 10 cannot move downwardly due to engagement with shoulder 55 of shaft 24, it will be apparent that such frame member 10 is moved downwardly with reference to the bushing 42 which it carries.

If the bushing is forced outwardly in the aperture a few ten-thousandths of an inch at a time, testing the shaft after each blow, it can be readily determined when the shaft is free to turn, and at such time it will be observed that the end play of the shaft is almost imperceptible. The relation of the parts when the bearing structure is finished is shown in Fig. 5, although, of course, this shows an exaggerated amount of end play in the shaft. It will be noted that the slot or recess cut by the spline terminates at the point designated 59. This shoulder or terminal of the slots prevents

further outward movement of the bearing bushing.

When both dies are recessed, as shown in Fig. 4, each blow causes both bearing bushings 42 and 43 to move slightly outwardly in their supporting frames, although if one die is a flat surface, the blow will cause only one bearing bushing to move outwardly, namely, the one adjacent to the recessed die, and in such a case the frame may then be reversed and the opposite frame member struck, thus according similar treatment to the other bearing bushing. It has been found in actual practice that good results are obtained by the arrangement shown in Fig. 4, although excellent results have also been obtained by a slow application of pressure to the opposite frame members rather than the quick hammer blow.

One method of employing a slow application of pressure is illustrated in Fig. 6 wherein frame members 10 and 11 are illustrated as supporting shaft 24 in bearing bushings 42 and 43. The instrument utilized may comprise a substantially C-shaped clamping member 64 having a recessed head portion 65 which engages frame member 10 without engaging bearing bushing 42. At its lower end the clamping member is provided with a horizontal portion 66 which supports a micrometer screw 67 having a thumb turn 68 or other means for permitting manual rotation of the screw. At its inner end the screw engages the center of shaft 24. It will thus be seen that as the screw is turned, the upper shoulder 55 of the shaft bears against bearing bushing 42 and forces it outwardly in its supporting aperture in frame member 10. Screw 67 is provided with graduations, and frame portion 66 is likewise provided with a fixed reference ring 69. Readings may be provided in thousandths of an inch. As before, the shaft 24 is initially frozen against rotation.

In the event that the micrometer screw is turned to permit longitudinal movement one-thousandth of an inch for each partial rotation, and the shaft then tested for rotation, it will be seen that when the shaft finally rotates, the end play will not be more than one-thousandth of an inch. In other words, if the shaft has one-thousandth of an inch clearance between its opposed shoulders and the bearing bushing, it may freely rotate. Accordingly, if the micrometer lead screw is not moved more than one-thousandth of an inch between successive testings of the shaft for rotation, the bearing bushing 42 will not have been moved outwardly more than one-thousandth of an inch between its position wherein it freezes shaft 24 against rotation, and its position wherein it frees the shaft for rotation. In the event that considerable movement of the bearing bushing is necessary, that is to say, some five to twenty-thousandths of an inch, before rotation of the shaft is permitted, it may be desirable to reverse the clamping element and move bearing bushing 43 outwardly after some movement has been accorded to bearing bushing 42. It will also be appreciated that instead of applying the pressure to the lower end of the shaft, as shown in Fig. 6, a recessed die may engage frame member 11 and the screw engage the recessed die, thus causing both bearing bushings to move outwardly at the same time.

Fig. 6 further shows in broken lines another method of moving bearing member 42 outwardly in its supporting aperture in frame 10. In this case, a bifurcated element 74 is carried on the clamping member 10, and this bifurcated element engages the enlarged central portion 28, thus forcing the shaft upwardly, and the shoulder 55

5

moves against the thrust-bearing surface of the bearing bushing, thus forcing the latter outwardly. It will be appreciated, of course, that some appropriate screw means will be employed for moving the bifurcated element upwardly.

In the bearing structure of the present invention, as in other bearing structures for instruments of this general character, the reason for inserting the bearing bushings in the frame is that the insertable bushing normally is made from a metal which provides a better bearing surface than would the metal which is usually used in making the frames. In accordance with common practice, the bearing bushings are preferably made from relatively hard metal, such as stainless steel, whereas the frames are usually formed from brass. In all cases wherein the bearing bushing is made from harder metal than is the frame, the staking, splining, or other deformation, should be confined to the bearing bushing since it is the harder metal which must cut the slots or keyways in the softer metal. In cases, however, wherein it is desired to use a soft bearing metal, the deformation or staking is done in the frame member, as illustrated in Fig. 7. In this instance, frame element 70 is provided with an aperture for the reception of the bearing bushing 71, and before the bushing is inserted in the aperture, the marginal edges of the aperture are upset at a plurality of spaced points adjacent to the outer surface of the frame member, as shown at 72. In this case, the offset portions cut the splines or keyways in the bearing bushing, as is shown at 73.

By forming the splining or the staking on the bearing bushing only adjacent to the inner surface of such bearing bushing, a shoulder is formed in the bearing bushing aperture as such bushing is moved outwardly. For heavy-duty work, this method of forming a bearing is desirable since the bushing cannot move outwardly beyond the point at which it has been moved by the application of force. In many relatively delicate measuring instruments, however, there is no considerable end thrust in the shaft, and accordingly the formation of the shoulder is not necessary. In such instances, the bearing bushing may be splined over its entire width, and then inserted within the bearing bushing aperture from either end thereof, and finally moved to its desired position by the application of pressure. Such a method is illustrated in Figs. 8 to 11, inclusive.

Referring particularly to Figs. 8 and 9, 76 represents the frame element having bearing bushing aperture 77 which receives bearing bushing 78 which is formed with splines 79 over its entire width. The bushing is formed with a bearing aperture 80 which receives the reduced terminal portion 81 of shaft 82. In following out this method, the bearing bushing is first inserted within the aperture and moved inwardly by any suitable means to substantially the position shown in Fig. 8. The frame may then be assembled with the shaft 82 in place. It is then only necessary to move the bearing bushing further inwardly to a point where its inner surface 84 gives a desired measure of clearance to the shoulder 85 formed at each end of the shaft. This may be done by any suitable instrument, such as that shown in Figs. 8 and 9. This instrument includes a base 87 upon which is mounted a vertical, bifurcated support 88 having a substantially U-shaped recess 89 extending downwardly from its upper end. The frame may be inserted in the position shown wherein the shaft projects through the

6

opening, the opposed sides of the bifurcated member supporting frame 76 against movement. Another vertical member 90 forms a journal support for a screw element 91 having a thumb turn 92, the screw element carrying at its inner end a die 93 having a recess 94. The recess provides clearance for the shaft, and the outer diameter of the die is less than the diameter of the bushing which the die engages.

It will thus be seen that as the screw element is rotated, bearing bushing 78 is moved inwardly to a point wherein its inner surface 84 approaches shoulder 85 of the shaft. If a reasonable amount of care is taken, the moving of the bearing bushing can be stopped before the shaft is frozen, and, at the same time, provide a desired minimum of end play in the shaft. In some instances, however, the bushing may be moved inwardly too far, and thus rotation of the shaft is prevented. In order to move the bushing outwardly to again free the shaft, the instrument shown in Figs. 10 and 11 may be employed. In this case, the bifurcated support 94 having recess 95 receives the shaft, the side walls of the opening engaging the inner surface 84 of the bearing bushing 78. In this instance, die 96 having a somewhat larger opening 97 than does die 93 is mounted on a similar screw element 98, and as this screw element is manipulated, the die moves the frame member in the direction of the shoulder 85 of the shaft, and thus moves the bushing outwardly relative to its supporting aperture.

A number of preferred ways of carrying out the method of the present invention have been described herein, but it will be appreciated that the procedures are suggestive only, and that the method may be otherwise performed.

What I claim is:

1. The method of mounting a shouldered shaft in spaced frame members provided with aligned bearing apertures, and a bearing bushing in at least one of such apertures, in order to secure a predetermined amount of end play in the shaft, which method consists in forming, on the outer periphery of the bearing bushing adjacent to the inner thrust-bearing surface, a plurality of outwardly-disposed, offset portions which are adapted to cut keyways in the frame aperture as the bushing is moved outwardly therein, force-fitting such bushing into the aperture from the inner end of such aperture, assembling the frame with the inner surface of the bushing in relatively firm contact with the adjacent shoulder of the shaft, then, while supporting the frame member, causing the adjacent shaft shoulder to move against the inner surface of the bushing, moving the same outwardly in its supporting aperture a sufficient distance to secure the desired amount of end play for the shaft.

2. The method of mounting a shouldered shaft in a frame comprising spaced frame members provided with aligned bearing apertures, and a bearing bushing in at least one of such apertures, in order to secure a predetermined amount of end play in the shaft, which method consists in forming projections on the outer periphery of the bushing at a point spaced inwardly from its outer surface, force-fitting the bearing bushing into its aperture from the inner end of such aperture, assembling the frame with the inner surface of the bushing in relatively firm contact with the adjacent shoulder of the shaft, then, while supporting the frame member against movement, driving the shaft in the direction of such frame member, causing the adjacent shaft shoulder to

move against the inner surface of the bushing, moving the same outwardly in its supporting aperture a sufficient distance to secure the desired amount of end play for the shaft.

3. In a measuring instrument or the like provided with a shouldered shaft, a frame comprising spaced frame members formed with aligned bearing apertures for the shaft, and a bearing bushing in one of such apertures, formed with a plurality of projections on its outer periphery adjacent to its inner surface, the method of securing a predetermined amount of end play in the shaft which consists in force-fitting such bushing, smaller end forward, into its supporting aperture from the inner end of such aperture, thus forming a complementary recess therein, limiting outward movement of such bushing, then assembling the frame and shaft with the inner surface of the bearing bushing in engagement with the adjacent shoulder of the shaft, and finally forcing the shoulder of the shaft against the bushing, while the adjacent frame member is supported against movement, to move the bushing outwardly in its aperture a sufficient distance to secure the desired end play for the shaft.

4. In a measuring instrument or the like provided with a shouldered shaft, a frame comprising spaced frame members formed with aligned bearing apertures for the shaft, and a bearing bushing in at least one of such apertures, the method of securing a predetermined amount of end play in the shaft which consists in forming outwardly-disposed splines on the outer periphery of the bushing adjacent to its inner surface, force-fitting such bushing into its aperture, thus cutting a shoulder therein, limiting further outward movement, then assembling the frame and shaft with the inner surface of the bearing bushing in engagement with the adjacent shoulder of the shaft, and then forcibly moving the shoulder of the shaft against the bushing, while the adjacent frame member is supported against movement,

thus moving the bushing outwardly in its aperture a sufficient distance to secure the desired end play for the shaft.

5. In a measuring instrument or the like provided with a shouldered shaft, a frame comprising spaced frame members formed with aligned bearing apertures for the shaft, and a bearing bushing in at least one of such apertures, the outer periphery of the bushing being formed with splines at a point spaced inwardly from its outer surface, the method of securing a predetermined amount of end play in the shaft which consists in force-fitting such bushing into its aperture from the inner end of such aperture, the splines cutting shoulders therein, limiting further outward movement, then assembling the frame members and shaft with the inner surface of the bearing bushing in engagement with the adjacent shoulder of the shaft, and then forcibly moving the shaft, by a micrometric screw drive, in the direction of the bushing while the frame member carrying the bushing is supported against movement, thus causing the shoulder of the shaft to move the bushing outwardly in its aperture a sufficient distance to secure the desired end play for the shaft.

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