Feb. 19, 1952 W. G. BALDENHOFER 2,585,990

METHOD OF GRINDING INTRICATE CONTOURS

Filed Sept. 8, 1947 3 Sheets-Sheet 1

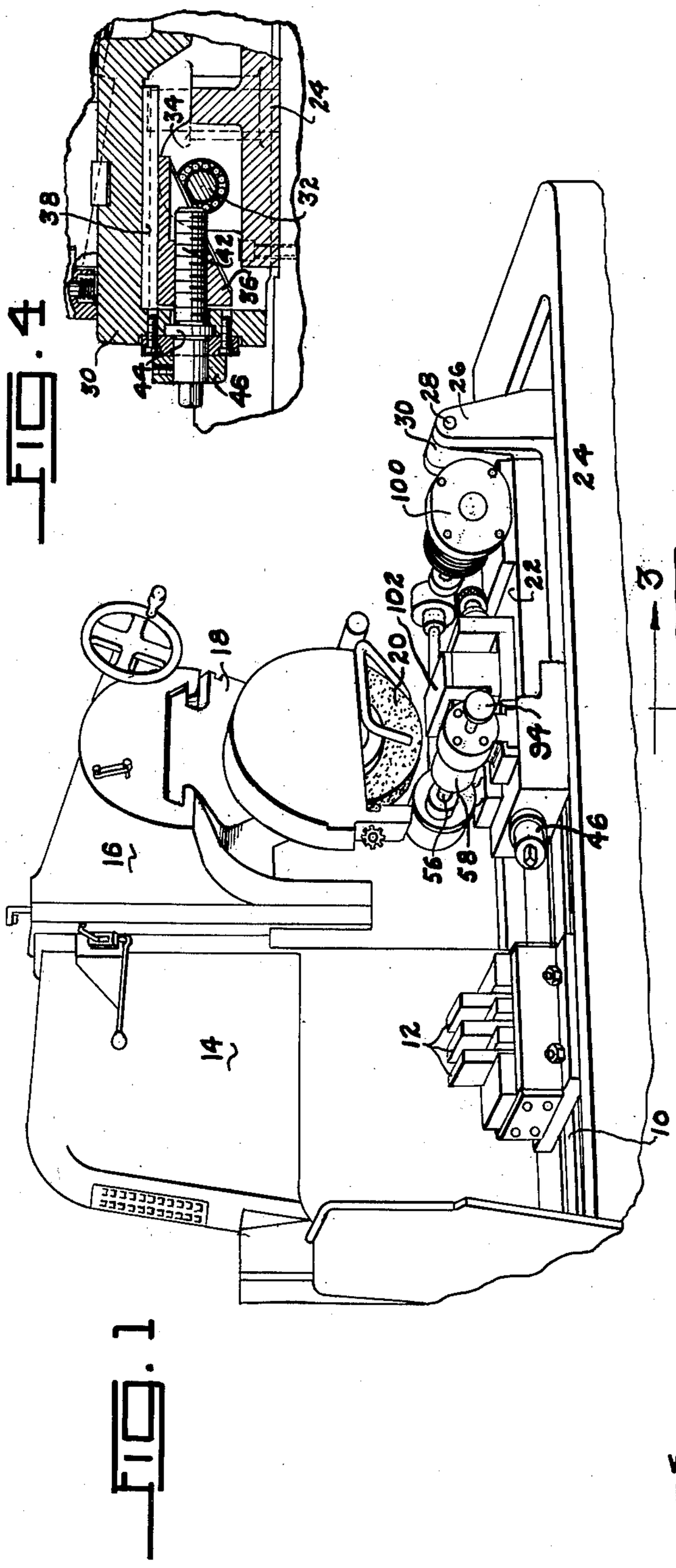

FIG. 1

FIG. 4

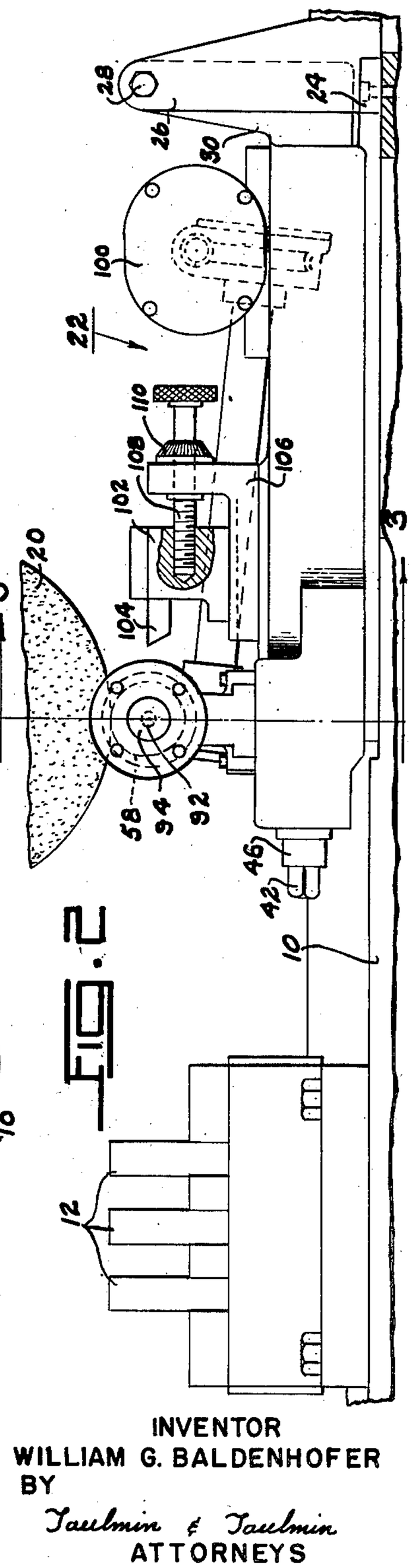

FIG. 2

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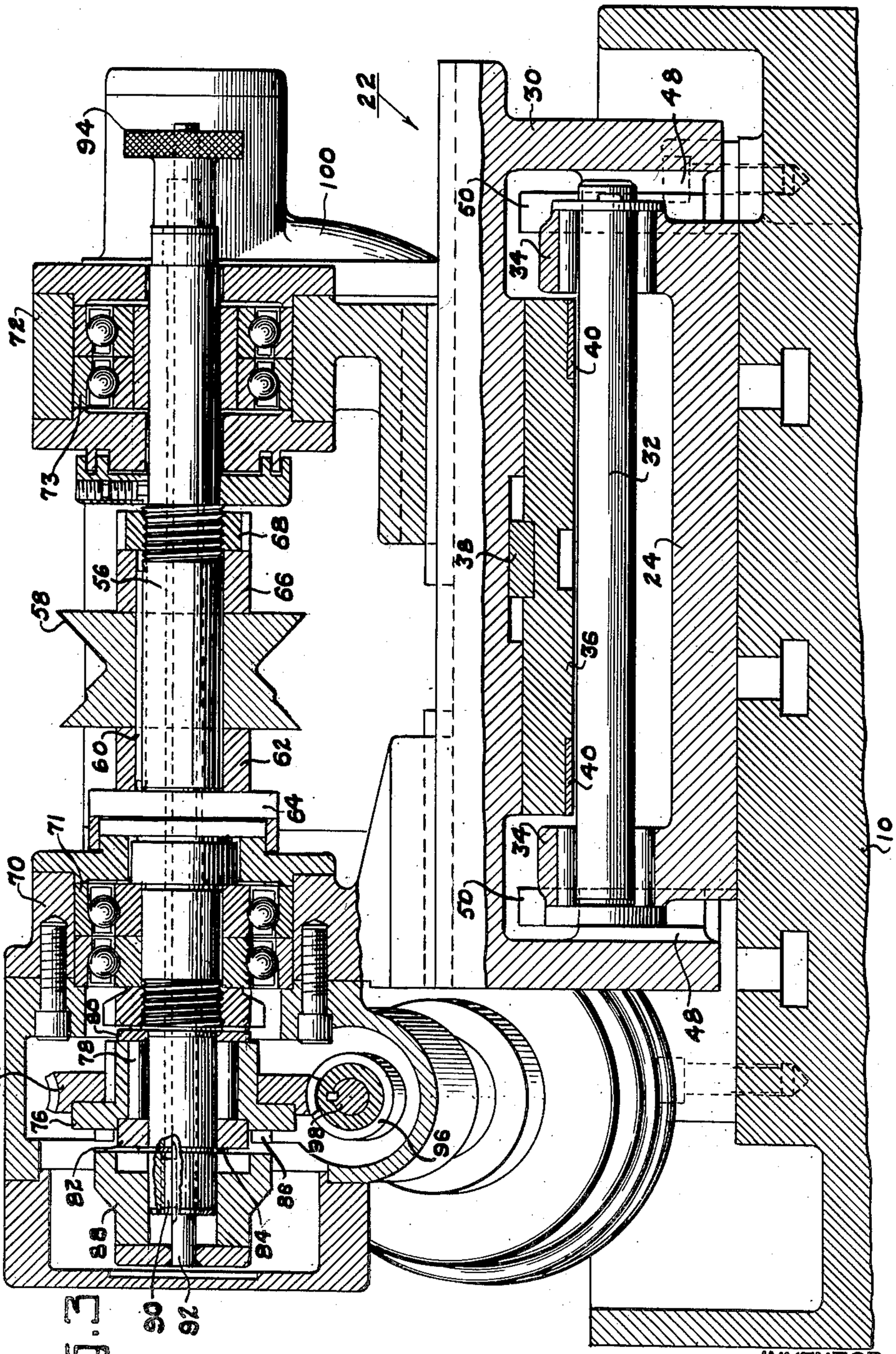

FIG. 3

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FIG. 5

STEP 1
FORM ROLL BY TOOL OF SHAPE TO BE MADE

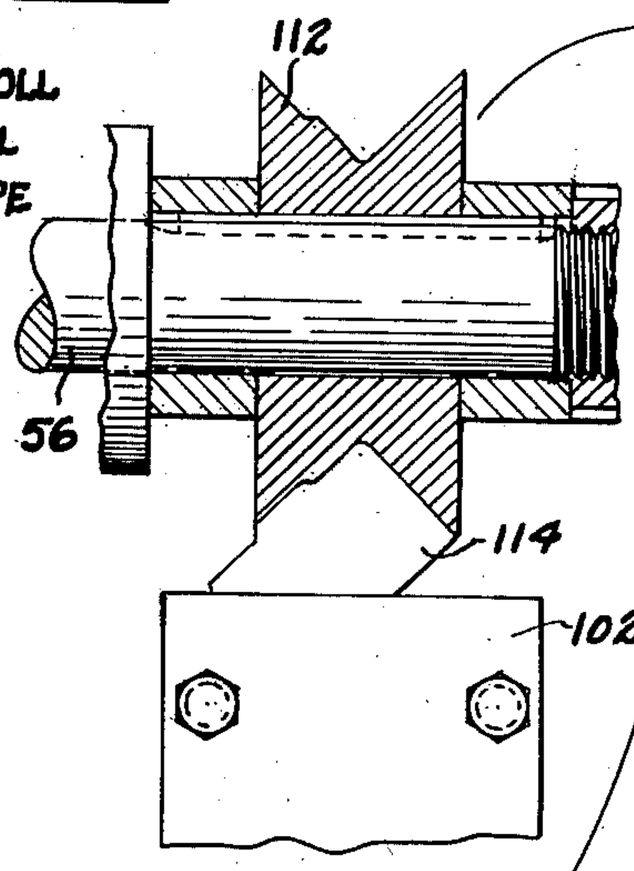


FIG. 6

STEP 2
USE ROLL MADE IN STEP 1 TO CRUSH FORM WHEEL

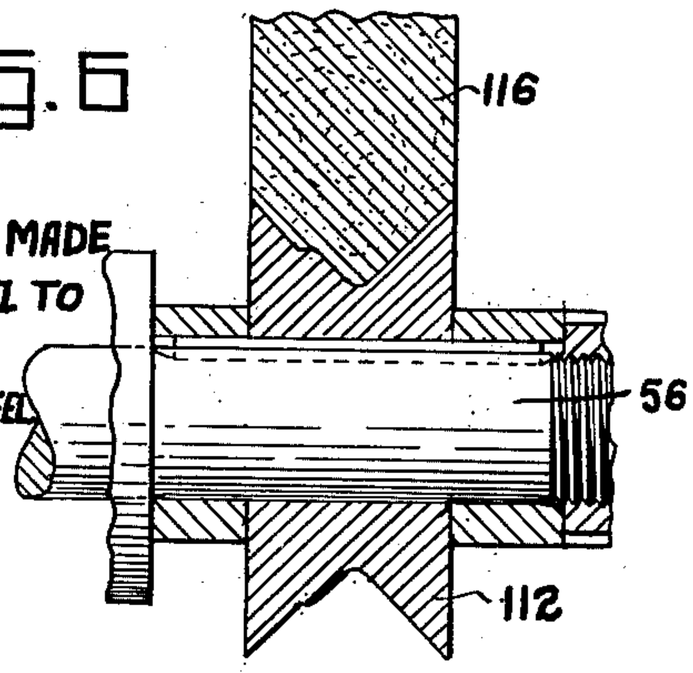
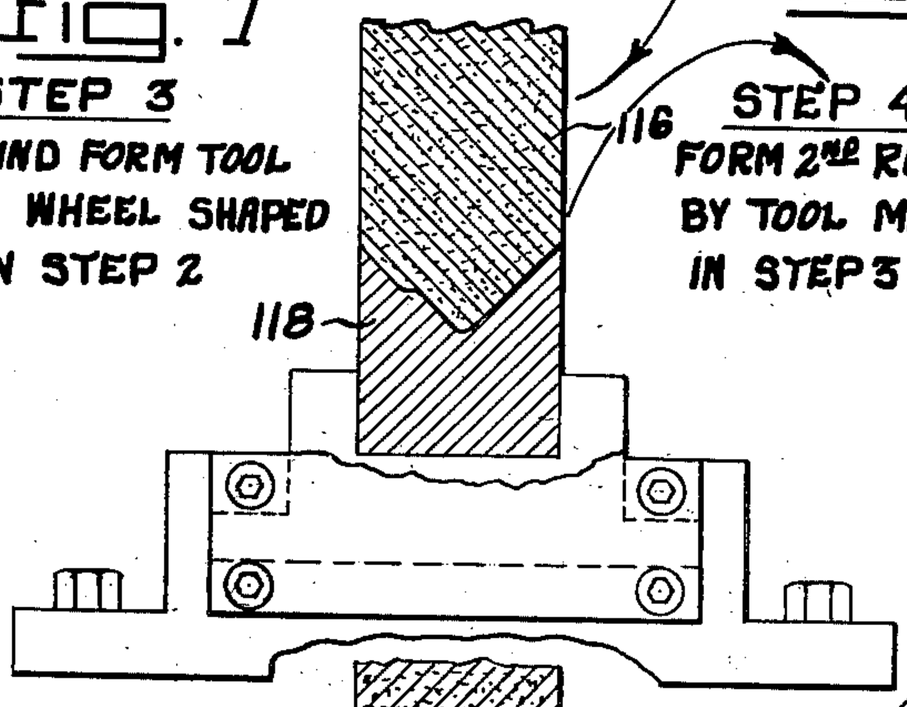


FIG. 7

STEP 3
GRIND FORM TOOL BY WHEEL SHAPED IN STEP 2



STEP 4
FORM 2ND ROLL BY TOOL MADE IN STEP 3

FIG. 8

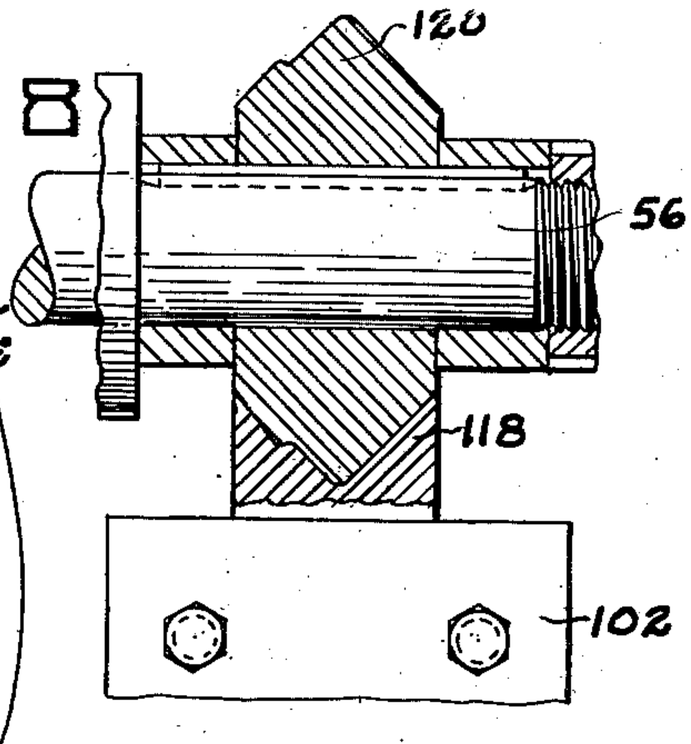


FIG. 9

STEP 5
CRUSH FORM A 2ND WHEEL BY ROLL MADE IN STEP 4

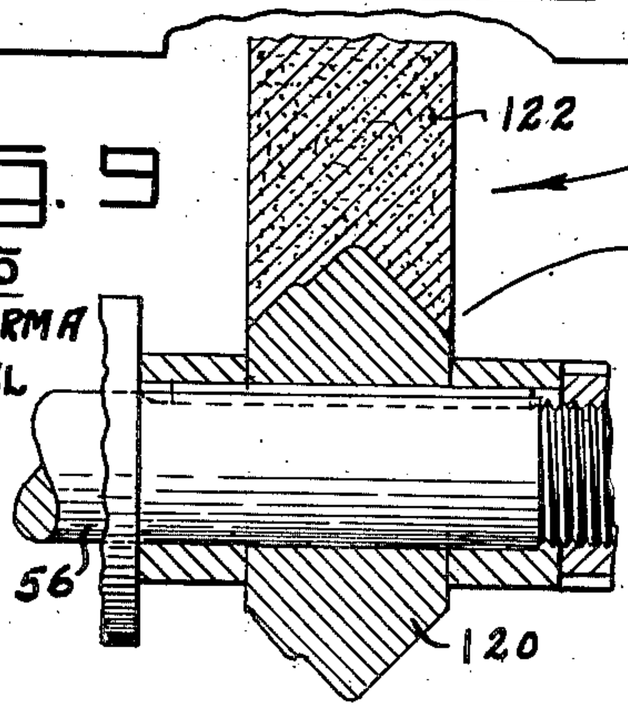
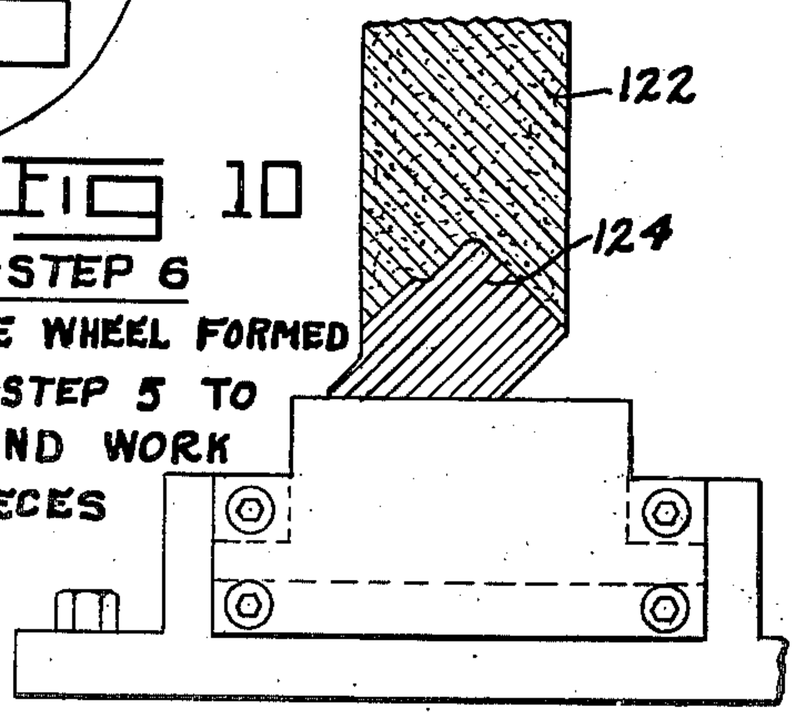


FIG. 10

STEP 6
USE WHEEL FORMED IN STEP 5 TO GRIND WORK PIECES



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METHOD OF GRINDING INTRICATE CONTOURS

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Application September 8, 1947, Serial No. 772,605

5 Claims. (Cl. 125—11)

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This invention relates to grinding machines, and particularly to methods and apparatus employed in connection with grinding machines for producing intricate contours.

In the forming of intricate contours, as for example, form tools for certain types of turning work, the most practical procedure is to shape these members by a grinding process. Examples of tools of this type will be found in the art of manufacturing crankshafts and other automotive workpieces.

Tools of this type are usually required in great number and must be maintained in high production and, accordingly, tools for such parts must likewise be produced in quantity. Thus, it is customary for the manufacturers to carry a rather heavy inventory of forming tools of this type in order to prevent any curtailment of the production of the workpieces being formed thereby.

It is customary in forming tools of this type to produce them by grinding, and generally by truing a grinding wheel to the shape of a small portion of the form and producing the entire tool by a series of grinding operations with frequent reshaping of the grinding wheel and relative movement between the tool and wheel. The entire contour of the tool is thus reproduced thereon.

This method of producing form tools, especially those which are intricately shaped, is slow and expensive. Furthermore, due to the fact that only a small part of the tool is ground at a time, the accuracy of the finished tool is often not as great as desirable.

Tools of this nature can be formed to highly accurate dimensions and with reasonable rapidity by using a grinding wheel having a width at least equal to the surface of the tool to be ground, and shaping the periphery of the wheel to be complementary to the configuration of the form tool being operated thereby.

This method of producing the tools is rapid and relatively inexpensive and produces workpieces accurate within close limits. The best method of shaping a wheel for an operation of this type is by crush forming with a roll. However, the forming of a wheel requires the use of an accurately shaped roll having a cross-sectional configuration equivalent to that of the workpiece which is to be formed. Heretofore it has been necessary to form the rolls for dressing the grinding wheel to the proper shape by slow and expensive processes similar to the process mentioned above in connection with former processes for producing the finished form tools.

The particular object of the present invention is to provide an improved method whereby form tools of intricate contours can be inexpensively and rapidly produced by a process utilizing the technique of crush forming a grinding wheel.

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It is a further object of this invention to provide a method of reproducing form tools and the like having intricate contours whereby the said tool or article can be made or duplicated from an existing tool having the same configuration.

It is a further object to provide an improved apparatus for grinding workpieces to intricate contours and utilizing crush forming of the grinding wheel.

It is also an object to provide an apparatus for forming grinding wheels to intricate configurations and including means for generating intricate contours on crushing rolls to be employed in the shaping of the grinding wheel.

These and other objects and advantages will become more apparent upon reference to the following description taken in connection with the accompanying drawings in which:

Figure 1 is a perspective view showing a typical grinding machine having a dressing and roll forming apparatus according to this invention mounted on the table thereof, and adapted for practicing the methods of this invention;

Figure 2 is a somewhat enlarged view of a part of the machine looking from the operator's side thereof;

Figure 3 is an enlarged transverse section indicated by the line 3—3 on Figure 2 and showing details in connection with the driving and supporting of the dressing roll;

Figure 4 is a fragmentary view showing an adjustment for adjusting the elevation of the dressing roll relative to the grinding wheel; and

Figures 5 through 10 are views of successive steps in a dressing and grinding cycle according to this invention.

Referring to the drawings, Figure 1 illustrates a grinding machine having a table 10 which is adapted for supporting workpieces to be ground as at 12. The machine also incluudes a column 14 which reciprocably mounts a saddle 16 that carries the wheel head 18. A grinding wheel at 20 is journaled in the wheel head 18 and is driven by any suitable motor means. Also mounted on the table 10 of the machine is the dressing and roll forming fixture of this invention as at 22.

Referring to Figures 2 and 3 it will be seen that the fixture 22 comprises a first bed part 24 which is rigidly secured to the table 10 and which includes an upstanding part at one end as at 26 which provides a transverse pivot shaft 28. Supported on the pivot shaft 28 is a second bed member as at 30 which extends along and substantially parallel with the bed 10. The left end of the upper bed member 30, as viewed in Figure 2, is supported on a shaft 32 which is journaled in a pair of upstanding flanges 34 at the left end of the stationary or a sub-bed 24.

Relative angular adjustments between the beds is accomplished by the wedge shaped shoe 36

which is mounted on the underneath side of the upper bed **30**, and guided thereon as by the key **38** and which is positioned between the bottom of the bed **30** and the shaft **32**. Preferably, the shoe **36** includes the wear plates **40** which engage the shaft **32**.

Adjustment of the shoe **36** longitudinally of the bed **30** in order to vary the relative angularity of the beds and thereby to adjust the elevation of the dressing roll carried by the upper bed is accomplished by means of the screw **42** which engages the shoe **36** and which is mounted in the end of the bed **30** as shown in Figure 4.

It will be evident that the screw can be rotated relative to the bed but is held against axial movement therein by means of the collar **44**. Means may be provided for determining the amount of adjustment given the bed **30** by placing suitable indicia on the collar **46** attached to the screw **42** if so desired.

In order to insure that the bed **30** will move exactly vertically relative to the bed **24**, one of the beds may be provided with machined flats or pads as at **48** which bear against flat keys as at **50** provided on the other of the said beds. This arrangement prevents any lateral movement of the end of the bed **30** remote from the pivot shaft **28**.

Mounted on the upper surface of the bed **30** on the left end thereof is a shaft **56** which is adapted for mounting the dressing roll **58** which is locked against rotation on the shaft as by a key **60** and which is held against axial movement relative to the shaft by the sleeve **62** which abuts the enlarged portion **64** of the shaft on one side of the said roll and by the sleeve **66** which is abutted by the nut **68** threaded to the shaft on the other side of the said roll.

The ends of the shaft **56** are suitably supported in the bearing boxes **70** and **72** on anti-friction bearings **71** and **73** according to individual preference.

The shaft **56** is adapted for being selectively driven or being rotatable idly in its said supporting bearings, by means of an arrangement shown at the left end of the said shaft in Figure 3. This arrangement comprises a worm wheel **74** mounted on a member **76** that is journaled on the shaft **56** as by the roller bearings **78**. The worm wheel **74** and member **76** are retained in position by a washer **80** at one side thereof, and by a collar **82** and snap ring **84** at the other side thereof. The member **76** includes clutch teeth as indicated at **86** which are engageable with corresponding teeth on a clutch member **88** slidably carried at the extreme left end of the shaft **56**. The member **88** is keyed to the shaft by the keying means indicated at **90** in Figure 3 and is selectively movable into or out of engagement with the clutch member **76** by means of the drawbar **92** extending completely through the shaft **56** and terminating in the knurled knob **94**. This arrangement permits the knurled knob **94** to be placed at the operator's side of the dressing fixture while the more bulky drive and clutch mechanism is positioned at the back of the fixture.

The worm wheel **74** meshes with a worm gear **96** carried on a shaft **98** that extends toward the pivot end of the bed **30** to be drivingly engaged by the output shaft of a geared head motor **100**.

According to this invention means are provided for shaping rolls mounted on the shaft **56** and this is preferably accomplished by a fixture **102** adapted for mounting the forming tool **104** and being movable toward and away from the axis of the said roller by its mounting on a bed member **106**. A screw **108** is preferably provided which may be rotated for positioning the fixture **102**. Graduations may be provided at **110** on the shaft **108** for determining the exact positioning of the fixture **102** if desired.

According to the process of reproducing intricate contours as proposed by this invention, a form tool is placed in the fixture **102** and a dressing roll is shaped thereby by bringing the tool into position to bear against the periphery of the said roll and then by driving the shaft **56** through engagement of the clutch members **76** and **88**. At this time the tool acts as a shaving member and shaves material from the periphery of the roll until its shape exactly conforms to that of the forming tool.

In most instances when it is desired to reproduce a contour, there will be a previously made form tool available. While such a tool may be worn to the point where it is not suitable for production processes it will nevertheless be adequate for shaving a roll to shape for the purposes of the present invention. Also, the shape which the roll will be formed to will be accurate since the shape of a form tool is generally the same through its thickness.

The steps mentioned above are shown in Figure 5 of the drawings wherein a roll **112** is being shaped by a form tool **114** which may be a tool taken from a production machine. The tool **114** is clamped in the fixture **102** and urged against the periphery of the roll **112** while the roll is driven by the shaft **56**.

After the roll **112** has been formed to the proper shape, it is utilized for crushing a grinding wheel **116** to shape as shown in Figure 6. It will be apparent that the outline of the grinding wheel is the same as the outline of the form tool **114**.

After the wheel **116** has been formed by the roll **112** it is utilized for grinding one or more tools **118** to shape as shown in Figure 7. These tools are preferably mounted as the workpieces are mounted at **12** in Figure 1. The tools **118** are form tools of the standard type, or are particularly shaped to be employed as shaving members.

After the tools **118** have been ground to shape, one thereof is then mounted in the fixture **102** as shown in Figure 8 and is employed for shaving another crushing roll **120** to shape. The crushing roll **120** is mounted on shaft **56** and is driven thereby as the roll **112** in Figure 5.

After the roll **120** has been properly shaped, it may be employed to crush a grinding wheel as shown in Figure 9. The grinding wheel in Figure 9 is indicated at **122** and it will be observed that its configuration is complementary to that of the roll **120**.

The final step in reproducing a contour is indicated in Figure 10 wherein the wheel **122** is grinding one or more form tools **124** to the proper configuration.

It will be apparent that the tools **124** carry exactly the same shape as the original tool **114** and may therefore be utilized in the same production process from which the tool **114** is taken.

The wheel **122** may be maintained by the roll **120** which does not need to be removed from the shaft **56** once it is mounted thereon, while the said roll may be maintained by the shaving tool **118** which, likewise, does not need to be removed from the fixture **102**.

The operations shown in Figures 5, 6 and 7 may be performed in the fixture **22** if desired, but it will be understood that a separate machine could

be utilized for these steps if desired while retaining the carrying out of the final steps shown in Figures 8, 9 and 10 on the production machine on which the final product is produced.

It will be seen that the method and apparatus according to this invention are particularly well adapted for use by manufacturers having production processes which require the use of form tools.

Essentially the method outlined in this application is that of utilizing an old form tool for shaping a crushing roll; thereafter using the roll so shaped to form a wheel; grinding a second form tool by the wheel so shaped; shaving still another crushing roll to the proper configuration by the tool last ground; and forming a grinding wheel by the last mentioned roll. The grinding wheel dressed by the said last mentioned roll can then be utilized for reproducing the contour of the original form tool.

While the preferred method of this invention utilizes an original form tool retired from a production operation, or taken therefrom, it will be understood that the original tool could be produced on an accurate tool grinding machine from a master layout or part print if desired. In either case an exact duplicate of the original form tool can be made because tools of this nature are not form relieved, being of the same configuration completely through their thickness. Thus, in utilizing a tool of this type, if the tool becomes worn, it can be restored to its original configuration by grinding a predetermined amount off the working edge thereof.

By providing the pivot shaft **28** at a position remote from the axis of the shaft **56**, and at substantially the same horizontal level, the adjustments made in the angularity of the beds **24** and **30** will be such that the said roll will move substantially vertically over a wide range of adjustment of the shoe **36**. This is of advantage because the table can be reciprocated relative to the wheel by a fixed amount and always bring the grinding wheel and crushing roll to proper relative position. Also, substantially all thrusts on the crushing roll due to the wheel being pressed thereagainst will be carried by the shaft **32** and not transmitted to the pivot shaft **28**.

It will be understood that the arrangement shown proposes unclutching the roll shaft **56** from its drive motor during the dressing of the wheel and that the wheel is driven at low speed during the dressing cycle. However, this invention also contemplates driving the shaft **56** and permitting the wheel to idle during the dressing cycle if it should be so desired.

It will be understood that this invention is susceptible to modification in order to adopt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

I claim:

1. The method of producing dressing rolls for shaping production grinding wheels to a predetermined contour which comprises: mounting a unit having the desired contour in radial alignment with a crushing roll; shaping said crushing roll to a reverse configuration by contacting said unit thereto through relative radial movement of said unit and roll; bringing said formed roll into co-planar surface contact with a grinding wheel and crushing the same in pressured revolving engagement to a positive reproduction of the original contour; bringing the said grinding wheel into true radial disposition with a blank unit and grinding a surface of the same to produce a reverse reproduction of the desired contour; mounting said reversed unit in radial alignment with a crushing roll; cutting the roll to a positive reproduction of the desired contour by driving said crushing roll in contact with said ground surface of said reversed unit; and bringing the roll into co-planar surface contact with and crushing a said production grinding wheel in pressured revolving engagement to a negative reproduction of the original unit whereby the complementary shape ground will be identical to the configuration of the original unit.

2. The method of producing dressing rolls for shaping production grinding wheels to a predetermined contour which comprises: mounting a unit having the desired contour in radial alignment with a crushing roll; shaping said crushing roll to a reverse configuration by contacting said unit thereto through relative radial movement of said unit and roll; bringing said formed roll into co-planar surface contact with a grinding wheel and crushing the same in pressured revolving engagement to a positive reproduction of the original contour; bringing the grinding wheel into true radial disposition with a blank unit and grinding a surface of the same to produce a reverse reproduction of the desired contour; mounting said reversed unit in radial alignment with a crushing roll; cutting the roll to a positive reproduction of the desired contour by driving said crushing roll in contact with said ground surface of said reversed unit; and bringing the roll into co-planar surface contact with and crushing a said production grinding wheel in pressured revolving engagement to a negative reproduction of the original unit by movement of said roll in an arcuate path intersecting the periphery of said grinding wheel at a point tangent to a radius plane of said grinding wheel.

3. The method of reproducing contours by means of grinding and production grinding wheels which comprises: mounting on a support a member having a shape it is desired to reproduce; moving the member into engaegment with the surface of a crushing roll with the cutting edge of said member having all parts thereof in true radial disposition relative to said roll; forming said crushing roll to the shape of said member by rotating said roll relative to said member; bringing the said formed roll into co-planar surface contact with said grinding wheel and crushing the same in pressured revolving engagement to a positive reproduction of the original contour; bringing the grinding wheel into true radial disposition with a blank unit and grinding a surface of the same to produce a reverse reproduction of the desired contour; mounting said reversed unit in radial alignment with a crushing roll for shaving said roll to a shape which is a positive reproduction of the desired contour by driving said crushing roll in contact with said ground surface of said reversed unit; and bringing the shaped roll into co-planar surface contact with and crushing a said production grinding wheel in pressured revolving engagement to a negative reproduction of the original unit whereby the complementary shape ground will be identical to the configuration of the original unit.

4. The method of reproducing contours by means of grinding and production grinding wheels which comprises: mounting on a support a member having a shape it is desired to reproduce; moving the member into pressured engage-

ment with the surface of the roll while the same is rotating relative to said member and with the cutting edge having all parts thereof in true radial disposition relative to said roll; bringing the said formed roll into co-planar surface contact with a grinding wheel and crushing the same in pressured revolving engagement to a positive reproduction of the original contour; bringing the grinding wheel into true radial disposition with a blank unit and grinding a surface of the same to produce a reverse reproduction of the desired contour; mounting said reversed unit in radial alignment with a crushing roll for shaving said roll to a shape which is a positive reproduction of the desired contour by driving said crushing roll in contact with said ground surface of said reversed unit; bringing the shaped roll into co-planar surface contact with and crushing a said production grinding wheel in pressured revolving engagement to a negative reproduction of the original unit whereby the complementary shape ground will be identical to the configuration of the original unit; and intermittently dressing the grinding wheel by the last mentioned roll.

5. The method of reproducing contours by means of grinding and production grinding wheels which comprises: mounting on a support a member having a shape it is desired to reproduce; moving the member into pressured engagement with the surface of the roll while the same is rotating relative to said member and with the cutting edge having all parts thereof in true radial disposition relative to said roll; bringing the said formed roll into co-planar surface contact with a grinding wheel and crushing the same in pressured revolving engagement to a positive reproduction of the original contour; bringing the grinding wheel into true radial disposition with a blank unit and grinding a surface of the same to produce a reverse reproduction of the desired contour; mounting said reversed unit in radial alignment with a crushing roll for shaving said roll to a shape which is a positive reproduction of the desired contour by driving said crushing roll in contact with said ground surface of said reversed unit; bringing the shaped roll into co-planar surface contact with and crushing a said production grinding wheel in pressured revolving engagement to a negative reproduction of the original unit whereby the complementary shape ground will be identical to the configuration of the original unit; and at least intermittently causing the truing device and the crushing roll to be brought into engagement with the complementary shaped edge of the truing device to maintain the shape of said crushing roll accurate within predetermined limits.

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