July 5, 1927. 1,634,328

E. J. LEES

TESTING APPARATUS

Filed July 20, 1922

Fig. 1.

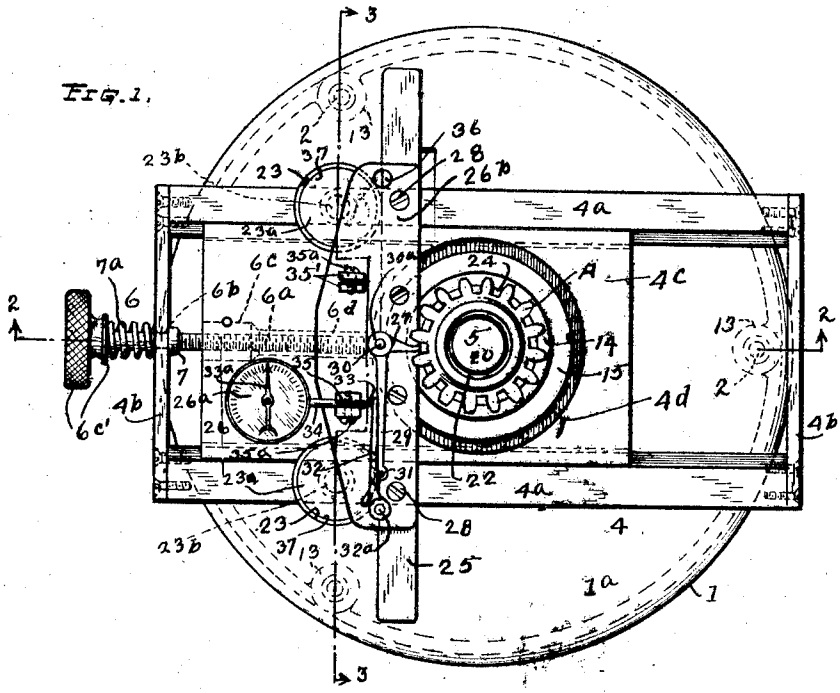


Fig. 2.

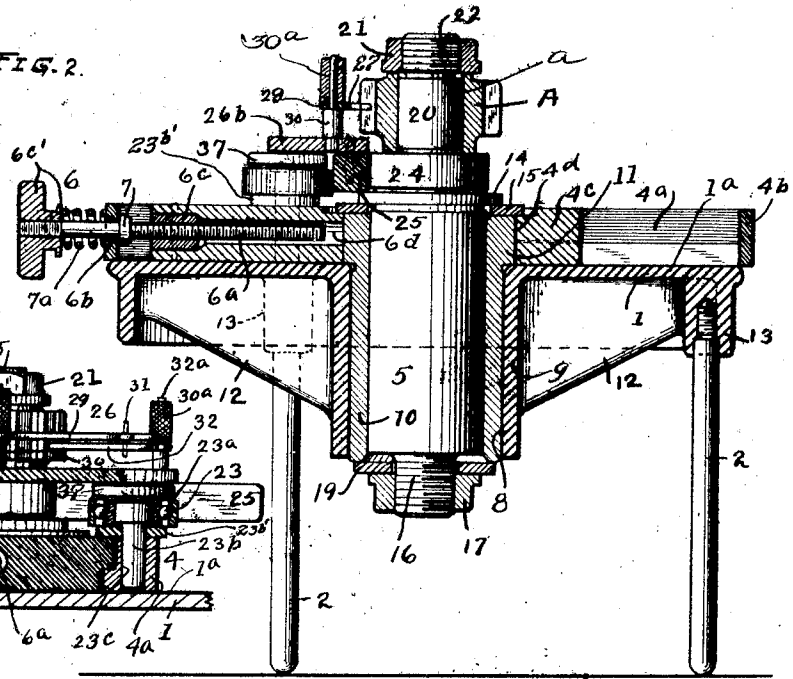


Fig. 3.

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UNITED STATES PATENT OFFICE.

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TESTING APPARATUS.

Application filed July 20, 1922. Serial No. 576,268.

This invention relates to apparatus for testing gear teeth to determine their accuracy or inaccuracy.

One object of the invention is to provide an apparatus of this character of relatively simple construction capable of testing gear teeth, whereby their accuracy or inaccuracy may be indicated or determined.

Another object of the invention is to provide an improved apparatus of this character in which means are provided for measuring inaccuracies in gear teeth.

A further object of the invention is to provide an improved apparatus of this character in which the accuracy or inaccuracy of gear teeth generated according to the involute system may be readily determined.

Other objects of the invention will be apparent to those skilled in the art to which my invention relates from the following description, taken in connection with the accompanying drawings, wherein

Fig. 1 is a top plan view of an apparatus embodying my invention.

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

Fig. 3 is a section on the line 3—3 of Fig. 1.

Referring to the drawings, 1 indicates a base or bed of any desired construction, but preferably supported on a plurality of legs 2. The top 1^a of the base or bed 1 is preferably disposed horizontally. The top 1^a consists of a plane on which a frame 4 has sliding engagement as it rotates about the axis of a gear A in the manner to be later set forth. The frame 4 may comprise a pair of bars 4^a connected together at their opposite ends and held in spaced parallel relationship by links 4^b, and an intermediate member 4^c preferably disposed between the bars 4^a. The intermediate member 4^c is formed with an opening 4^d to receive a suitable supporting means for the gear A, herein illustrated as a spindle or shaft 5, which (or an element thereon) may serve as a bearing for the frame 4 to rotate on, as will be hereinafter set forth. The inner side edge of the bars 4^a and outer side edges of the member 4^c are shaped to form inter-engaging guide surfaces, whereby the bars 4^a may be moved or adjusted relative to the member 4^c by means indicated as an entirety at 6. Of these moving means, 6^a indicates a rod extending through and having bearing in an opening 6^b formed in one of the links 4^b. The inner end of the rod is screw threaded and engages a nut 6^c fixed in an opening 6^d formed in the member 4^c (see Fig. 2). The rod 6^a is held against endwise movement outwardly by a collar 7, which engages the inner face of the adjacent link 4^b; to control its movement inwardly, I provide between the link 4^b and a shoulder $6^{c'}$ (which shoulder may comprise a head by which the rod 6^a is rotated) a spring 7^a; the collar 7 and spring 7^a through their engagement with the link 4^b serving to insure movement of the bars 4^a relative to the intermediate member 4^c when the rod 6^a is rotated in one direction or the other.

The base or bed 1 is formed with an opening 8, surrounding which is a depending member 9, preferably of tubular shape, adapted to receive a bushing 10, the latter being provided with an annular collar 11, which engages the top 1^a and supports the bushing in the tubular member 9. The tubular member 9, as well as the strengthening ribs 12 and lugs 13 (to which the legs 2 are secured) are preferably formed integrally.

The shaft or spindle 5 removably fits the bushing 10, being provided with a ring 14 which engages a washer 15, disposed on the upper end of the bushing 10, to support the shaft or spindle 5 in position. As shown in Fig. 2, the washer 15 extends circumferentially beyond the inner periphery of the intermediate frame member 4^c to hold it, and through it the bars 4^a, in engagement with the top 1^a. At its lower end, the shaft or spindle 5 is preferably reduced, as shown at 16, and such reduced end is provided with screw threads to receive a nut 17, which may be tightened against a washer 19. As the washer 19 engages the lower end of the bushing 10, it will be seen that the nut 17, when tightened, serves to removably secure the ring 14 in engagement with the washer and to prevent endwise as well as rotary movement of the shaft or spindle 5. At its upper end the spindle 5 may be suitably shaped to engage the gear to be tested; since the gear illustrated is formed with an opening *a* through it, the upper end of the spindle is reduced to provide an arbor or support 20 for the gear A. In this form of construction, the gear A may be removably held on and fixed to the arbor 20 by a nut 21 engaging screw threads 22 provided on that

portion of the shaft or spindle 5 which extends beyond the arbor 20.

23, 23, indicate a pair of abutments carried by the frame 4, each abutment being mounted on one of the bars 4^a, and preferably arranged equal distances from one end of the frame. As shown, the abutments are disposed upon opposite sides of a plane containing the axis of the shaft 5 for a purpose which will later be apparent. Each abutment 23 preferably comprises a roller 23^a mounted on a shaft 23^b fixed in an opening 23^c formed in the adjacent bar 4^a. To eliminate friction, the roller may consist of an anti-friction bearing having inner and outer races with balls between them. In this form of construction, the inner races fitted to the upper end of the shaft 23^b and may rest on a washer $23^{b'}$; whereas the outer race will serve as the rotating element for a purpose that will later appear.

24 indicates an annulus fixed to the shaft 5 and corresponding in diameter to one of the circles of the gear A, preferably the base circle thereof. The annulus 24 may be connected to the shaft 5 in a manner which permits its removal, whereby an annulus of a different diameter may be substituted, when desired. It is not essential however that the annulus be removable, for, as above stated, it may be fixed to the shaft 5, as for example in some cases, by forming it integral with the shaft 5. The essential requirements of the socalled "annulus" 24 are that it shall provide a circular edge or cylindrical surface concentric or co-axial with the axis of the gear A to be tested; and that the outside diameter of said circle or cylinder shall be the same as that of one of the circles of the gear as above stated; and that it shall provide a suitable surface or edge for engagement by the contact element 25 to be described. The word "annulus" used for convenience herein, particularly in the claims, is to be read with this definition and is not to be restricted to mean only a ring.

25 indicates a contact element extending transversely of the frame 4 and disposed between the abutments 23 and the annulus 24, being held against the latter by the abutments, so that upon rotary movement of the frame 4 on the collar 11 about its axis, the contact element 25 will roll on the annulus 24, while moving in an endwise direction on the roller abutments 23 relative to the frame 4 during movement thereof about the axis of the shaft 5. Accordingly, if the contact element 25 be marked at any point of its contact with the annulus 24 and the frame 4 is then moved, such marked point will describe an involute curve. In order to take advantage of this principle of operation, I mount upon the contact element 25 a registering mechanism, indicated as an entirety at 26, and a pivoted member 27, which constitutes a describer, the nose of which is disposed in engagement with a gear tooth and in registry with the point of contact between the contact element 25 and annulus 24, and hence will describe the involute curve in the manner already set forth when the frame 4 is moved. As shown in Figs. 1 and 2, the describer 27 engages the face of a tooth of the gear A and rides thereon as the frame 4 rotates; accordingly, if the tooth face is inaccurate, such inaccuracy will displace or cause or permit movement of the describer 27 about its pivot, which movement or displacement will be transmitted by the elements of the registering mechanism to its indicator 26^a, whereby the amount of the inaccuracy will be indicated.

Of the registering mechanism 26, 26^b indicates a plate carried by the contact element 25, being preferably secured thereto by a plurality of screws 28. 29 indicates a lever preferably integrally connected with the member 27 and forming therewith a bell crank mounted on a pivot pin or shaft 30 which is supported on the plate 26^b. The free end of the lever 29 carries a projecting element 31 which engages a second lever 32 and the latter in turn engages a thrust rod 33 slidably mounted in a sleeve 34. The sleeve 34 is supported between a pair of standards 35, being removably held thereon by a clamping screw 35^a. The movement of the thrust rod 33 is indicated by the hand 33^a. The sleeve 34 is connected to the casing of the indicator 26^a. The second lever 32 is mounted on a fulcrum or shaft 32^a supported on the plate 26^b. The bell crank is preferably removably held on the pivot pin 30 by a knurled sleeve 30^a.

It will be noticed that I provide a second pair of standards, indicated at 35′, and an opening 36 and extend the projecting element 31 upwardly, as well as downwardly see Fig. 3. This construction permits the sleeve 34 to be mounted in the standards 35′ and the levers 29, 32, to be supported in a position reversed to that shown, with the fulcrum 32^a mounted in the opening 36. Accordingly, after the corresponding faces of all the gear teeth have been tested, these elements may be arranged or assembled in their other position and permit the testing of one or more of the other faces of the gear teeth, without removing the gear A from the shaft or spindle 5.

In the construction herein shown the contact element 25 is supported between the annulus 24 and the abutments 23, the latter being held against the contact element by the rod 6^a acting through the bars 4^a and member 4^c, against the collar 11. By positioning between the head $6^{c'}$ and the adjacent link 4^b a spring, which is compressed when the rod is operated, I provide means that will exert a yielding pressure upon the contact

element 25, so that sufficient friction will be created between it and the annulus 24 to cause the contact element to roll thereon without slipping while moving endwise on the rollers 23. As will be understood, the opposite faces of the contact element which engage the annulus 24 and rollers 23, are parallel to each other to insure accuracy in operation as the frame 4 moves about the axis of the shaft 5.

37, 37, indicate a pair of supporting members, preferably carried by the shafts 23^b, one on each shaft, adapted to support the plate 26^b, and the elements carried thereby, whenever the shafts are retracted due to the operation of the rod 6^a. When it is desired to move the frame 4, registering mechanism 26 and describer 27 around into a new testing position for testing the face or faces of one or more additional gear teeth, the head $6^{c'}$ is rotated to move the bars 4^a toward the left as viewed in Figs. 1 and 2, which operation retracts or moves the shafts 23^b away from the annulus 24, and allows the contact element 25 (which was held between the roller 23^a and annulus with the plate extending outwardly above the supporting members 37) to drop. As the supporting members 37 are below the plate 26^b, they will be engaged by the plate and thus serve to support it and the contact element 25 until the head $6^{c'}$ is again operated to effect re-engagement of the contact element between the rollers 23^a and annulus 24. The supporting members 37 may comprise disks each secured to the upper end of the adjacent shaft in any desired manner.

To those skilled in the art to which my invention relates many modifications and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope thereof. It will be understood that the descriptions and disclosures herein are purely illustrative and are not intended to be in any sense limiting.

What I claim is:

1. In apparatus of the class described, the combination of a base, a support mounted in said base and arranged to carry a gear, an annulus corresponding in diameter to one circle of the gear fixed to said support, a frame, said shaft and frame being mounted to permit relative movement between them about the axis of the gear, a contact element engaging said annulus and disposed between it and said frame and arranged to roll on said annulus when relative movement between said frame and support takes place, and means engaging the face of a gear tooth during such relative movement to determine inaccuracies therein.

2. In apparatus of the class described, the combination of a base, a support, mounted in said base and arranged to carry a gear, an annulus corresponding in diameter to one circle of the gear fixed to said support, a frame mounted to rotate about the axis of the gear, and a contact element disposed between said annulus and said frame and arranged to roll on said annulus and move relative to said frame as the latter rotates, and means engaging the face of a gear tooth during such rotary movement to indicate inaccuracies therein.

3. In apparatus of the class described, the combination of a support, a shaft mounted on said support and arranged to carry a gear, an annulus corresponding in diameter to one circle of the gear carried by said shaft, a contact element having a straight edge arranged to engage said annulus, means for moving said contact element about the axis of said shaft, whereby it may roll on said annulus, and an indicating mechanism on said contact element having a member engaging the face of a tooth of the gear, whereby inaccuracies therein may be determined.

4. In apparatus of the class described, the combination of a support, a shaft on said support arranged to carry a gear, an annulus on said shaft corresponding in diameter to one of the circles of the gear, a frame mounted to rotate about the axis of the gear carried by said shaft, a pair of abutments carried by said frame, a contact element disposed between and engaging said abutments and said annulus and arranged to roll on the latter while moving relative to said abutments during movement of said frame, and indicating means having a describer on said contact element for engaging a gear tooth, whereby the same may be tested.

5. In apparatus of the class described, the combination of a support, a shaft on said support arranged to carry a gear, an annulus on said shaft corresponding in diameter to one of the circles of the gear, a frame mounted to rotate about the axis of the gear carried by said shaft, a pair of abutments carried by said frame at opposite sides of a plane containing the axis of said shaft, a contact element disposed between and engaging said abutments and said annulus and arranged to roll on the latter while moving relative to said abutments during movement of said frame, and indicating means having a describer on said contact element for engaging a gear tooth, whereby the same may be tested.

6. In apparatus of the class described, the combination of a support, a supporting member on said support arranged to carry a gear, an annulus on said supporting member corresponding in diameter to one of the circles of the gear, a frame mounted to rotate about the axis of the gear carried by said supporting member, a pair of abutments carried by said frame, a contact element disposed between and engaging said abutments and said annulus and arranged to roll on the latter

while moving relative to said abutments during movement of said frame, indicating means having a describer on said contact element for engaging a gear tooth, whereby the same may be tested, and means for moving said abutments toward said supporting member.

7. In apparatus of the class described, the combination of a support, a shaft on said support arranged to carry a gear, an annulus on said shaft corresponding in diameter to one of the circles of the gear, a frame mounted to rotate about the axis of said shaft, a pair of abutments, each comprising a roller, carried by said frame at opposite sides of a plane containing the axis of said shaft, a contact element disposed between and engaging said abutments and said annulus and arranged to roll on the latter while moving relative to said abutments during movement of said frame, and indicating means having a describer on said contact element for engaging a gear tooth, whereby the same may be tested.

8. In apparatus of the class described, the combination of a support, a shaft on said support arranged to carry a gear, an annulus on said shaft corresponding in diameter to one of the circles of the gear, a frame mounted to rotate about the axis of said shaft, a pair of abutments carried by said frame, a contact element disposed between and engaging said abutments and said annulus and arranged to roll on the latter while moving relative to said abutments during movement of said frame, indicating means on said contact element having a member for engaging a gear tooth face of a gear carried by said shaft, whereby inaccuracies therein may be determined, and two sets of supporting means for said indicating means, whereby they may be assembled for operation upon either face of each gear tooth.

9. In apparatus of the class described, the combination of a shaft adapted to carry a gear and an annulus corresponding in diameter to one of the circles of the gear, a contact element having a straight edge or surface engaging said annulus, a support rotatable about the axis of said shaft and engaging said contact element to cause it to roll on said annulus and move relative to said support, and an indicating mechanism having a member disposed in alignment with the point of contact between said element and said annulus for engaging a gear tooth face of a gear carried by said shaft while said element is being operated.

10. In apparatus of the class described, the combination of a supporting member adapted for positioning a gear, an annulus arranged on said supporting member in concentric relation to the gear, a contact element disposed in engagement with and arranged to roll on said annulus, and indicating mechanism having a member carried by said contact element and arranged to engage a tooth of the gear positioned on said supporting member.

11. In apparatus of the class described, the combination of a shaft arranged to support a gear, an annulus disposed concentric to said shaft, a contact element disposed in engagement with said annulus, said contact element and said annulus being mounted to move relatively to each other about the axis of said shaft, and a describer carried by said contact element and arranged to engage a gear tooth of a gear supported on said shaft as relative movement takes place between said element and said annulus.

12. In apparatus of the class described, the combination of a shaft arranged to support a gear, an annulus disposed concentric to said shaft, a contact element disposed in engagement with said annulus, means for rolling said contact element about said annulus relative to the gear supported on said shaft, and a describer carried by said contact element and arranged to engage a gear tooth of the said gear as relative movement takes place between said element and said annulus.

13. In apparatus of the class described, the combination of a shaft arranged to support a gear, an annulus disposed concentric to said shaft, a contact element disposed in engagement with said annulus, said contact element and said annulus being mounted to move relatively to each other about the axis of said shaft, means for yieldingly maintaining said contact element in engagement with said annulus, and a describer carried by said contact element and arranged to engage a gear tooth of a gear supported on said shaft as relative movement takes place between said element and said annulus.

14. In apparatus of the class described, the combination of an annulus, means for supporting a gear in fixed relation and concentric to said annulus, a straight edge disposed in engagement with said annulus, said annulus and said straight edge being mounted for relative movement whereby rolling contact one with the other is effected, and a describer movably mounted on said straight edge and disposed in engagement with a gear tooth face of a gear supported by said means.

15. In apparatus of the class described, the combination of an annulus, means for supporting a gear in fixed relation and concentric to said annulus, a straight edge disposed in engagement with said annulus, said annulus and said straight edge being mounted for relative movement whereby rolling contact one with the other is effected, means for yieldingly maintaining said straight edge in engagement with said annulus, and a describer movably mounted on

said straight edge and disposed in engagement with a gear tooth face of a gear on said gear supporting means.

16. In apparatus of the class described, the combination of a pair of members mounted to move relatively to each other about an axis and comprising an annulus and an element having a straight edge in contacting engagement with said annulus, means for maintaining said element in engagement with said annulus to cause it to roll thereon while permitting it to move endwise during relative movement between said element and annulus, means for supporting a gear in fixed relation and concentric to said annulus, and a describer carried by said element and arranged to engage a gear tooth of a gear on said gear supporting means during relative movement of said element and annulus.

17. In apparatus of the class described, the combination of an annulus, means for supporting a gear in fixed relation to said annulus, a pair of rollers disposed upon opposite sides of a plane containing the axis of said annulus, said pair of rollers and annulus being mounted to move relatively to each other, a contact element disposed between said pair of rollers and said annulus, and means acting through said rollers to maintain said contact element in engagement with said annulus, whereby it rolls on the latter during relative movement of said annulus and said pair of rollers, and means including a describer on said contact element arranged to engage a gear tooth of a gear on said gear supporting means for indicating any displacement of said describer during said relative movement.

18. In apparatus of the class described, the combination of a support, a supporting member on said support for supporting a gear, an annulus disposed concentric to said supporting member, a frame mounted to rotate about the axis of a gear supported on said supporting member, a contact element mounted between and having sliding engagement with said frame and a rolling engagement with said annulus, whereby relative rolling movement takes place between said contact element and said annulus during relative rotating movement between said frame and said supporting member, a describer movably mounted on said contact element and disposed in engagement with a tooth face of the gear on said supporting member.

19. In apparatus of the class described, the combination of an annulus, means for supporting a gear in a fixed relation and concentric to said annulus, a contact element having a straight edge disposed in engagement with said annulus, said annulus and said contact element being mounted for relative movement whereby a rolling contact one with the other is effected, means acting in a direction substantially radially of said annulus for maintaining said contact in engagement with said annulus, and a describer movably mounted on said contact element and disposed in engagement with a tooth face of a gear on said supporting means.

20. In apparatus of the class described, the combination of a support for a gear, an annulus member co-axial with a gear on said support, a contact element having a straight edge in engagement with the annulus and adapted to be rolled thereupon and around the axis of the supported gear, a describer mounted for movement with the contact element and engaging a tooth face of the supported gear, and means acting radially with respect to said axis to maintain the contact element and the annulus in engagement with each other.

21. In apparatus of the class described, the combination of a supporting means for a gear, an annulus in concentric relation to one circle of the gear when on said supporting means, a pair of relatively movable elements, one of said elements and said supporting means being mounted for relative movement about the axis of the supported gear and the other element being disposed between said first mentioned element and said annulus and arranged to roll thereon during relative movement between said first mentioned element and said supporting means.

22. In apparatus of the class described, the combination of a supporting means for a gear, an annulus in concentric relation to one circle of the gear when on said supporting means, a pair of relatively movable elements, one of said elements and said supporting means being mounted for relative movement about the axis of the supported gear and the other element being disposed between said first mentioned element and said annulus and arranged to slide on said first mentioned element and to roll on said annulus during relative movement between said first mentioned element and said supporting means.

23. In apparatus of the class described, the combination of a support for a gear, an annulus in concentric relation to one circle of the gear when on said support, a frame, a pair of abutments on said frame disposed at opposite sides of a plane containing the axis of the supported gear, a contact element disposed between said abutments and said annulus, and indicating means mounted on said contact element and having a member arranged to engage the tooth of the supported gear.

24. In apparatus of the class described, the combination of a support for a gear, an annulus in concentric relation to one circle of the gear when on said support, a frame, a pair of abutments on said frame disposed at opposite sides of a plane containing the

axis of the supported gear, a contact element disposed between said abutments and said annulus, and indicating means removably mounted on said contact element and having a member arranged to engage corresponding faces of the supported gear teeth, the mounting devices for said indicating means being arranged to support them in a reversed relation to permit engagement of said member with the other tooth faces of the supported gear.

In testimony whereof, I have hereunto signed my name.

ERNEST J. LEES.