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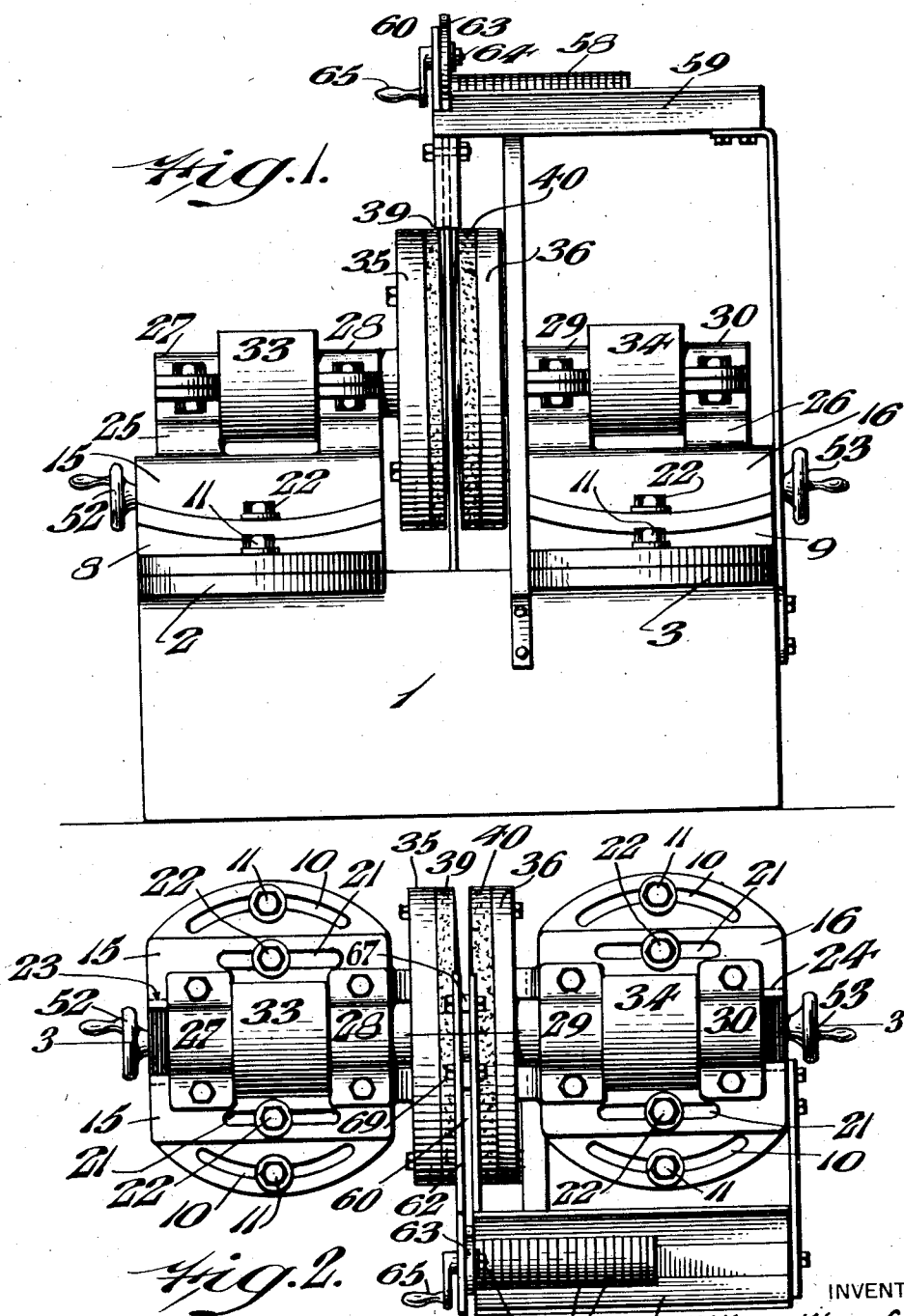
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1,906,731

ABRADING MACHINE AND METHOD OF GRINDING

Filed Sept. 23, 1926

4 Sheets-Sheet 1



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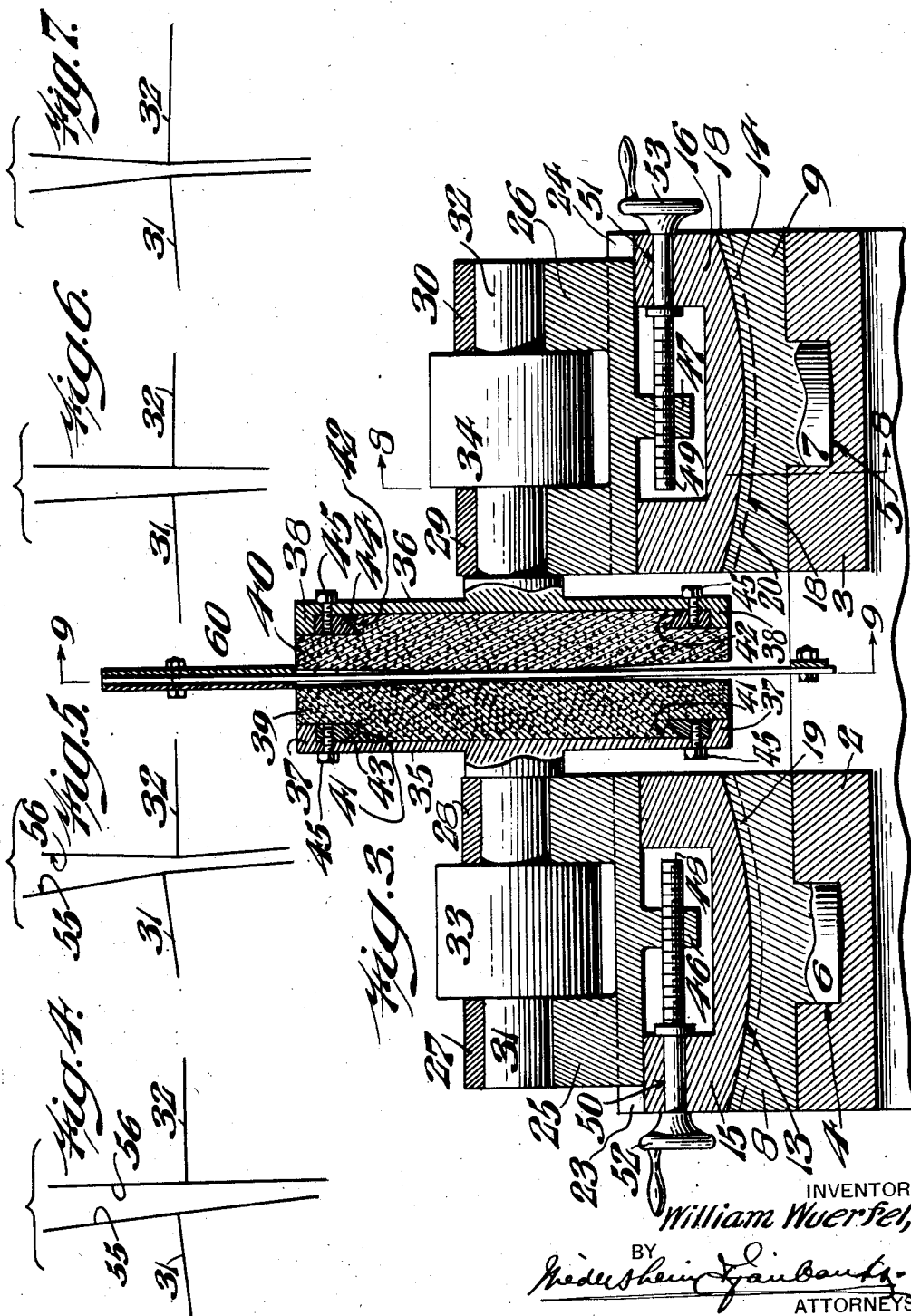
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4 Sheets-Sheet 2



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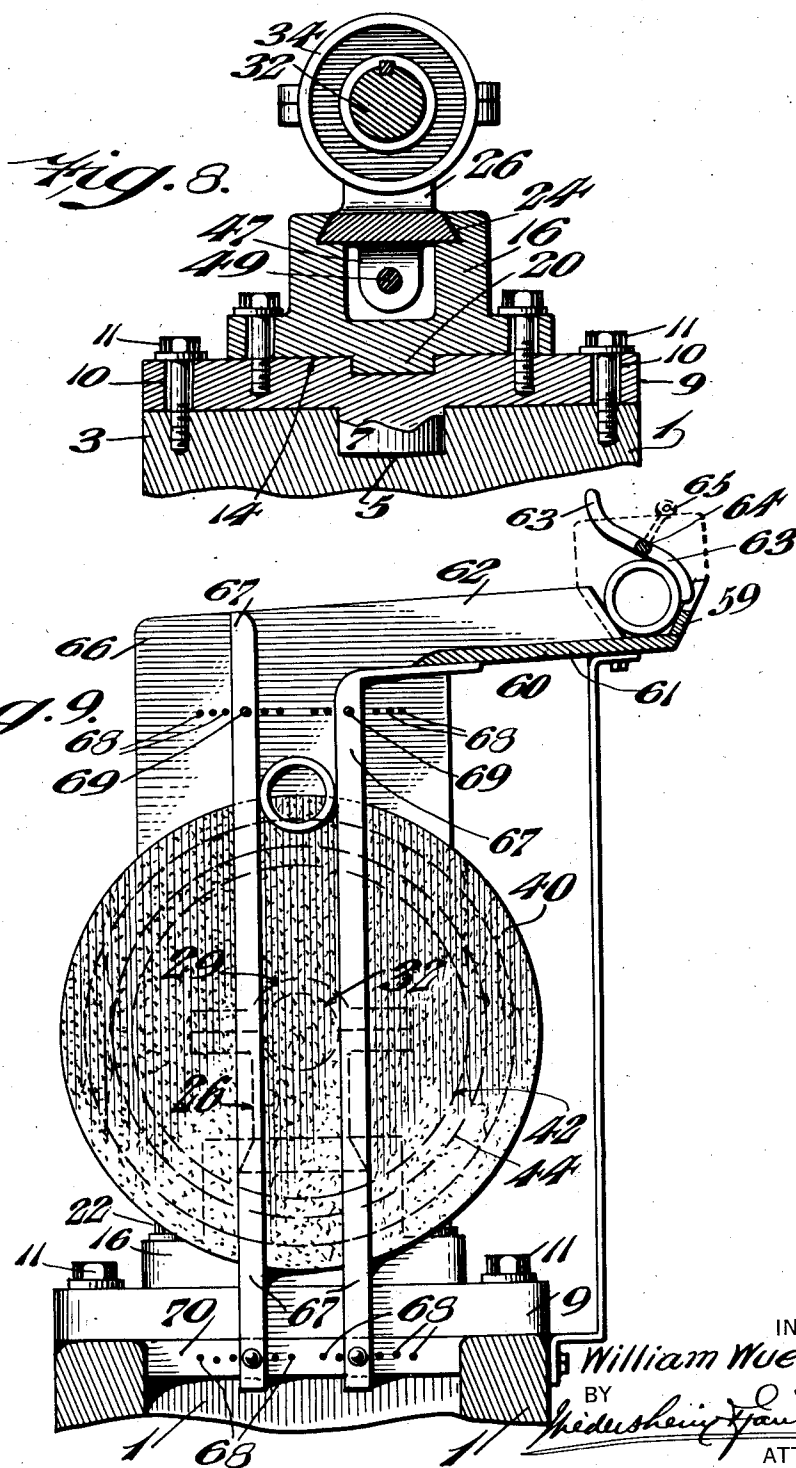
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ABRADING MACHINE AND METHOD OF GRINDING

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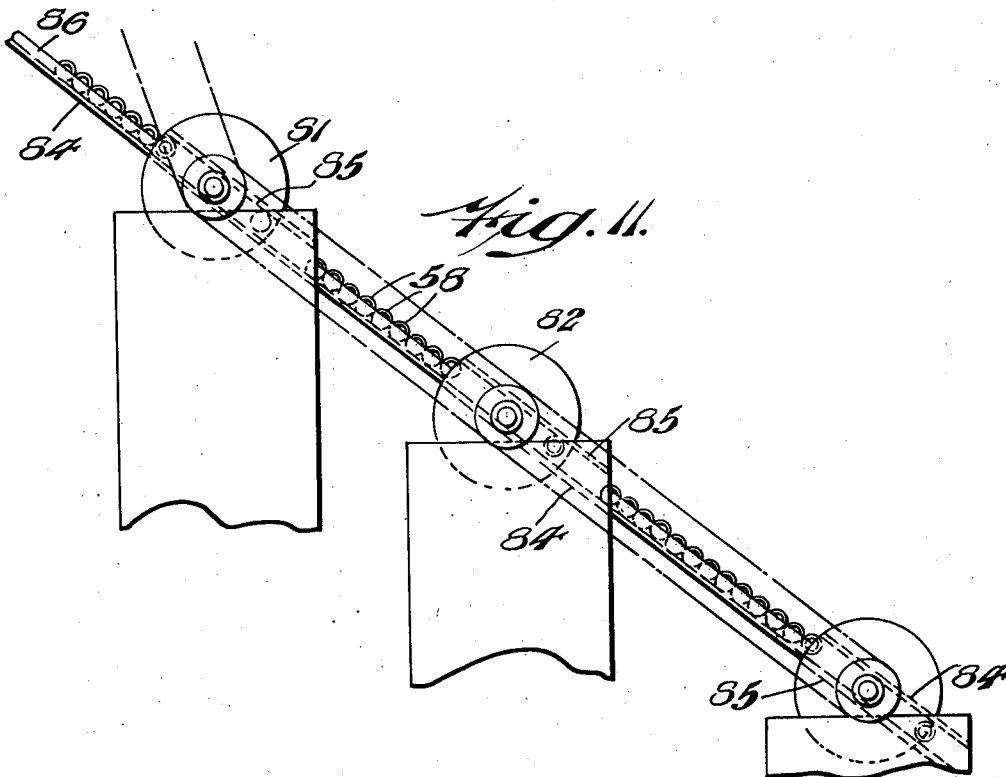
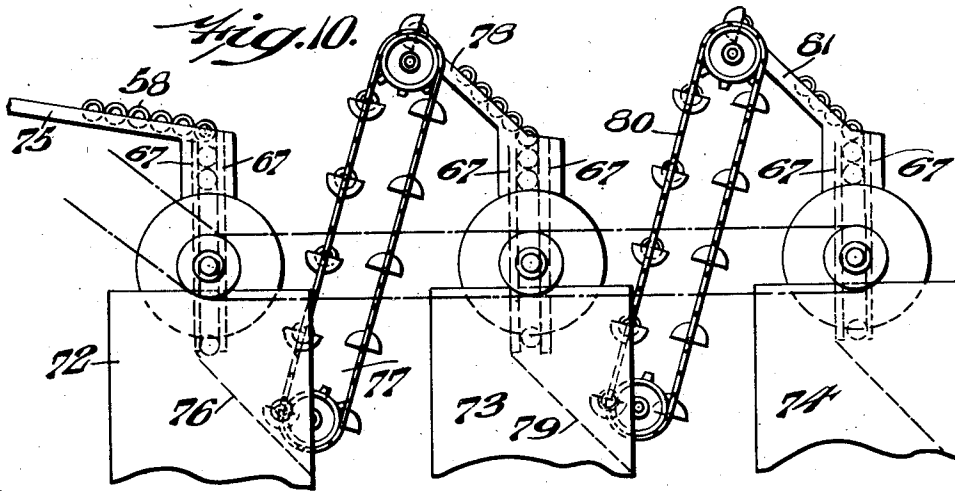
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ABRADING MACHINE AND METHOD OF GRINDING

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4 Sheets-Sheet 4



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ABRADING MACHINE AND METHOD OF GRINDING

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My invention relates to a new and useful grinding or abrading machine, adapted to grind two opposed flat surfaces, to smoothly finished parallel planes, by means of suitable abrasives. My machine is particularly adapted for grinding opposed flat surfaces of discs, rings or the like, to smooth highly finished and perfectly parallel planes; as for instance, the opposed flat faces or edges of piston rings.

In grinding the opposed parallel surfaces of piston rings, it has been the practice heretofore, to place the piston rings individually, between the juxtaposed flat and parallel revolving abrasive surfaces and to retain the individual piston rings fixedly between such flat and parallel abrasive surfaces, until ground down to the desired thickness and finish. In these prior art machines, the abrasive surfaces were formed on two disc-shaped grind stones carried by suitable spindles and juxtaposed to each other at a suitable distance. To insert the ring initially, between these two juxtaposed grinding surfaces, it was necessary, and hence it was the practice, to separate the two grind stones a greater distance, position the ring, by means of a suitable ring holder, between the two grinding surfaces, and then move the grinding stones towards each other, into engagement with the opposed edges of the piston ring. The revolving grind stones were then pressed towards each other, until the ring was ground down to the desired thickness. Thereafter, the grind stones were again separated and the finished ring removed from between the same.

By the prior art practice it was therefore necessary and essential to separate the two grinding surfaces and then to bring them together again for the insertion and removal of the piston rings. Moreover, the grind stones were brought together gradually, by a manual operation as the ring was ground down to the desired size. Not only was the time consumed by this operation very great, but it also required a manual operation for the insertion and removal of these individual piston rings, as well as a manual feeding of the grind stones to the finished dimensions. By

the machine and construction of my present invention, I am enabled to feed a continuous series of piston rings through and between two juxtaposed revolving grinding surfaces, without changing the distance between the two grinding surfaces, for the insertion and removal of the piston rings, or for the actual removal of the metal to the finished thickness of the ring.

In order to overcome and eliminate these disadvantages and insufficiencies of the prior art practice, my invention contemplates a novel grinding machine, having two opposed grinding discs or wheels, having juxtaposed circular grinding surfaces which are substantially continuous and preferably without any indentations or apertures there-through, said grinding surfaces being placed at a slight angle to each other, at a suitable distance apart, so that the surfaces will diverge toward one point along the periphery thereof, so that the unfinished or rough piston ring may be freely inserted at that point, without separating the grinding wheels further to permit the insertion of the rings. Thus I may either provide two grinding or abrasive discs having slightly tapered or conical opposed surfaces, placed upon the juxtaposed ends of two axially aligned spindles whereby the opposed surfaces of said grinding wheels will converge slightly from the periphery thereof towards the center of rotation, so that the piston ring may initially be inserted between the two grinding discs at the diverged outer peripheral edge, and fed gradually towards the center, either by gravity or otherwise, as it is being reduced in thickness, by the abrasive action of the two opposed revolving grinding discs.

In lieu of the slightly tapered or conical discs, however, I may provide two grinding discs having perfectly plane opposed surfaces, in which case the shafts or spindles carrying the two discs are deflected or inclined slightly out of axial alignment with each other, so as to diverge the two opposed grinding surfaces slightly across a diameter of said discs. In this embodiment of my invention, the grinding surfaces will converge from one point along the periphery,

straight across the grinding surfaces, to a diametrically opposed peripheral point and the piston ring will then be inserted at the point of greatest divergence and will be fed between the grinding surfaces in a diametrical direction to the opposed point of greatest convergence, at which point they will be abraded to the desired finished thickness.

In another embodiment of my invention however, I may provide both an inclined spindle as well as a conical or tapered grinding wheel. By this latter embodiment of my invention, two juxtaposed, slightly conical or tapered rotating abrasive discs are mounted upon two spindles slightly inclined or slightly deflected from axial alignment with each other, so that in the plane of the deflection of the spindles, it is possible to incline the grinding surfaces with respect to each other on one side of the center of rotation, and maintain said grinding surfaces more or less parallel to each other in a diametrically opposed direction, on the opposed side of the center of rotation. Thus, in this embodiment of my invention the piston rings are inserted between the two grinding wheels at the peripheral point of greatest divergence of the two slightly conical and tapered abrasive discs, that is, at the point of divergence in the plane of deflection of the spindles, and the rings are then moved inwardly towards the center of rotation of the abrasive discs, in a diametrical or radial direction, as they are being reduced in thickness by the abrasive action. While so being ground down or reduced in thickness, the opposed edges of the piston rings may be slightly out of true parallel, that is, they will be tapered outwardly in a radial direction throughout their circumference, to the extent of the inclination of the two abrasive surfaces. However slight this taper may be, it is entirely eliminated as the piston rings pass the center of rotation of the grinding discs and pass between the two more or less parallel portions of the opposed grinding surfaces, that is, the portion on the other side of the center. In passing through the parallel portion of the grinding wheels, also in a radial or diametrical direction, they are ground down perfectly parallel, and plane, to the desired thickness, which is determined by the distance between the more or less parallel zone of the wheels. The piston rings then emerge at an opposed peripheral point, in perfectly parallel and finished condition.

One of the objects of my invention is to obtain great accuracy and uniformity in the parallel surfaces of machine elements, as for instance, piston rings, wrist pins, and the like, by causing the end-point of the final grinding, and hence the final finished dimension of the ground surface, to be determined by the final gravitational discharge of the

machine element from between two abrasive surfaces.

With the above ends in view, my invention consists of a suitable housing or frame, two pairs of juxtaposed journals mounted upon said housing and adapted for an axial movement for varying the distance between the grinding wheels or discs, and also adapted for two angular deflecting movements in two different planes at a right angle to each other, whereby the two opposed pairs of journals may be deflected with respect to each other in two different planes, from their normal and axially aligned positions, so as to place the two axes of the journals at any desired inclination to each other.

My invention further consists of a suitable pair of opposed spindles rotatably carried by the opposed pairs of journals, and suitable abrasive discs or wheels carried by the juxtaposed or inner ends of said spindles, and suitable means for revolving said spindles, such as pulleys, gears or the like.

My invention further consists of a pair of opposed abrasive discs or wheels carried by the inner or juxtaposed ends of said spindles, having two slightly conical or tapered juxtaposed abrasive surfaces, whereby said abrasive surfaces will diverge from the center outwardly, towards the peripheries, to a sufficient extent so that the unfinished ring may be inserted at the periphery. Such divergence or inclination may be further varied by the deflection of the axis of rotation of said spindles, by the means mentioned hereinbefore.

By positioning the two juxtaposed grinding surfaces at a suitable and slight inclination to each other, preferably with their axes of rotation slightly deflected out of alignment with each other, and with the lower halves of the discs more or less parallel with each other along a pair of radial elements, while the upper halves diverge towards the periphery, it is possible to insert the piston rings between the two opposed grinding surfaces, at the peripheral point of greatest divergence, and then to pass the ring in a diametrical direction towards the centers of the discs, thereby reducing the thickness thereof, and finally passing the ring outwardly towards the periphery, between the more or less parallel portions of the revolving abrasive discs, thereby finishing the opposed edges of the rings to true parallel planes. In the preferred practice of my invention, the rings are allowed to gravitate downwardly through the two revolving abrasive surfaces, by their own weight, until they are ground down to the desired finished thickness in between the lower and more or less parallel portions of the grinding surfaces. In the preferred practice of my invention, moreover, the grinding discs are revolved in opposite directions.

For the purpose of illustrating my inven-

tion, I have shown, in the accompanying drawings, forms thereof which are at present preferred by me, since they will give in practice, satisfactory and reliable results, although it is to be understood that the various instrumentalities of which my invention consists can be variously arranged and organized and that my invention is not limited to the precise arrangement and organization of these instrumentalities as herein shown and described.

Referring to the drawings,

Figure 1 represents a front elevation of a machine embodying my invention, illustrated in a diagrammatic manner.

Figure 2 represents a top plan view of the same.

Figure 3 represents a section on line 3—3 of Figure 2, on a greatly enlarged scale.

Figures 4, 5, 6 and 7 represent diagrammatic illustrations of the alternative manners of inclining the two grinding discs with respect to each other.

Figure 8 represents a section on line 8—8 of Figure 3.

Figure 9 represents a section on line 9—9 of Figure 3.

Figure 10 represents a novel arrangement of a series of machines of my novel construction, whereby the piston rings may be ground to successive dimensions and degrees of finish, through a series of successively graded machines, instead of by a single machine.

Figure 11 represents a similar arrangement or series of machines, whereby the piston rings may gravitate through the successive machines, without any mechanical conveying means.

Referring to the drawings, in which like reference characters indicate like parts, 1 designates a frame or housing of my novel machine, having two opposed horizontal and substantially similar upper circular beds 2 and 3, each having a corresponding central pivot socket 4 and 5 respectively, adapted to receive the corresponding pivot pins 6 and 7 respectively, of the corresponding turn-tables 8 and 9 respectively. Each of the two opposed turn-tables 8 and 9, is provided with suitable arcuate slots 10, centered about the corresponding pivot pins 6 and 7. The bolts 11 pass through the arcuate slots 10 and are threaded into circular beds 2 and 3 respectively, thereby rigidly to secure the rotatable turn-tables 8 and 9, in any desired adjusted position, that is, in any angularly inclined position with respect to each other.

Each of the turn-tables 8 and 9 is provided with a corresponding concaved arcuate tilting bed or surface 13 and 14 respectively, upon which are mounted the corresponding tilting heads 15 and 16 respectively, having corresponding convexed lower surfaces, seated upon said concaved beds. Suitable arcuate guide slots 17 and 18 respectively, are provided in the two corresponding tilting

beds 13 and 14, into which corresponding arcuate guide ribs 19 and 20 project, thereby to guide the tilting heads 15 and 16 upon the beds 13 and 14 respectively. Each of the tilting heads is also provided with the slots 21, through which the bolts 22 pass, which in turn are threaded into the tilting beds, thereby rigidly and fixedly to secure the two tilting heads 15 and 16 in any desired adjusted position.

Each of the tilting heads 15 and 16 in turn carries an upper dove-tailed or other suitable guide channel 23 and 24 respectively, extending horizontally and in alignment with each other in the normal positions, in which are slidably mounted the corresponding journal blocks 25 and 26 respectively, carrying the pairs of aligned and spaced journals 27 and 28, and 29 and 30 respectively. A pair of juxtaposed spindles 31 and 32 are rotatably mounted in the journals 27 and 28, and 29 and 30 respectively. Each of the spindles 31 and 32 carries a suitable pulley 33 and 34 respectively, adapted to receive a suitable belt or the like, (from countershafts not shown in the drawings, whereby the spindles may be suitably revolved, preferably in opposite directions, and the juxtaposed ends of the spindles carry corresponding opposed circular, grinding disc supports or holders 35 and 36 respectively. Each of the grinding disc supports or holders 35 and 36, comprises a circular disc shaped portion positioned at a right angle to the axes of the spindles, and centered with respect thereto, having the laterally and oppositely projecting peripheral flanges 37 and 38 respectively.

Grinding or abrasive discs 39 and 40 are secured to the holders or supports 35 and 36, in a manner shown particularly in Figure 3. Thus the grinding discs 39 and 40 are provided with annular V shaped flanges 41 and 42 at the rear surface thereof, and extending around the entire periphery. Split V shaped locking rings or retaining rings 43 and 44 are placed about and in locking engagement with, the flanges 41 and 42, and are in turn engaged by a series of screws 45, and extending through the plates 35 and 36 and threaded into said split rings 43 and 44, respectively. By this means, the grinding or abrasive wheels or discs 39 and 40 are brought up tightly against the flat inner surfaces of the supports or holders, and retained there rigidly. By this means, the abrasive discs are secured to the spindle ends, without the latter extending through the center of said grinding discs, thereby leaving the opposed surfaces of the abrasive discs entirely clear and free of any projection, or retaining means.

Each of the journal blocks 25 and 26 is provided with a downwardly projecting lug 46 and 47 respectively, having longitudinal threaded openings extending therethrough for the reception of the feed screws 48 and 49

respectively, which in turn are journaled in corresponding bearing openings 50 and 51 respectively, and to the outer ends thereof, corresponding hand wheels or handles 52 and 53 respectively, are secured. By this means, the journal blocks 25 and 26 may be moved longitudinally towards and away from each other, by merely revolving the handles 52 and 53 respectively, thereby to vary the distance between the grinding surfaces of the abrasive discs 39 and 40, as may be desired for regulating the finished thickness of the piston rings.

It will thus be seen from the foregoing that by the novel provision of the turn tables 8 and 9, and the tilting heads 15 and 16 mounted thereon, it is possible to deflect or incline the two spindles 31 and 32 at any desired angle with respect to each other, (within the limits of the machine), thereby to incline the opposed faces of the grinding discs at any desired angle with respect to each other. Thus by tilting the heads 15 and 16, the shaft or spindle 31 and 32 are deflected in a vertical plane, while by revolving the turn tables 8 and 9 respectively, the spindles 31 and 32 are deflected in a horizontal plane. When properly deflected the spindles may be fixed in the angularly adjusted positions, by the bolts 11 and 22 respectively, as pointed out hereinbefore. By the combination of the two angular adjustments, to wit, the vertical inclination and the horizontal inclination, the two spindles may be deflected in any plane intermediate the vertical and horizontal, and to any degree within the limits of the machine, as may be desired.

In Figures 1, 2 and 3, there are shown the preferred type of grinding discs or wheels, having the opposed surfaces thereof of a slightly conical shape, indicated diagrammatically in Figures 5 and 7. Thus, the opposed surfaces 55 and 56 are each tapered outwardly from the center or axis of the discs, to a suitable degree, so that the two discs when placed upon aligned axes, will diverge from the centers towards the peripheries of the two opposed grinding surfaces, whereby it is possible to insert the piston rings to be ground, without separating the grinding surfaces for the operation of insertion, but merely inserting them at the periphery where they are more distant, and then allowing the piston rings to be fed or moved towards the center of rotation, of the converging surfaces, as the thickness of the rings is being reduced by the abrasive action of the two grinding surfaces.

The amount of taper necessary between the two opposed grinding surfaces depends primarily on the amount of metal necessary to be removed from the opposed edge surfaces of the piston ring, and upon the diameter of the grinding discs or wheels. It will thus be seen that with abrasive discs or wheels of

approximately 20 inch diameters, and with the amount of metal to be removed approximately ten to fifteen thousandth of an inch, more or less, the amount of inclination used will be but very slight, to wit, possibly fifteen to twenty thousandth of an inch between the outer periphery at the point where the piston rings are inserted between the abrasive discs, and the points where the discs approach each other the closest, to wit, where the distance is substantially equal to the thickness of the finished ring.

Considering first the embodiment of my invention, that is, the modification shown in Figures 1, 2 and 3, and Figures 5 and 7, there are shown grinding discs or abrasive wheels, having slightly tapered or conical grinding surfaces 55 and 56 respectively. In employing this modification it is possible so to adjust the inclination of the two spindles 31 and 32, as to bring the maximum inclination between the abrasive surfaces, entirely on one side of the abrasive discs. Thus, with the spindle 32 in the neutral and horizontal position, shown in Figure 5, the spindle 31 may be tilted or deflected from its normal position until the lower portions of the conical discs are entirely parallel to each other. It is preferred however, to tilt or deflect both the spindles 31 and 32, each to half the extent, as indicated in the diagram in Figure 7. In this manner, it will thus be seen, that while the upper halves of the two opposed grinding surfaces in the plane of deflection of the spindles, diverge towards the periphery, the lower portions thereof, in the same plane, are entirely and perfectly parallel. Thus by inserting the piston ring at the upper or diverged peripheral edges of the abrasive discs, they will be ground down to the desired thickness, while moved from the outer periphery towards the center of the revolving grinding discs, and will be finished to the exact desired thickness and will be finished moreover perfectly parallel as they pass through and between the lower more or less parallel halves of the two revolving grinding discs.

Since the amount of divergence of the grinding surfaces is slight, relative to the diameters of the opposed abrasive surfaces, it is quite feasible and possible to produce substantially parallel opposed edge surfaces on the piston rings, by two inclined or slightly diverged grinding surfaces as shown in Figures 4 or 6. In this modification the surfaces of the grinding discs are not tapered or conical, but are perfectly plane, and the amount of divergence necessary at the point of insertion of the rings is obtained entirely by the inclination of the grinding surfaces, by the tilting of the axes, of the spindles 31 and 32. Thus, in Figure 4 there is shown an arrangement whereby one of the axes 31 is alone tilted or deflected while in Figure 6

both axes are tilted or deflected, to one half of the extent however, in order to obtain the necessary divergence at the upper, or point of insertion of the ring.

It will be observed that by passing the ring through and between the two opposed grinding surfaces of the revolving abrasive discs 39 and 40, there is a tendency for the piston rings to revolve constantly, due to the slight differences in the force exerted upon the edges of the ring by the two grinding surfaces. This revolving action on the piston rings is also accentuated and increased by feeding or passing the piston rings in a line slightly off a true diametrical direction, that is, slightly off the center of the abrasive discs. It is partly due to this constant rotation of the piston rings, as they pass through and between the two juxtaposed revolving abrasive surfaces, that the rings are ground uniformly throughout their entire circumferences.

Referring to Figures 1, 2 and 3, and 9, there is shown a novel arrangement whereby the piston rings may be fed through and between the two opposed grinding surfaces 55 and 56 of the grinding wheels 39 and 40. Thus a series of aligned piston rings 58 are positioned in a substantially horizontal stack in a horizontal, or substantially horizontal trough or guide channel 59. One end of the trough is in substantial vertical alignment with the grinding surfaces of the abrasive wheels and has secured thereto, a transverse guide 60, having a bottom 61 and two parallel side plates 62, spaced from each other at a distance substantially equal to the thickness of the unfinished ring, so that but a single ring can pass between the plates 62. A pair of suitable feeding arms 63, supported upon a shaft 64, are provided for the purpose of forcing the individual rings from the stack 58 into the transverse guide 60. A handle 65 is provided on the shaft 64 for the purpose of revolving said shaft and thereby to feed the individual rings into the transverse guide 60.

The side plates 62 of the transverse guide 60, are continued downwardly in the supporting plates 66, to which are adjustably secured the upper terminals of a pair of guide strips 67, of a thickness somewhat less than that of the finished piston rings, so that they will clear the abrasive discs, when placed between the two grinding surfaces 55 and 56, without being affected by said grinding surfaces. The distance between the two guiding strips is adjusted or controlled by any suitable means, such as the series of openings 68 in the plates 66. The guide-strips 67 may thus be secured rigidly in any desired adjusted position to suit the diameter of the particular size ring, by means of the two screws or the like 69, passing through the two plates 66, as indicated particularly in Figures 1, 2,

3 and 9. The lower terminals of the guide-strip 67 are similarly secured to a lower transverse supporting member 70, which is rigidly secured to the frame, so that the two guide-strips may be maintained rigidly and parallel to each other against the dislodging force of the grinding surfaces upon the ring, tending to carry the rings out of the linear path between the two parallel guide strips 67. By means of the guide strips 67, the piston rings are fed through and between the two grinding surfaces 55 and 56 in a straight path from the upper peripheral point of insertion to the lower peripheral point of discharge of the rings, substantially diametrically opposed to it, and the rings are preferably passed in a generally downward direction, so that the piston rings will be urged toward the peripheral discharge point of the grinding wheels, by gravity.

In Figure 9, the guiding strips 67 are shown arranged substantially symmetrically with respect to the axis of the spindles although the guiding strip may be offset a slight distance from the symmetrical arrangement shown. By offsetting the guide strips 67, an additional rotary motion is imparted to the piston rings, as they travel downwardly between the two revolving grinding surfaces, thereby producing a more uniform and finer finish throughout the circumference of the edges of said rings.

It will thus be seen, that by my novel construction it is possible to pass a series of piston rings through and between a pair of opposed rotating grinding surfaces, in a continuous and uninterrupted manner, without changing the distance between the grinding surfaces for the insertion and removal of the piston rings. This, as brought out hereinbefore, is made possible by the slight divergence of the two grinding surfaces towards the point of insertion of the ring. Thus, in any one of the several modified arrangements indicated diagrammatically in Figures 4 to 7 inclusive the farthestmost point of the two grinding surfaces is at the point of insertion of the ring. By the provision of the slightly conical or tapered grinding wheels it is possible moreover to have the grinding surfaces perfectly parallel at the bottom, while the top halves of the wheels diverge, as shown in Figures 5 and 7.

The degree of inclination between the two grinding surfaces may, in any instance, be reduced somewhat by suitably beveling the opposed peripheral corners of the grinding discs or wheels, so as to facilitate reception and grinding of machine elements which may be of slightly greater initial dimension.

Since by my novel construction, the individual manual insertion and removal of the rings is thus entirely eliminated, I am enabled to coordinate a plurality of grinding machines of this type in what may be called

a "series" arrangement, to wit, I am enabled to pass a continuous series of piston rings through successive and aligned machines, each adapted to remove successive amounts of metal and thus to reduce the rings to successive thicknesses.

Thus, the maximum amount of metal should be removed in the first or second machine, allowing the last machine to remove but a very slight amount of metal, thereby producing a more accurate and more finely finished ring.

Two arrangements of this type, are shown in Figures 10 and 11 respectively. Thus, in each of these figures there are shown three machines, designated by the numerals 72, 73 and 74, illustrated merely in a diagrammatic manner, without reference to the detail construction thereof. In the modification shown in Figure 10, there is arranged on top of the machine 72, the feeding device 75 of substantially the same nature as that shown in Figures 1 to 3 inclusive, together with the guide strips 67. The rings 58 are fed into the guide strip 67 in the usual manner and gravitated through the abrasive wheels of the first machine. Here they are guided by another suitable lower guide 76 onto a suitable continuous bucket conveyer 77 of any desired construction, which raises the individual rings and places them onto a second guide 78. From there, the piston rings again gravitate down through and between the two revolving abrasive discs of the second machine, guided by the guide strips 67. A similar guide 79 guides the rings onto a second conveyer 80, which delivers the rings onto the guide 81 at the top of the last or finishing wheels of the machine 74.

In the arrangement illustrated in Figure 11, the successive sets of revolving grinding discs 81, 82, and 83 as well as their respective mountings and spindles etc. are positioned at successive levels, so that their successive centers of rotation or axes of rotation, will be positioned in substantial alignment with each other along an inclined line, as will readily be seen from Figure 11. By this arrangement it is possible to provide substantially continuous guiding means, such as the guide strips 84 and 85, and the side guide plate 86, arranged in a substantially continuous manner, through the successive grinding wheels, so that the piston rings 58 may gravitate through the successive grinding wheels in a continuous and uninterrupted manner without the intervention of any mechanical feeding or conveying devices.

It is to be understood that in the drawings accompanying this description there have been illustrated merely schematic showings of the embodiment of my invention and chiefly in a diagrammatic manner, and the machine is, therefore, not limited to the exact arrangement of elements as shown in these

figures. Thus, for instance, in the two arrangements of successive sets of grinding wheels shown in Figures 10 and 11, it is quite feasible and practicable, and possibly more desirable to build the successive sets of grinding wheels upon a single frame, that is, to build them into one machine, rather than into successive independent machines as shown in the drawings. This, it is understood, will not in any way depart from the spirit of the invention disclosed in these figures.

Thus, also, in Figures 1, 2, 3, 8 and 9, the means shown for adjusting the distance between the grinding wheels or abrasive surfaces, that is, the slide and the screw feed therefor have been merely illustrated in a somewhat diagrammatic and conventional manner, it being understood that in the finished embodiment of this invention, such means may be altered to suit practical requirements without departing from the spirit of the invention. Similarly, diagrammatic means have been merely shown for obtaining the two angular adjustments of the axes of the spindles.

It will thus be seen, that gravitating the machine elements to be ground, through and between two abrasive surfaces more or less inclined with respect to each other, with frictional contact being maintained between the machine element and the opposed abrasive surfaces against the force of gravity,—the grinding end-point or the limit of grinding is determined, and the finished dimension of the work is likewise determined by the gravitational force on the work or machine element overcoming the frictional grip of the grinding surfaces on said work or machine element. This determination of the grinding end-point, and hence of finished dimension, by the gravitational discharge of the work against the frictional grip of the abrasive surfaces is particularly desirable in the final or finish grinding of machine elements which must be very accurate and uniform.

My present invention may be embodied in other specific forms and is susceptible of variations and changes without departing from the spirit or essential attributes thereof, and I therefore desire the present embodiments of my invention to be considered in all respects as illustrative rather than restrictive;—reference being had to the appended claims rather than the foregoing description to indicate the scope of the invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The method of finishing opposed plane parallel surfaces of machine elements, such as piston rings or the like, which consists in maintaining such elements between and in abrasive contact with two opposed, operatively inclined and oppositely revolving abra-

sive surfaces extending transversely of their axes of rotation, while gravitating said elements from one peripheral point of said abrasive surfaces to another, in the general direction of the convergence of said surfaces.

2. The method of finishing opposed plane parallel surfaces of machine elements, such as piston rings or the like, which consists in successively maintaining such elements between and in abrasive contact with successive sets of two opposed, operatively inclined and oppositely revolving abrasive surfaces extending transversely of their axes of rotation, while gravitating said elements from one peripheral point of said abrasive surfaces to another, in the general direction of the convergence of said surfaces; said successive sets of opposed inclined abrasive surfaces being spaced successively closer.

3. A grinding machine including, in combination, a pair of revolubly mounted abrasive members, each having a relatively imperforate effective surface extending transversely of its axis of rotation, said pair of effective surfaces being in juxtaposition and operatively inclined to each other in a generally radial direction and to a suitable degree, with the most distantly spaced peripheral points of said effective surfaces positioned higher than the most closely spaced peripheral points thereof, and a pair of generally parallel spaced, stationary guides disposed between said abrasive members to form a fixed passageway therebetween for the objects to be ground, with the receiving end of said passageway positioned higher than the discharge end thereof, to guide said objects in abrasive contact with said juxtaposed and gradually converging effective surfaces.

4. A grinding machine comprising a pair of revolubly mounted abrasive members, having a pair of juxtaposed effective surfaces in spaced relation to each other, extending transversely of their axes of rotation, said pair of effective surfaces being operatively inclined with respect to each other, and means for maintaining the objects to be ground, between and in abrasive contact with said pair of operatively inclined effective surfaces and conveying them by gravity in the general direction of their convergence, from one peripheral point of said effective surfaces to another.

5. A grinding machine including, in combination, a pair of revolubly mounted abrasive members, each having a relatively imperforate effective surface extending transversely of its axis of rotation, said pair of effective surfaces being in juxtaposition and operatively inclined to each other in a generally radial direction and to a suitable degree, with the most distantly spaced peripheral points of said effective surfaces positioned higher than the most closely spaced peripheral

points thereof, a pair of generally parallel spaced, stationary guides disposed between said abrasive members to form a fixed passageway therebetween for the objects to be ground, with the receiving end of said passageway positioned higher than the discharge end thereof, to guide said objects in abrasive contact with said juxtaposed and gradually converging effective surfaces, and means for revolving said abrasive members in opposite directions.

6. The method of finishing opposed surfaces of machine elements, which consists in maintaining such machine elements between and in abrasive contact with two inclined and oppositely revolving abrasive surfaces extending transversely of their axes of rotation and generally constantly spaced from each other, while gravitating said elements from one peripheral point of said abrasive surfaces to another peripheral point thereof, generally in line with the inclination of said surfaces, and causing said elements to be discharged when the gravitational force on the same overcomes the frictional grip of the abrasive surfaces upon the same, and determining the end-point of the grinding operation by such gravitational discharge.

7. The method of finishing opposed surfaces of machine elements, which consists in successively maintaining such elements between and in abrasive contact with successive sets of two inclined and oppositely revolving abrasive surfaces extending transversely of their axes of rotation and being generally constantly spaced from each other, while gravitating said elements from one peripheral point of said abrasive surfaces to another peripheral point thereof, generally in line with the inclination of said surfaces, and causing said elements to be discharged from between two inclined and oppositely revolving abrasive surfaces, when the gravitational force on the same overcomes the frictional grip of the abrasive surfaces upon the same, and determining the end-point of the grinding operation, and hence the ground dimension, of the finished machine element by such gravitational discharge; the effective distance between the two abrasive surfaces of the successive sets being successively less.

8. A grinding machine including, in combination, a pair of revolubly mounted abrasive members, each having a relatively imperforate effective surface extending generally transversely of its axis of rotation, said pair of effective surfaces being in juxtaposition and being inclined to each other in a generally radial direction, with the direction or line of inclination being at an angle with respect to the horizontal, means for maintaining said effective abrasive surfaces in generally constant spaced relation to each other while the machine is in operation, a pair of

- generally parallel spaced, stationary guides disposed between said abrasive members to form a fixed passageway therebetween for the objects to be ground, said pair of generally parallel, spaced stationary guides being arranged generally in line with the direction or line of inclination of said abrasive members and at an angle with respect to the horizontal with the receiving end of said passageway positioned higher than the discharge end thereof, to guide said objects in abrasive contact with said juxtaposed and inclined abrasive surfaces, said grinding machine being so arranged that the objects to be ground are discharged from between the two abrasive surfaces by gravity when the object to be ground has been ground to the desired and predetermined dimension, which is attained when the gravitational force upon the object overcomes the frictional grip of the abrasive surfaces upon the same. 70
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9. A grinding machine comprising a pair of revolubly mounted abrasive members, having a pair of opposed effective surfaces in predetermined and generally constant spaced relation to each other, extending transversely of their axes of rotation, said pair of effective surfaces being slightly inclined with respect to each other, means for maintaining the objects to be ground between and in abrasive contact with said pair of inclined surfaces, and for conveying them by gravity in the general direction of their inclination from one peripheral point of said effective surfaces to another peripheral point thereof, and for causing the automatic discharge of the ground object from between the opposed abrasive surfaces when the gravitational force upon the object overcomes the frictional grip of the abrasive surfaces upon the same, and for determining the end-point of the grinding operation by said automatic discharge. 80
10. A grinding machine, including, in combination, a pair of revolubly mounted abrasive members, each having a relatively imperforate effective surface extending transversely of its axis of rotation, said pair of effective surfaces being opposed and in a generally constant spaced relation to each other, and being inclined with respect to each other in a generally radial direction and to a suitable degree, with the direction of inclination being at an angle to the horizontal, a pair of generally parallel, spaced stationary guides disposed between said abrasive members to form a fixed passageway therebetween for the objects to be ground, with the receiving end of said passageway positioned higher than the discharge end thereof, to guide said objects in abrasive contact with said opposed and inclined abrasive surfaces, said grinding machine being so arranged that the objects to be ground are discharged from between the 85
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