May 12, 1959 D. J. WATT 2,885,830

GEAR LAPPING MACHINE

Filed Feb. 15, 1955 3 Sheets-Sheet 1

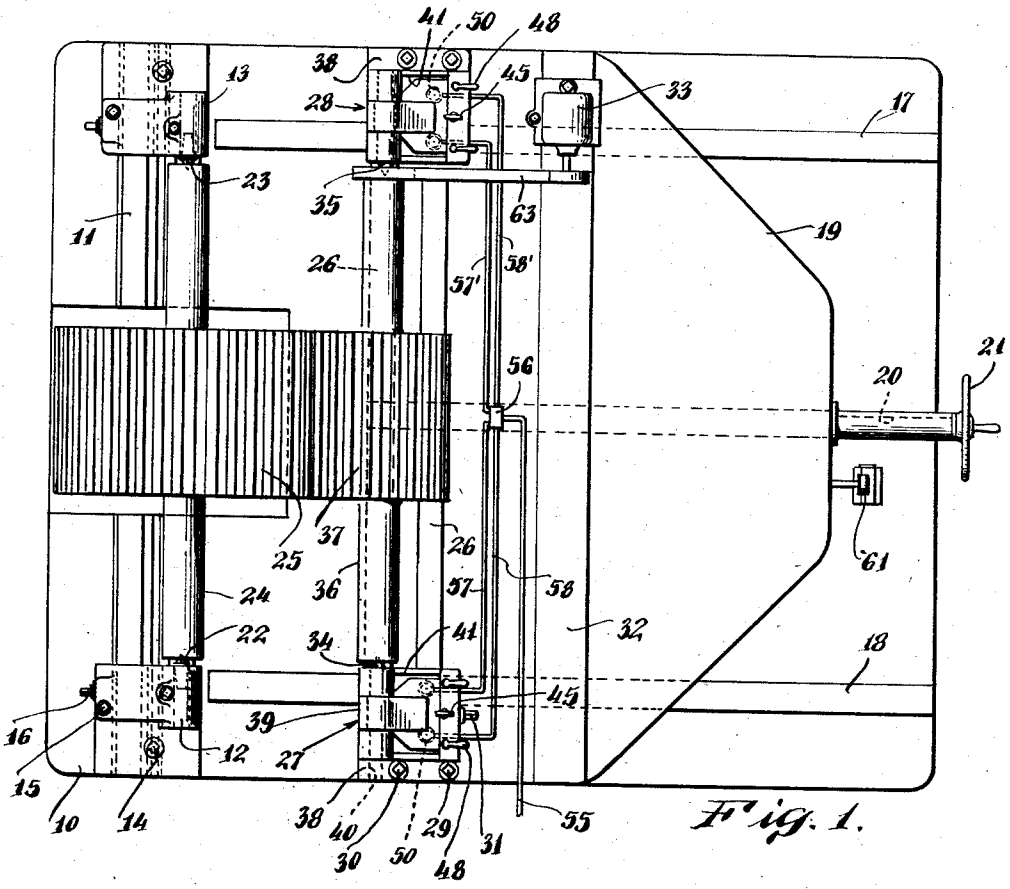


Fig. 1.

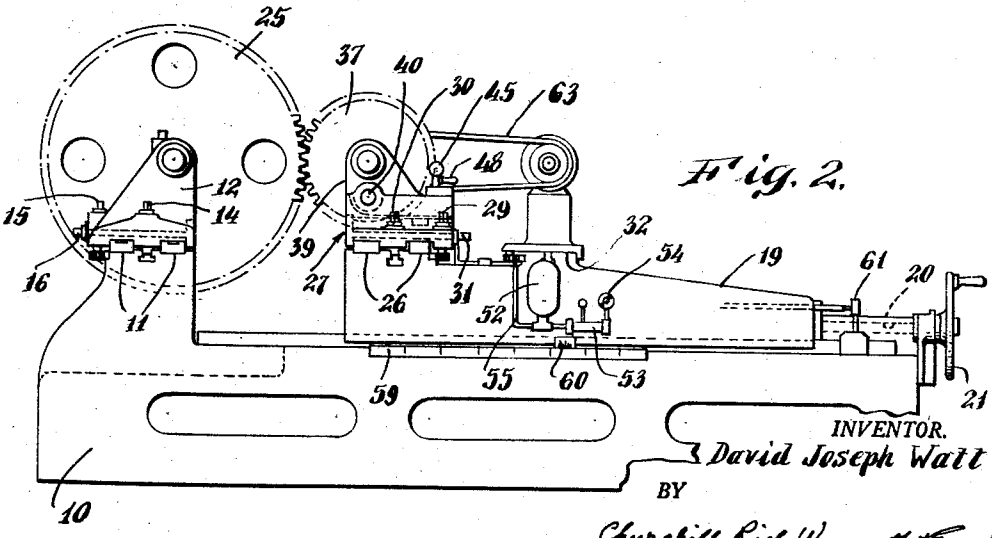


Fig. 2.

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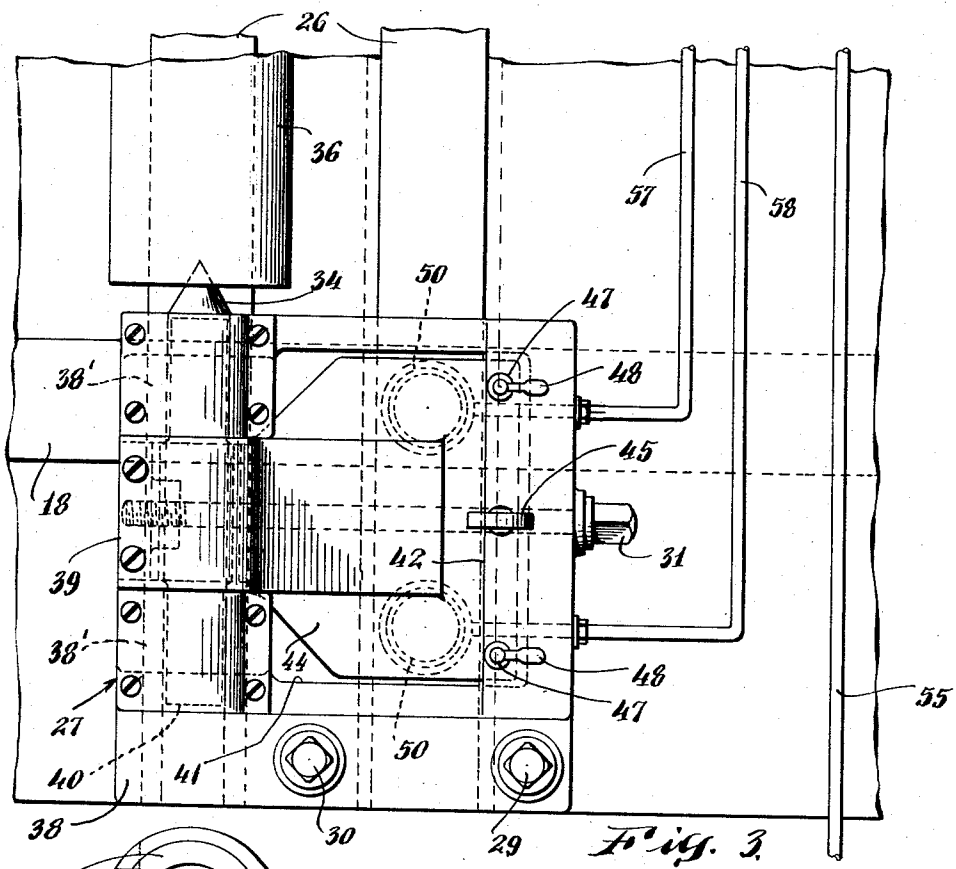


Fig. 3.

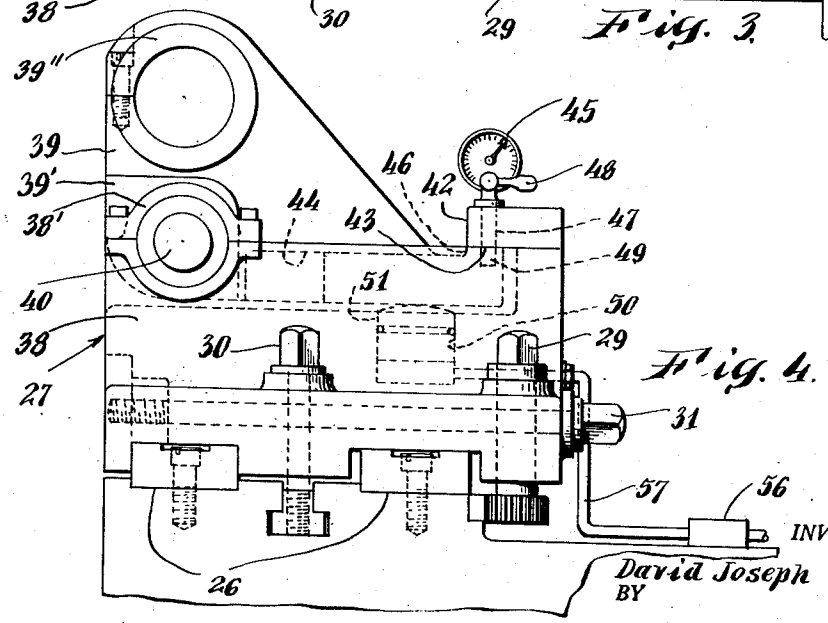


Fig. 4.

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GEAR LAPPING MACHINE

Filed Feb. 15, 1955 3 Sheets-Sheet 3

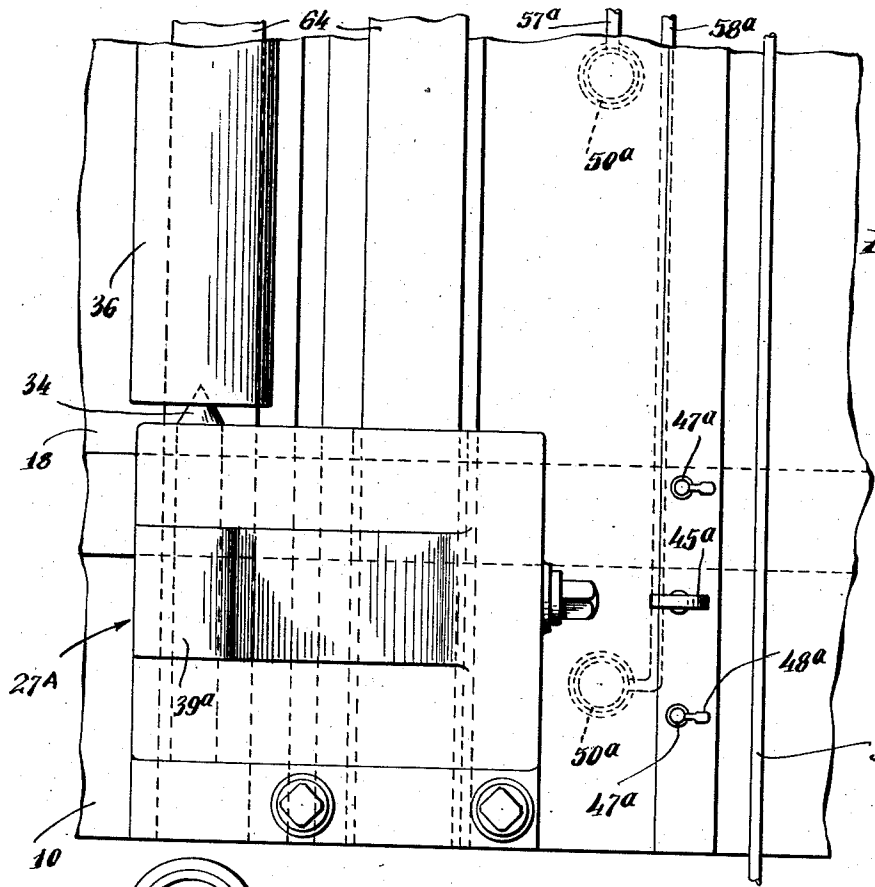


Fig. 5.

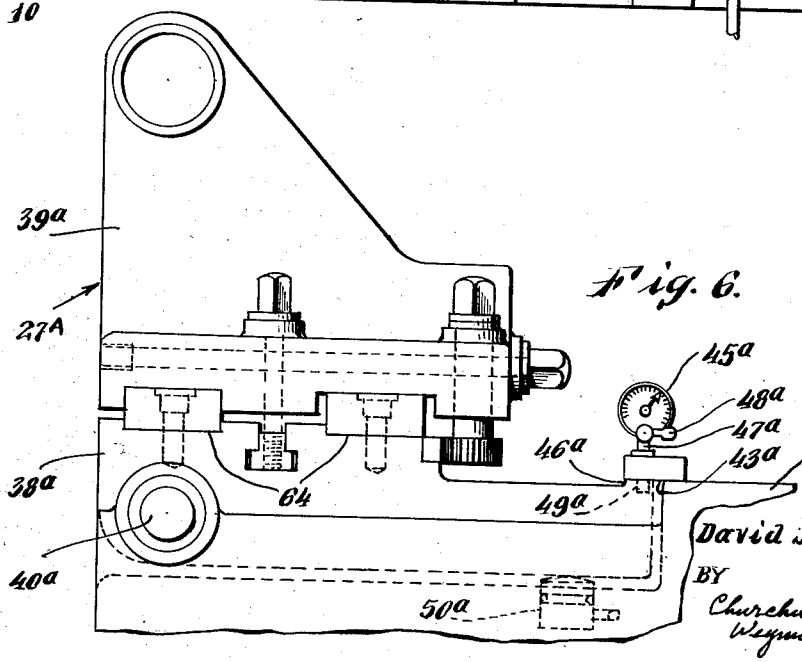


Fig. 6.

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2,885,830

GEAR LAPPING MACHINE

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6 Claims. (Cl. 51—26)

The present invention relates to a gear lapping machine and aims to provide certain improvements therein.

The lapping of gears so that they will properly mesh with one another and thereby operate most efficiently and quietly has been, up to the present, considered an art. In practicing this art, operators of lapping machines applied pressure between a pinion and a gear to be lapped by the simple procedure of progressively advancing, by screw means, the pinion and gear into intimate engagement with each other by closing the distance between the pinion shaft and the gear shaft. The force developed by the application of screw pressure resulted in a deflection or spring in the lapping mechanism or lapping setup, hence, neither exact pressures nor exact cycling were ever known and the results were dependent upon the operator's skill and attention devoted to the lapping operation. Moreover, lapping times could be extensive or relatively short, and the lost time, added expense incident to such lost time, and the questionable accuracy obtained has caused many gear manufacturers to abandon lapping as a finishing procedure in gear manufacture.

The primary object of the present invention is to eliminate the uncertainties incident in the art of gear lapping.

A further object of the invention is to transform gear lapping from an art to a science.

A still further object of the invention is to provide a machine for lapping gears under predetermined pressure between the mating gear and pinion and stopping such lapping action when the desired center distance between the gear-set is reached.

A still further object of the invention is to rely upon a controllable fluid pressure to apply the desired constant predetermined pressure between the pinion and the gear being lapped.

A still further object of the invention is to provide a machine of the character set forth which will provide an inspection medium for checking any pitch line run-out of a pinion and gear set and as an eccentricity check upon gearsets both before and after lapping.

The foregoing and other objects of the invention not specifically enumerated are accomplished by mounting a pinion on an axis which is parallel to and movable toward and away from the axis of a gear; applying a constant predetermined pressure, preferably through fluid pressure operated means, to press the pinion and gear into engagement; providing means for adjusting the desired center distance between the pinion and the gear; and providing stop means which will prevent further movement of the pinion toward the gear when the desired center distance between the pinion and gear is reached. The invention also embodies the use of instruments which will enable the pitch line run-out to be checked during and after the lapping operation.

The invention, which embodies a novel machine including the various combinations and sub-combination of parts, will be fully understood from the detailed description which follows, when considered in connection with the accompanying drawings, wherein:

Figure 1 is a top plan view of a machine embodying the invention.

Fig. 2 is a side elevational view of the machine shown in Fig. 1.

Fig. 3 is a partial top plan view, on an enlarged scale, of the pinion mounting and pressure-applying means therefor.

Fig. 4 is a side elevational view of the parts illustrated in Fig. 3.

Figs. 5 and 6 show views corresponding respectively to Figs. 3 and 4, of another embodiment of the invention.

Referring first to Figs. 1 to 4 of the drawings, the reference numeral **10** indicates a machine bed having transverse ways **11**, upon which are mounted a pair of spaced pedestal bearings or center heads **12** and **13** adapted to be adjustably positioned by pinion-operable means **15** and to be clamped to said bed by conventional means such as locking bolts **14** and **16**. Also formed on said bed **10** is a pair of longitudinally-extending ways **17**, **18**, upon which is slidably movable a saddle **19** operable by a saddle screw **20** controlled by a hand wheel **21**.

The pedestal heads **12** and **13** are herein shown fitted with centers **22** and **23**, respectively, adapted to rotatably support a shaft **24** upon which is mounted a gear **25** to be lapped. It will be obvious, however, that the gear, on its journals, may be mounted in the pedestal heads.

The saddle **19** is formed with transverse ways **26** upon which are mounted a pair of pedestal bearings, or center heads **27** and **28** which are adjustable toward and away from each other by pinion-operable means **29** and adapted to be secured to said ways by locking bolts **30** and **31**. Also formed on the saddle **19** is a transverse way **32** upon which a drive motor **33** is adjustably mounted. The pedestal heads **27** and **28** as herein shown are provided with centers **34** and **35**, respectively, adapted to rotatably support a shaft **36** upon which a pinion **37** is mounted. As in the case of the gear **26**, the pinion **37** may be mounted in the pedestal heads on its journals.

The pedestal heads **27** and **28** are substantially the same and only one of said heads will be described in detail. Each pedestal head **27** and **28** consists of a lower part **38** adapted to be clamped to the saddle, and an upper pivoted or rockable head **39**. The part **38** is formed with a pair of axially spaced bearings **38'** and with an extended base or foot portion, which is hollowed out, as indicated at **41**, and at its forward end or end spaced from and extending parallel to its axially spaced bearings, is formed with an overhanging or reentrant flange **42**, the under face of which provides a stop shoulder **43** for a purpose presently to be described. The pivoted or rockable head **39** is formed with a lower central bearing portion **39'** mounted on an intermediate portion of a shaft **40**, the ends of which shaft are mounted in the axially spaced bearings **38'** in the part **38** and with upper bearing portion **39''** for supporting the center **34** and with an extended base or foot portion **44** of a width to fit within the hollowed portion **41** of part **38**. The foot portion **44** is of a length to engage beneath the stop shoulder **43** on the flange **42**. The base or foot portion **44** is of a thickness to have limited movement within the hollowed part **41** as the head **39** pivots or rocks about the shaft **40**. Mounted in the overhanging flange **42** is an indicator **45**, the contact member of which is adapted to engage the top surface of an upstanding enlargement **46** on the foot portion **44** and to register when the enlargement **46** and stop shoulder **43** are out of engagement, the amount of such disengagement. At times it may be desirable to lock the rockable head **39** against movement relative to the part **38** and, for accomplishing this, a pair of locking screws **47** each having an operating handle **48**, may be

turned to engage threaded sockets **49** in the enlargement **46**. The part **38** is formed with a pair of cylindrical sockets **50** extending inwardly from the bottom of the hollowed out portion **41**, and mounted in each of said sockets is a piston **51** adapted to press against the under side of the foot portion **44** to urge the top surface of the enlargement **46** into abutting relation with the stop shoulder **43** when said piston is acted upon by fluid pressure admitted to the socket **50** from a fluid pressure system. As herein shown, the fluid pressure system is of the hydraulic type and comprises an accumulator **52** adapted to be charged by a hand pump **53** having a pressure gauge **54**, there being a conduit **55** leading from the accumulator to a distributor head **56** from which conduits **57**, **58**, **57'** and **58'** lead to the cylindrical sockets **50**.

The pressure to be employed in the fluid pressure system will be governed by experience and depends upon the size of gear to be lapped. For each diametral pitch of gear-set that is to be lapped, a predetermined unit pressure (or desired pressure per inch of face) will be determined. For example, if it be assumed that a 3 DP gear having a face width of 12" is to be lapped and it has been determined that the most desirable unit pressure is 40 pounds, under these conditions the hand pump **53** will be operated to apply pressure through the accumulator **52** to the four pistons **51** until the pressure gauge **54** reads 480 lbs. force, or 40×12. It will readily be seen that the pressure can be adjusted to any predetermined unit pressure for a given diametral pitch of gear, times the face width of the gear.

For indicating the center distance between the subject gear and the lapping gear, a scale **59** is mounted on the bed **10** for cooperation with a vernier **60** mounted on the saddle and with a cooperating indicator **61** mounted on the saddle.

Operation

The gear-set to be lapped, consisting of a gear **25** and pinion **37**, will be mounted on the centers, or bearings for the gear and pinion journals supported in the pedestals **12**, **13**, and **27**, **28**, respectively, and a predetermined fluid pressure will be applied to the pistons **51** in the cylindrical sockets **50** to force the top surface of the enlargements **46** against the stop shoulders **43**. The gear and its mating pinion will then be checked for parallelism of journals and face. The pinion **37** will then be moved toward the gear by actuating the saddle screw **20** through the hand wheel **21** until the indicator **45** moves slightly from its zero reading. This will indicate that the gear-set is meshed with zero backlash. The operator will then read the vernier scale **59**, **60**, and determine the amount that it is necessary to advance the pinion toward the gear to obtain the final desired lapped gear centers. For descriptive purpose, let it be assumed that the gear centers of the meshed gear-set is .010" wider than the finally desired lapped centers. Knowing the amount that the centers are in excess of desired specifications by a certain amount, the indicator **61** can be set to this amount. The operator will then set the indicator **61** to read .010" plus, and will then advance the saddle **19** through the hand wheel **21** and saddle screw **20** until the indicator **61** reads zero, at which time the scale **59**, **60**, will read the desired lapped gear center distance. This indicator **61** is merely a device used to allow the operator to control his action as he manipulates the hand wheel **21** to advance the pinion saddle **19** and heads **27** and **28** to the desired center distances. In other words, by again turning hand wheel **21** he can make the indicator **61** return to zero by moving the pinion saddle and head assembly toward the gear or away from indicator **61**. If desirable, he can again check the vernier scale **59**, **60**, by walking around the side of the mechanism to see that the finished center distance corresponds to the designed specification. This last operation of advancing the saddle to make the indicator **61** read zero, will, of course, tilt head **39** around the pivot shaft **40**, causing fluid under pressure to be forced out of the cylinders **50** back through the line into the accumulator **52** and also causing indicator **45** to read roughly twice the amount the saddle has been advanced. This multiplication arises because of the difference in length from the pivot axis to the indicator and the pivot axis to the axis upon which the pinion is supported. This will, in effect, apply the pre-set unit pressure against the gear-set teeth, at which time the lapping cycle is commenced, the pinion journal or shaft **36** being rotated by the drive motor **33** and belt **63**. A suitable lapping compound will, of course, be applied to the gears during the lapping operation. It will be readily seen that as material is removed from the gear and pinion by the lapping action, continuous predetermined pressure will be applied to the gear teeth until such time as the desired center distance is reached. When the desired lapped center distance is reached, the enlargement **46** on the swivel head **39** will abut against the stop shoulder **43**, preventing any further advancement of the pinion toward the gear, thus removing the predetermined lapping pressure. When this occurs, the lapping machine may be shut down.

The indicator **45** may also serve to check any pitch line run-out in the gear and the pinion and will serve as an eccentricity check of gear-sets, both before and after lapping, without the necessity of a separate set-up in a checking machine for this purpose. Pitch line run-out will be shown on indicator **45**, which, if there is pitch line run-out, should fluctuate to about twice the amount of the pitch line run-out at the start and can be observed at the discretion of the operator. It is obvious that the lapping will undoubtedly follow and perpetuate the pitch line run-out until the end of the lapping cycle, when the proper center distance is being approached, at which time the enlargement **46** on the head **39** will contact the stop shoulder **43** which will absorb the force exerted by the fluid pressure mechanism. If there is pitch line run-out, the stop will be contacted during the time that the pitch line is low, removing the force between the lapping gear and subject gear. When the pitch line run-out becomes high, the pressure between the subject gear and the lapping gear will separate the enlargement **46** from the stop, causing the fluid pressure force to be transmitted to the pinion and gear in mesh. This forces the gear to lap and remove metal at the high point on the pitch line run-out while the tendency to remove metal at the low point will be reduced to near zero. During this time there will be a continued period where the fluctuations in indicator **45** approach a condition of longer and longer periods of no fluctuation. As soon as the needle on the indicator **45** ceases to fluctuate, the lapping cycle has been completed, the gears may be cleaned of lapping compound, the fluid pressure can be reduced and the saddle advanced an additional few thousandths, so that the gears may run together and a pitch line line run-out check made of the finished lapped gears. At this point it would be necessary for the operator to continuously observe the indicator **45**.

In the embodiment of the invention shown in Figs. 5 and 6 the pivot shafts **40*a*** for the right and left side of the pinion have been lowered and incorporated in a single pedestal bearing, or center head **27A** in which the top surface of the enlargement **46*a*** which controls the maximum rotation about the pivot shaft **40*a*** has been moved to act against a shoulder stop **43*a*** formed on the saddle **19**. The lock **47*a*** and locking handle **48*a*** and the indicator **45*a*** have been moved correspondingly. In this embodiment the saddle **19** is formed with cylindrical sockets **50*a*** for the operating pistons, and conduits **55*a***, **57*a*** and **58*a*** correspond in function to the conduits **55** to **58** of Figs. 1 to 4. The lower member **38*a*** of the two-part pedestal **27A** is formed with transverse ways **64** on which the upper members **39*a***, which support the pinion,

are adjustably mounted. The difference between this embodiment of the invention and that shown in Figs. 1 to 4 is that a strong structural member 38*a* which extends completely under the pinion, ties both pinion supports 39*a* together, requiring unitary pivoting of both said supports. This provides a means of pre-assembly of the mating gear and pinion shafts and insures maintaining parallelism between said shafts throughout the lapping cycle. The operation of this embodiment is precisely the same as that of the mechanism shown in Figs. 1 to 4, although the performance may be slightly different.

In cases where the straightness of the teeth across the face has not been manufactured correctly, whereby to provide a concentration of force on one side of the contact with no contact on the other side, the procedure outlined above would, of course, apply considerably more pressure in the contact for the same fluid pressure as used previously for the mechanism shown in Figs. 1 to 4. This would, in effect, produce more rapid lapping where the load is concentrated in the pinion to give additional correction more rapidly at the start of a lapping cycle, with the finish lapping similar to that accomplished by the embodiment shown in Figs. 1 to 4.

In cases where previous processing of gears has produced tooth straightness or helix trueness, so that true distribution is obtained from one side of the face to the opposite, then the mechanism shown in Figs. 1 to 4 would be preferable, since small advances of each pedestal will be allowed to suit the lapping requirements of the mating gear and pinion and maintain constant tooth pressure throughout the lapping cycle. This procedure is also preferable for extremely rapid lapping, wherein it is desirable to apply pressure approaching, but not exceeding, the crushing pitting strength of the gear teeth being lapped. The crushing pitting strength refers to a fatigue characteristic which results in small, inverted cones of material extracted from the gear tooth at the pitch line. This phenomenon occurs when the Hertz stress for allowable sub-surface shear is exceeded.

The embodiment shown in Figs. 5 and 6 would allow more rapid correction utilizing lower overall pressures wherein tooth straightness or helix trueness required improvement. It will thus be seen that each of the embodiments of the invention has advantages in the control of the lapping procedures in converting such procedures from an art to a science.

Although there has been shown and described two embodiments of the invention applied to the lapping of spur gears, it is to be understood the invention is applicable to helical and herringbone gears and that these specific constructions disclosed may be modified within the range of engineering skill without departing from the spirit of the invention as hereinafter defined.

What I claim is:

1. A gear lapping machine comprising a bed having supports for rotatably mounting a gear, a saddle slidable on said bed having bearing supports for rotatably mounting a pinion on an axis parallel to and movable toward and away from the axis of said gear supports, cooperating means on said saddle and said bed for indicating the center distance between a gear-set consisting of a gear and a pinion when mounted in the respective supports, cooperating means on said bed and said saddle for presetting the desired lapped center distance of a gear-set to be lapped, said pinion supports consisting of a lower part fixable on the saddle and an upper part consisting of a pair of coaxially spaced heads for supporting a pinion rockably mounted on the lower part to permit movement of the pinion supporting axis through said heads toward and away from the gear supporting axis of the gear supports, means for applying an equal predetermined constant force to each of the rockably mounted upper parts to urge the supporting axis of the pinion toward the gear supporting axis and cooperating means on the lower and upper parts of the pinion supports for limiting such rockable movement of said upper part toward the gear to the pre-setting of the desired center distance of the gear-set to be lapped.

2. A gear lapping machine according to claim 1 wherein the means for applying an equal predetermined constant force against each of the rockably mounted upper parts are fluid pressure operable means.

3. A gear lapping machine according to claim 1 wherein the cooperating means on the lower and upper parts for limiting the rockable movement of the pinion comprises a base or wing portion on the upper part engageable with an overhanging flange on the lower part.

4. A gear lapping machine according to claim 1 wherein the upper heads are independently adjustable.

5. A gear lapping machine according to claim 1 wherein the lower part is formed integral with the saddle.

6. A gear lapping machine comprising a bed, bearing supports on said bed for rotatably mounting a gear, a saddle movable on said bed toward and away from said bearing supports, pedestal heads carried by said saddle and having bearing supports for rotatably mounting a pinion on an axis parallel to the axis of the bearing supports for the gear, said pedestal heads being rockable to move the bearing supports thereof toward and away from the axis of said gear bearing supports, means for maintaining a constant equal pressure on the pedestal head bearing supports transversely to the axis thereof to urge said axis toward the axis of the gear supports, means for limiting the rockable movement of said pedestal heads toward the axis of the gear supports so that said limiting position of the axis of said pinion supports is that of the pinion at the end of a lapping operation of a gear and pinion set mounted in the respective supports, cooperating indicating means on said bed and on said saddle for indicating the distance between the axes of the respective gear and pinion supports when the pinion supports are at the limit of their rockable movement toward the axis of the gear supports, and means for moving the saddle toward the gear supports a distance such that when the desired center distance of a gear-set to be lapped mounted in the supports in meshing engagement is indicated by said indicating means, the pinion supports of the pedestal heads will have been rocked back from the limiting mean an amount equal to the excess of the desired center distance of the gear-set before lapping.

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