March 11, 1952 E. A. NELSON 2,588,651

MACHINE FOR ROLLING TAPERED DISKS

Filed Feb. 21, 1945 4 Sheets-Sheet 1

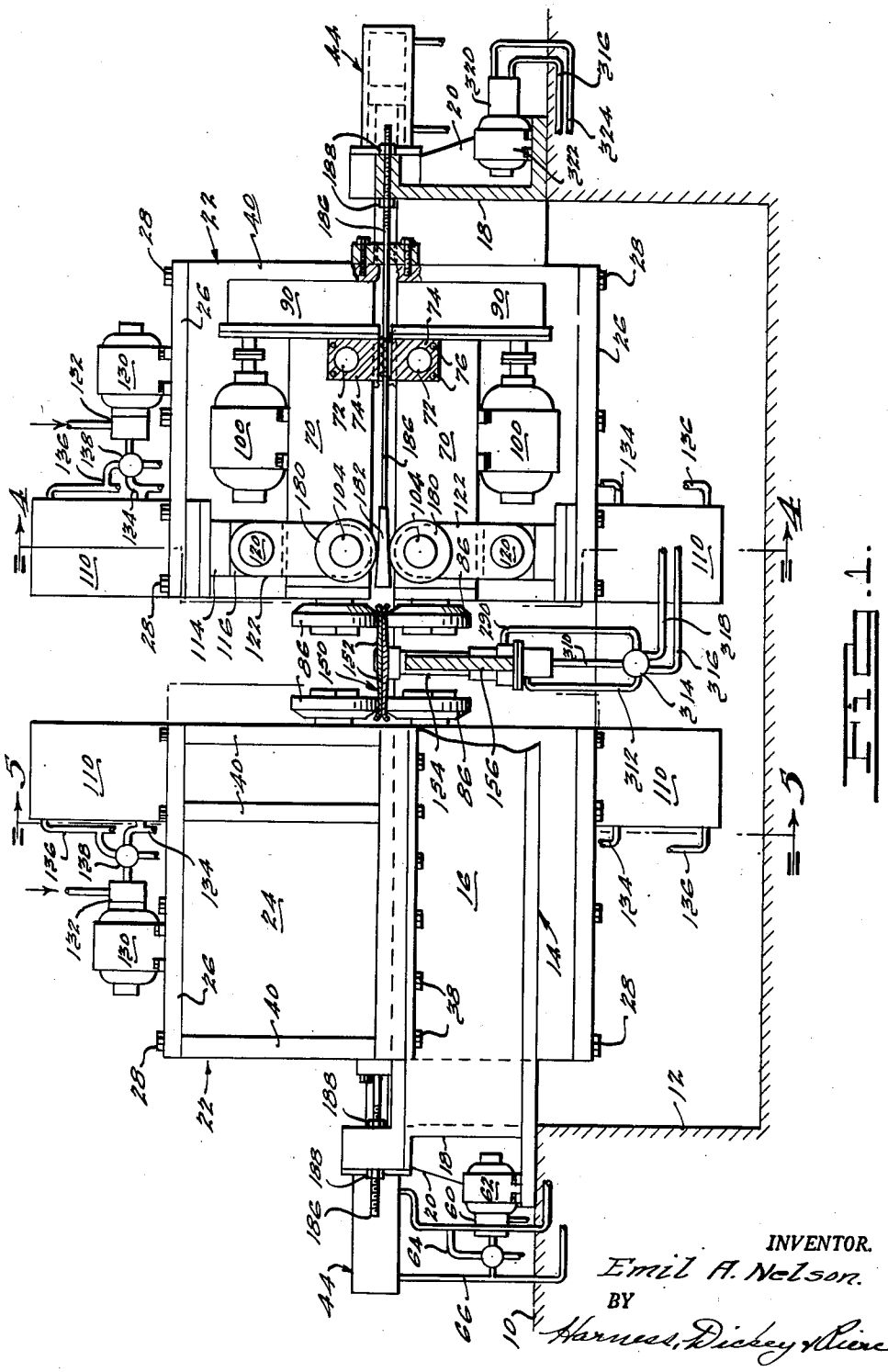


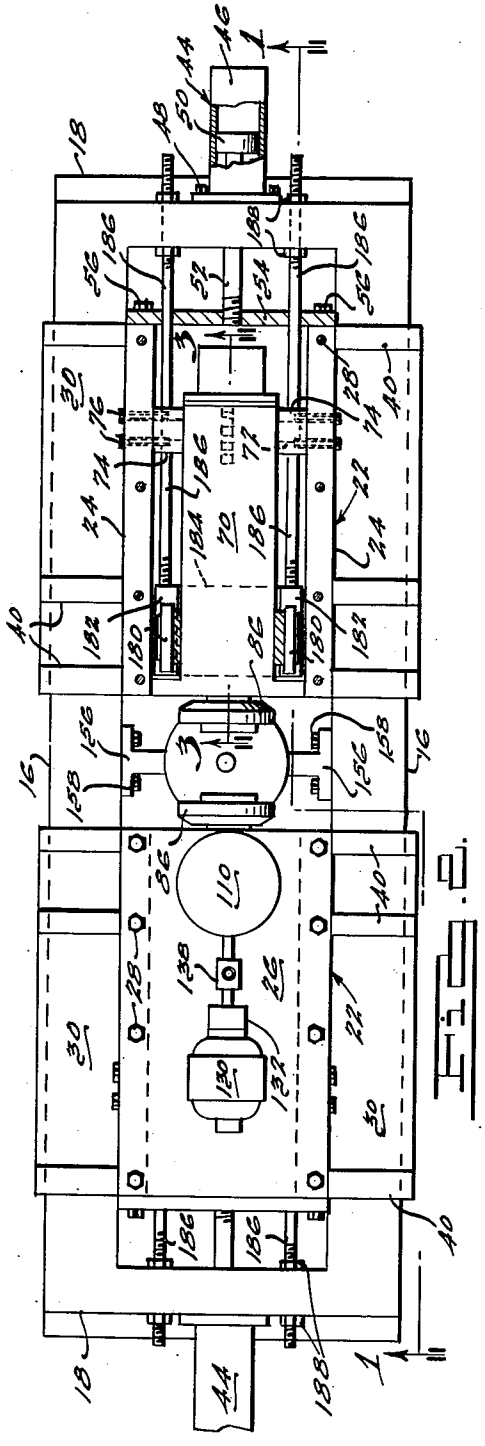
Fig. 1.

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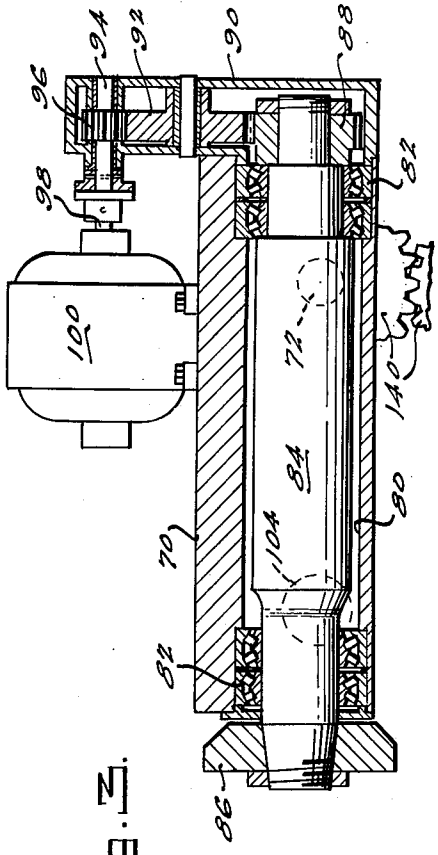


Fig. 3.

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Fig. 4.

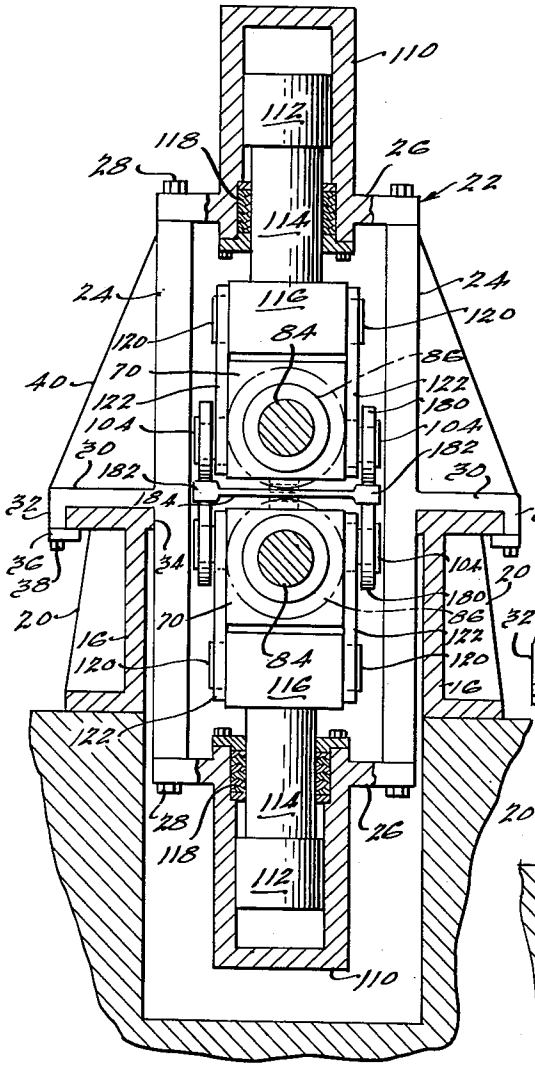
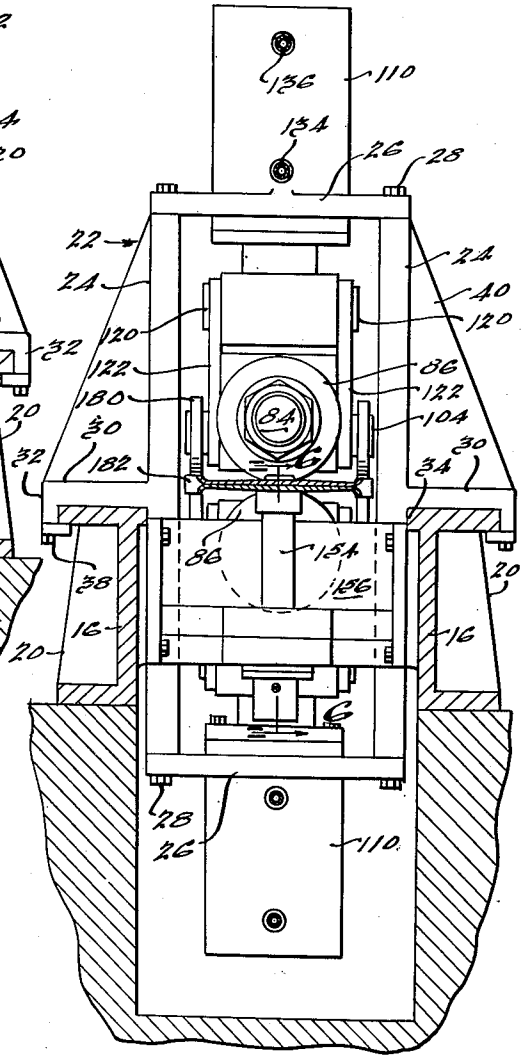


Fig. 5.

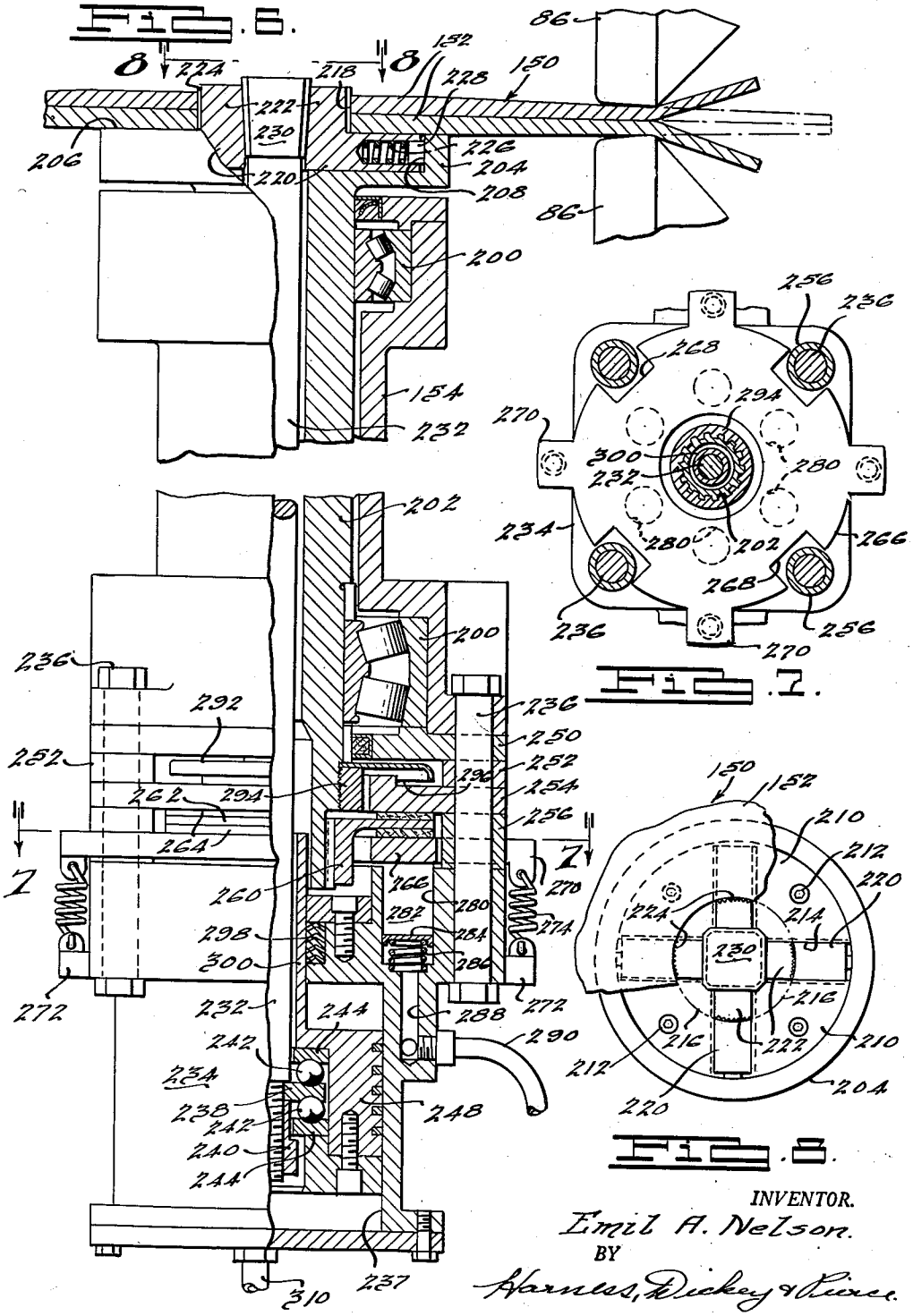


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UNITED STATES PATENT OFFICE

2,588,651

MACHINE FOR ROLLING TAPERED DISKS

Emil A. Nelson, St. Clair Shores, Mich.

Application February 21, 1945, Serial No. 579,106

4 Claims. (Cl. 80—16)

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This invention relates to the rolling of workpieces or discs which taper in thickness radially thereof, the principal object being the provision of a new and novel method and apparatus by means of which workpieces or discs of uniform thickness may be brought to radially tapered conformation in a quick, efficient and economical manner.

Objects of the invention include a method of operating upon metal workpieces or discs of uniform thickness to taper their thickness radially thereof including the steps of subjecting a disc or similar workpiece to pressure axially thereof by means of rolls pressed toward the disc under a pressure exceeding that required to imbed the rolls into the workpiece to an extent greater than that required to reduce the thickness of the disc to the desired extent, and controlling the penetration of the rolls into the material of the workpiece to that required to obtain the desired radially varying cross-sectional thickness of the workpiece; the method of varying the thickness of a workpiece as above described in which the workpiece and rolls are rotatable and the rolls are bodily moved relatively radial with respect to the axis of rotation of the disc during the rolling operation; and the provision of a method as above described in which two discs or like workpieces arranged in back-to-back relationship are simultaneously operated upon by the rolls to obtain the desired taper in thickness thereof.

Other objects of the invention include the provision of disc rolling apparatus including means for rotatably mounting one or more discs or similar workpieces, a pair of rolls engaging axially opposite sides of the disc or discs and mounted for movement radially of said disc or discs, means for urging said rolls toward each other axially of said disc or discs, and means for controlling the movement of said rolls toward one another under said urging; the provision of apparatus as above described in which the means urging the rollers toward one another applies a force to the rolls independently of the frame of the machine; the provision of apparatus of the type described in which cam means are provided for limiting the approach of the rollers toward one another whereby to accurately control the reduction in thickness of the disc during travel of the rolls radially thereof; the provision of apparatus as above described including a plurality of pairs of rolls operatively associated with the disc or discs being operated upon; the provision in an apparatus of the type described of

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a novel form of means for supporting the disc or discs to be operated upon and for locking the disc or discs to the support for rotation therewith; the provision of a novel supporting mechanism for discs which are to be operated upon to vary their thickness radially thereof; the provision of apparatus of the type described in which the apparatus is so constructed and arranged that the frame thereof is free of forces which during operation thereof approach any magnitude that might cause distortion of the same; and the provision of apparatus of the type described of new and novel design.

The above being among the objects of the present invention the same consists in certain novel features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawings, and then claimed, having the above and other objects in view.

In the accompanying drawings which illustrate a suitable embodiment of the present invention and in which like numerals refer to like parts throughout the several different views,

Fig. 1 is a partially broken, partially sectioned side elevational view, taken as on the line 1—1 of Fig. 2, of a machine embodying the present invention;

Fig. 2 is a plan view of the machine shown in Fig. 1 with parts broken away to better illustrate the construction of the same;

Fig. 3 is an enlarged, vertical sectional view taken on the line 3—3 of Fig. 2, illustrating the construction of the roll shafts, their carriers and the driving and supporting mechanism therefor;

Fig. 4 is an enlarged, vertical sectional view taken transversely of the machine as on the line 4—4 of Fig. 1;

Fig. 5 is an enlarged vertical, sectional view taken on the line 5—5 of Fig. 1;

Fig. 6 is an enlarged, partially broken, partially sectioned side elevational view of the work support and its control mechanism, illustrating the same as supporting a pair of workpieces and illustrating the engagement of the rolls therewith, the section being taken as on the line 6—6 of Fig. 5;

Fig. 7 is a slightly reduced, horizontal sectional view taken on the line 7—7 of Fig. 6; and

Fig. 8 is a reduced, partially broken plan view taken on the line 8—8 of Fig. 6.

The present invention relates to a machine for operating upon a piece of metal of uniform or substantially uniform thickness so as to vary such thickness radially of a line perpendicular to

the plane of the workpiece. While it is capable of operating upon workpieces of substantially any contour it has been designed particularly for the purpose of operating upon workpieces intended to be employed in the production of the disc or wheel body portions of wheels for automotive vehicles. Accordingly, and although reference hereinafter may be made only to the application of a machine and method for the production of such wheel discs, its use for producing any member formed from a blank of constant thickness and whose thickness in the final product varies radially with respect to a line perpendicular to the plane of the surface of the member will be made apparent to those skilled in the art and the application of the present invention to the production of such other members will thereby be made known to them.

In the application of the present invention to the production of wheel discs, it is generally preferable, although not necessarily in all cases, that the original blanks be circular or roughly of generally circular conformaton and of substantially uniform thickness throughout. Ordinarily they will be cut, punched or otherwise formed from sheets of metal of the required thickness and such metal will be of any suitable character such as, for instance, steel or aluminum particularly where employed for wheel discs.

For the purpose of obtaining a maximum amount of strength for a minimum amount of weight such wheel discs are generally made of maximum thickness at their central portion and taper in thickness radially outwardly from their center or central portion, usually but not necessarily, uniformly, and it is in connection with the tapering of the thickness of such discs that the present invention deals with.

One thing that is to be particularly noted is that in accordance with the present invention the variation in thickness between the central portion of the disc and the peripheral portion thereof may be varied uniformly or otherwise in any manner desired, a feature which may be of major importance under some circumstances. This is accomplished by the employment of rolls having a limited amount of contact with the workpieces radially of their axis of rotation and controlling the penetration of the rolls into the workpieces during travel of the rolls radially thereof by means of cams or contour controlling members. To facilitate the formation of such wheel discs under such circumstances and in order that they may be completely rolled with one pass of the rolls over the surface thereof, it is preferable that the force tending to imbed the rolls into the workpiece is sufficiently great as to insure the cams or contour controlling members being effective to limit such penetration. For this reason it is preferable to use a pressure tending to imbed the rolls into the work of such magnitude that without the use of the cams or contour controlling members the reduction in thickness of the work would exceed that desired in the final product.

While in a broad sense the use of cams or contour controlling members for limiting penetration of the rolls into the work is applicable to the conventional platen type of disc rolling apparatus and it is intended to broadly cover such application herein, ordinarily such an arrangement will not be employed as in such case the force which tends to imbed the rollers into the work is taken through the frame of the machine and, therefore, subjects such frame, bearings and other elements of the machine to undue forces which not only tend to foster early destruction of certain of the parts thereof but to cause distortion of the frame itself and consequent nonuniformity of the parts produced.

Preferably and as shown in the drawings the rolls are mounted in opposition to each other on opposite faces of the work and are urged toward one another in such a manner that the pressure of the rolls on the opposite faces of the work is equalized. Such pressure is preferably applied to the rolls by fluid pressure cylinder and piston assemblies whose axes are substantially aligned with the direction of movement of the rolls normal to the plane of thickness of the workpiece as controlled by the cam or contour members, and the cooperating pairs of rolls on opposite faces of the work are connected by tension members preferably arranged as to entirely free the frame of the machine from any stress due to the force transmitted to the rolls. The rolls of each cooperating pair being substantially free to float axially with respect to the work, the work itself is substantially relieved of any stress tending to displace it axially with respect to its spindle or other supporting member.

One pair of rolls between which a workpiece may be engaged and operated upon in accordance with the present invention is sufficient to carry out the purposes of the present invention. However, it will be appreciated that a plurality of such pairs of rolls acting simultaneously upon a workpiece will permit the described operation on the workpiece to be speeded up and for this reason it will ordinarily be preferable to employ a plurality of pairs of such rolls, two of such pair being illustrated in the machine shown in the accompanying drawing by way of illustration.

It will also be appreciated from the following description that a single workpiece, that is a single disc or the like serving as a workpiece may be operated upon alone. On the other hand it will be understood and as shown and described in connection with the construction shown in the drawings that two workpieces placed in flat contacting relationship with respect to each other may be simultaneously operated upon to bring both of them to their final condition and inasmuch as by this arrangement the capacity of the machine is doubled as compared to a condition in which a single workpiece alone is operated upon it will ordinarily be preferable to roll two workpieces simultaneously. For the above described reasons in the following specification and claims where reference is broadly made to a workpiece it is to be understood that such workpiece may comprise either one disc or other workpiece alone or two discs or other workpieces arranged in back-to-back relationship as the occasion may require.

Now referring to the accompany drawings it will be noted from Fig. 1 that the machine there shown seats upon a floor 10 over a pit 12 provided for reception of the lower portion of the machine. As indicated in Figs. 1, 3, 4, and 5 the machine comprises a frame or base indicated generally at 14 of rectangular conformation in plan view as seen in Fig. 2 and the sides 16 and ends 18 of which are of outwardly opening channel section the lower flanges of which are shown as resting directly upon the floor 10 to which they are suitably secured. Preferably vertical reinforcing webs such as 20 are extended between the upper and lower flanges of the frame 14 to aid in rendering the same more rigid. The

frame 14 may be formed of a single integral casting or of separate rolled or cast members suitably welded or otherwise fixed together into a unitary and preferably integral structure as shown.

The upper faces of the frame side members 16 are formed to provide ways upon and between which are received a pair of units, indicated generally at 22, which are slidable thereon toward and from one another. Each unit 22 comprises a pair of spaced, parallel, relatively thick and heavy plate or wall members 24 arranged with their planes of thickness vertical and in parallelism to the frame side members 16, one adjacent each frame side member 16, and they are connected together at their upper and lower ends by cross-walls 26 fixedly secured thereto as by means of bolts 28. The walls 24 and 26 of each unit thus form, in effect, a sub-frame.

As best brought out in Figs. 4 and 5 each member 24 approximately midway between its upper and lower edges has fixed thereto and preferably formed integrally therewith an outwardly directed flange 30 which overlies and is slidably received upon the upper face of the upper flange of the corresponding side member 16. The flanges 30 outwardly terminate in downwardly projecting flanges 32 which slidably embrace the lateral outer edges of the upper flanges of the frame side members 16 thereby to aid in guiding the members 24 in their slidable movement longitudinally of the frame side members 16. Such guiding of the units 22 may be further aided by extending the upper flanges of the frame side members 16 laterally inwardly as at 34 into substantially slidable contacting relationship with respect to the corresponding side members 24 as indicated in Figs. 4 and 5. Strips 36 are preferably secured to the lower edges of the flanges 32 with their laterally inner edges projecting under the outer marginal edges of the upper flanges of the frame side members 16 to prevent inadvertent lifting of the units 22 with respect to the frame 14. Such strips 16 are preferably removably secured in place as by means of screws 38. A plurality of vertically directed webs 40 are preferably provided in outstanding relationship with respect to the planes of the side members 24 between the members 24 and their corresponding flanges 30 to render the structure more rigid.

The units 22 are controlled in their sliding movements on the frame side members 16 by means of a cylinder and piston assembly indicated generally at 44 and each comprising a cylinder 46 one end of which is suitably secured as by means of bolts 48 to the corresponding frame end member 18 with its axis in parallel relationship with respect to the path of movement of the corresponding unit 22 on the frame side members 16, and preferably centrally between such frame side members. Each cylinder 46 is provided with a piston 50 therein provided with a piston rod 52 which slidably projects through the corresponding frame end member 18 with its end opposite the piston 50 suitably secured to a cross-bar 54, best brought out in Fig. 2, which extends across the outer ends of the members 24 of the corresponding unit 22 and is fixed to such ends as by means of bolts 56.

Preferably the piston and cylinder assembly 44 are controlled by liquid under pressure and to this end, and as illustrated in Fig. 1, a liquid pump 60 secured to an end of and driven by an electric motor 62 mounted upon the lefthand end of the frame 14 is connected by a pipe line 64

with the axially inner end of the cylinders 46 and by a pipe line 66 with the axially outer ends of such cylinders. A suitable or conventional valve 68 is interposed between the pump 60 and the lines 64 and 66 so as to optionally control the flow of liquid from the pump to either the line 64 or 66 and to simultaneously relieve the pressure in the other so as to cause the units 22 to move simultaneously either toward or away from each other and preferably at equal speeds.

As best brought out in Figs. 1, 2, and 3, between the side walls 24 of each unit 22 are received a pair of carrier housings 70 arranged vertically one over the other and, particularly when in operative position, with their lengths approximately horizontal. Adjacent its outer or rear end each housing 70 has fixed to it, one on each side thereof, a pair of outwardly projecting pins or pintles 72 axially aligned with each other and arranged with their axes in a horizontal plane and at right angles to the axis of the housing 70. The pintles 72 are each received in a bearing block 74 fixed to the inner face of the corresponding side member 24 as by means of screws or bolts 76. The bearing blocks 74 not only serve to pivotally support the housing 70 about the axes of the pintles 72 but also serve to space the rear ends of the housings 70 equally from the opposite side wall members 24.

As brought out in Fig. 3 each housing 70 is provided with a bore 80 within which is rotatably mounted by means of bearing assemblies 82 located at opposite ends thereof a heavy roll shaft or spindle 84 one end of which is somewhat reduced in diameter and which, as illustrated in Fig. 3, projects beyond the inner end of the housing where it has suitably but removably fixed thereto a roll 86. It will be understood, of course, that all of the rolls 86 are of the same diameter and preferably of the same character, and that they are positioned inwardly beyond the inner end of their corresponding side members 24 as shown.

The rear end of each shaft 84 is reduced in diameter and has fixed thereto a spur gear 88. A housing 90 is fixed to the rear end of each carrier housing 70 in surrounding relationship with respect to the gear 88 and projects laterally therefrom in a direction away from the opposed faces of each cooperating pair of housings 70. Each housing 90 rotatably supports therein a spur gear 92 lying in mesh with the gear 88 and beyond the gear 92 from the gear 88 rotatably supports a shaft 94 therein to which is fixed a pinion gear 96 lying in mesh with the corresponding gear 92. The shaft 94 projects from the housing 90 and is suitably coupled to the shaft 98 of an electric motor 100 suitably fixed to that side of the housing 70 opposite the cooperating housing 70 of the same unit 22. The gears 96, 92, and 88 serve as a speed reduction between each motor 100 and the corresponding shaft 84 for driving such shaft and, accordingly, its corresponding roll 86 at a reduced rate of rotation.

Each housing 70 adjacent its inner or lefthand end, as shown in full lines in Figs. 1, 2, and 3, is provided with a pair of oppositely projecting relatively large pins or pintles 104 arranged with their axes aligned with one another, in a horizontal plane perpendicular to the axes of the roll shafts 84 in plan view and, therefore, parallel to the axes of the corresponding pins 72. In vertical alignment with the axes of the pins 104 of each unit 22 and as best brought out in Fig.

4. the upper and lower walls 26 of each unit 22 each has a cylinder 110 fixed to it which, as best brought out in Fig. 4, is preferably formed integrally with such top or bottom wall 26 and with its axis vertical and positioned midway between the side members 24 for the corresponding unit. Each cylinder 110 projects outwardly away from its corresponding wall 26 and slidably receives therein a piston 112 provided with a piston rod 114 which projects inwardly therefrom and through the corresponding wall 26 where it is provided with a head 116. Suitable packing 118 serves to seal each cylinder 110 against leakage between its open end and the corresponding piston rod 114.

Each head 116 is provided at its opposite sides with an outwardly projecting pin 120 arranged in substantially vertical alignment with respect to the pins 104 on the housing 70 immediately vertically above or below it as the case may be and each pin 120 is connected to the pin 104 on the corresponding side of the unit 22 by means of a link 122. Thus it will be appreciated that the pivotal position of each housing 70 about its corresponding pin 72 is controlled by the position of the corresponding piston 112 in the corresponding cylinder 110.

The positions of the pistons 112 in the cylinders 110 for each unit is controlled by fluid pressure introduced and discharged from the opposite ends of each cylinder 110 and preferably by the use of liquid under pressure. While in the broader aspects of the invention such liquid may be placed under pressure and introduced in any suitable manner, preferably and as best brought out in Fig. 1 each unit 22 has mounted on its upper wall 26 an electric motor 130 supporting and driving a liquid pump 132 connected as by means of pipe lines 134 and 136 with the inner and outer ends, respectively, of both cylinders 110 for such unit. Suitable or conventional valve mechanism indicated diagrammatically at 138 serves to control the fluid under pressure to the desired ends of the cylinders 110 of each unit and the escape of liquid from the opposite ends thereof. It will be noted that in being connected to the pump 132 in the manner described the pistons 112 are caused to move either inwardly or outwardly in their respective cylinders 110 simultaneously with one another.

While not essential, it may be desirable under some circumstances that the carrier housings 70 of each unit 22 be so interconnected that their movement either toward or from an operative or an inoperative position be equal and simultaneous with each other, and while any suitable mechanism may be provided for insuring this result the following mechanism is shown provided for this purpose. As best brought out in Figs. 1 and 3 each housing 70 has fixed to it a gear segment 140 concentric with the axes of the pins 72 thereof and projecting therefrom toward the cooperating housing 70. The gear segments 140 are of such size that the teeth of each cooperating pair intermesh with one another and thus insure equal angular movement of each housing 70 with respect to the axes of its pins 72 but in opposite directions of rotation. Where the gear segments or their equivalent are not employed, then cooperating pairs of rolls 82 and their carriers are more or less free to float vertically relative to the work in a rolling operation.

It will be appreciated from the foregoing that the workpiece to be operated upon is received between the rolls 86 of each unit 22 and is squeezed between such rolls as such rolls are rotated by the electric motors 100 and then each housing 22 is moved longitudinally of the frame 14 by means of the piston and cylinder assemblies 44 to cause the rolls 86 to traverse radially over the opposed faces of the workpiece. In the particular embodiment of the invention shown and as brought out in Fig. 1, for instance, the workpiece is illustrated generally at 150 and as comprising a pair of discs 152 arranged with their planes of thickness horizontal and in back-to-back relationship, and fixed to the upper end of a work spindle rotatably mounted in a vertically directed housing 154 positioned midway between the inner ends of the unit 22 and midway between the opposite side frame members 16. The housing 154 is supported in such position by means of laterally outwardly projecting brackets 156 fixed with respect to it and secured to the opposite inner faces of the frame side members 16 by means of bolts 158 as brought out in Fig. 2.

It has been previously mentioned that the workpiece 150, whether formed of a single or a pair of discs such as 152, is originally of preferably approximately disc-like form and of constant thickness throughout. The workpiece is placed upon the upper end of the work spindle with the rolls 86 of each unit 22 in outwardly separated relation with respect to each other, the piston and cylinder assemblies 44 are actuated to move the units 22 inwardly toward one another until the rolls 86 are in a position to grip the workpiece adjacent its radially inner margin, the motors 130 are put into operation and the control valve mechanism diagrammatically illustrated at 138 is operated to cause the rolls 86 of each unit 22 to be urged toward one another and to grip the workpiece 150 between them, the electric motors 100 are put into operation to cause the rolls 86 to be relatively rapidly rotated, and then the piston and cylinder assemblies 44 are operated to cause the units 22 to be slowly separated from one another and thereby cause the rolls 86 to travel radially outwardly with respect to the axis of rotation of the workpiece 150 to effect a tapering or reduction in thickness of the workpiece 150 radially thereof. It will, of course, be appreciated that the rolls 86 in rotating with the workpiece 150 gripped between opposed pairs thereof cause the workpiece to be correspondingly rotated so that the path of movement of the rollers 86 with respect to the opposed surfaces of the workpiece 150 is a spiral path of relatively small pitch in order that the entire workpiece from the point of initial engagement of the rolls 86 therewith to its periphery is evenly worked by the rolls 86.

It is to be particularly noted that the force exerted by the opposed pistons 112 on the rolls 86 tending to imbed the rolls in the work is taken directly by the sub-frame structure including the walls 24 and 26 entirely independently of the main frame 14, so that regardless of the intensity of this force it cannot be transmitted to the main frame 14 and consequently cannot cause any distortion thereof which might adversely affect the final product being made. The sub-frame structure is preferably of heavy construction as shown so as to take these forces without material distortion thereof, but because of this part of the structure and because of the manner of controlling the spacing of the rolls 86 as will hereafter be explained, a limited amount of distortion of such sub-frame is of no material consequence in the control of the final product and is, therefore, relatively unimportant in any case.

It has also been previously explained that preferably the pressure with which the rolls 86 are pressed toward the workpiece 150 is in excess of that actually required to effect the desired reduction of thickness in the workpiece, this feature being desirable from the standpoint of both speeding up the production of such workpieces and from the standpoint of insuring a complete reduction in thickness thereof in one pass of the rolls 86 thereover. Under such circumstances it will be appreciated that the movement of the rolls 86 of each unit 22 must be controlled in their movement toward one another so as to prevent them from reducing the thickness of the workpiece 150 beyond that desired, and to effect this result the following described mechanism is provided as an important part of the present invention.

Outwardly from the carrier housings 70 with respect to their corresponding links 122, each pin 110 thereof rotatably supports thereon a roller 180. The rollers 180 are of such diameter that those of opposed pairs in each unit 22 remain spaced from each other when the rolls 86 of such unit have approached each other to the minimum extent desired and as controlled by the desired thickness of the workpiece being operated upon. Interposed between each opposed pair of rollers 180 is a cam or sectional contour controlling element or member 182. Preferably and as brought out in Fig. 4 the cams 182 for each unit are transversely interconnected by a web 184 preferably integral therewith. These cams 182 serve as an abutment between the corresponding pairs of rollers 180 of each unit 22 to limit the approach of the cooperating rolls 86 of each unit toward one another. The cams 182 are so contoured in side elevation as illustrated in Fig. 1 as to vary the spacing of the corresponding rolls 86 of the same unit 22 as the rolls 86 move radially of the workpiece during a rolling operation. In the particular instance shown by way of illustration it is assumed that it is desired to uniformly reduce or taper the thickness of the two discs 152 constituting the workpiece 150 from a point adjacent the inner margin thereof to the outer margin thereof, under which circumstances it will be appreciated that the opposite upper and lower faces of the cams 182 are flat and arranged at an angle with respect to each other corresponding to the combined angle of the taper desired in the two discs 152 of the particular workpiece 150 as shown. At the same time it will be appreciated that if the contour of a diametric section of the workpiece is not desired to be reduced to a uniformly tapered conformation the contours of the cams 182 may be varied to obtain any contour of a workpiece section desired.

In the last-mentioned respect it will be appreciated that where a uniform taper is desired in the workpiece the rolls 86 may be of any width of face desired. In other words they may be provided with relatively narrow faces providing such a short line of contact with the work radially of the center of the work as to approach point contact or, on the other hand, they may be of such length as to provide substantial line contact with the workpiece over substantially the whole radial dimension of the workpiece to be reduced in thickness. I have found it preferable, however, to provide the rolls 86 of a material face width but of a width constituting only a portion of the radial dimension of the workpiece to be reduced in thickness. Even under such circumstances, however, I have found it

preferable to so form the periphery of the rolls 86 that they bear against the work substantially entirely at or adjacent to those edges thereof more remote from the axis of the work as best brought out in Fig. 6. Preferably the extent of radial contact between the rolls 86 and the work is limited so that the resulting action is more of a spinning action than a rolling action as in such case it is found that faster operation with the expenditure of less power results.

The workpieces 150 may be operated upon either in hot or cold condition, in many cases depending upon the character of the metal from which the workpiece is formed, and in some cases depending upon the extent and character of the reduction in thickness required. Generally it is preferable to operate on cold workpieces as it eliminates the problem of scale always associated with hot steel, and this is particularly true when rolling wheel discs.

It will be appreciated that it is necessary to fix the cam members 182 in position longitudinally with respect to the frame 14 so as to enable accurate control of the cooperating pairs of rollers 86 thereby during sliding movement of each unit 22 on the frame 14. While any suitable means may be provided for effecting this result, that shown in the accompanying drawings by way of illustration and as best brought out in Figs. 1 and 2, is as follows. A rod 186 is fixed at one end to each cam 182 and extends horizontally outwardly therefrom in parallelism with the frame side members 16 out through the corresponding end member 18 of the frame. That portion of each rod which projects through the frame is threaded and is provided with a nut 188 thereon on each side of the corresponding frame end member 118. The rods 186 thus serve to fix the cams 182 longitudinally with respect to the frame and at the same time the nuts 118 permit adjustment of the position of the cams 182 longitudinally of the machine so as to permit adjustment of the reduction in thickness of the reduced areas of the workpiece and/or variation of the cross-sectional configuration of the workpiece with respect to the center line thereof as may be the case. Because of the length and resiliency of the rods 186 the cams 182 are supported in such a manner as to be capable of floating vertically a limited amount without substantial resistance, and this is of advantage inasmuch as it thereby insures an equal pressure of the opposed rolls 86 acting against each cam 182 and relieves the cams from taking anything except pure compressive stresses.

One thing to be noted in connection with the use of the cams 182 in accordance with the present invention is, and this applies whether the cams are used in conjunction with rolls operating against opposite faces of the workpiece or against one face of the workpiece supported by a platen as earlier suggested, that by the use of the cams one material disadvantage of previously suggested machines of this general character is effectively overcome. This advantage is obtained because of the fact the spacing of the rolls with respect to the work, and which spacing controls the reduction in thickness of the work, is continued, or at least is capable of being continued, until the rolls have passed beyond the periphery of the work. In the prior art structures where such control has not been afforded, when the rolls have reached the peripheral edge of the work, because of the reduced mass of metal being operated upon by the rolls at such

time, an excessive penetration of the rolls into the work results and excessively thinning the peripheral margin of the work occurs, often causing radial cracks to appear in the periphery of the work which cracks often necessitate scrapping of the work. Where, as in the present case, the spacing of the rolls with respect to the work is continued until after the rolls have passed beyond the periphery of the work, this above described effect is eliminated with the result that a material saving of scrap is achieved as compared to the prior art structures.

It also may be noted at this point that where and as in the case shown the rolls **86** are of a face width materially less than the radial width of that portion of the work which is to be reduced in thickness, the rolls initially are applied to the work adjacent the radially inner margins of the work, that is at the point where the reduction of thickness is to begin, and are moved radially outwardly with respect to the center of the work during the rolling operation. Where two discs such as **152** are simultaneously operated upon, as the discs are reduced in thickness during the rolling operation the peripheral edges of the discs curl up axially away from each other as brought out in Fig. 1 but best brought out in Fig. 6, this permitting the metal of the discs **152** to flow along a path of least resistance. These outwardly turned peripheral edges are, of course, straightened out and thinned as the rolls **86** progress radially outwardly from the center of the work until they are entirely eliminated as indicated in Fig. 6 by the dot and dash lines.

In the broader aspects of the invention it will be appreciated that the particular work spindle employed for freely rotatably supporting the workpiece **150** during a rolling operation may be more or less unimportant. However, in a machine designed for quantity production the capacity of the machine may depend to a great extent upon the ability to apply the workpieces to and remove the workpieces from the work spindle in a quick and easy manner and without undue delay once the rolls **86** have passed out of operative relation with respect to the workpiece upon completion of an operation thereon. To obtain these benefits it is necessary to provide a work spindle to which the workpieces may be readily applied and to which they may be readily and quickly secured and likewise readily removed. Inasmuch as it would be difficult and dangerous in any case to attempt to remove the workpieces from the work spindle while rotating, means are desirably provided for braking the rotation of the work spindle and the work carried thereby as soon as the rolling operation on the workpiece has been completed thereby to prevent any delay in waiting for the workpiece to come to rest. A more limited phase of the present invention deals with the provision of a work spindle structure for accomplishing these ends.

Referring to Figs. 6, 7 and 8 it will be noted that the work spindle housing **154** rotatably supports therein for substantially free rotation by means of bearing assemblies **200** a hollow work spindle **202**. The upper end of the work spindle **202** is circularly enlarged as at **204** to provide an upper work receiving surface **206** upon which the workpiece **150** and particularly the lower disc **152** thereof, where two discs **152** constitute the workpiece as in the case shown, are supported in position to be operated upon by the rolls **86**. The head **204** is concentrically and circularly recessed as at **208** from its axially upper face and received in such recess **208** are four identical segmentally shaped blocks **210** secured in position by means of screws **212**. The segments **210** are spaced from one another at their opposed edges so as to form between each pair of them a radially directed slot **214** of constant width. The radially inner end of each segment **210** is preferably provided with an axially upwardly directed projection **216** of segmental shape, the radially outer edges of which lie in a circle which circle is sufficiently smaller than the central openings **218** of the discs **152** constituting the workpiece **150** to be relatively closely but readily receivable therein. These projections **216** thus combine to form a pilot for reception in the central openings 218 of the workpieces to locate the workpieces centrally with respect to the work spindle **202**.

In each slot **214** is received a chuck jaw member **220** each of which in radial section as illustrated in Fig. 6 is more or less L-shaped so as to provide each with an upwardly projecting jaw portion **222** the radially outer face of which is serrated as at **224**. The serrated faces **224** have a radius substantially equal to the radii of the radially outer faces of the projections **216** so as to be correspondingly readily received within the opening **218** of the workpieces **150** when in radially inwardly collapsed condition. A coil spring **226**, brought out in Fig. 6, held under compression between the inner end of radially directed blind opening in the radially outer end of each jaw member **220** and a plug **228** fitting within the radially outer end thereof and bearing against the periphery of the recess **208**, constantly urges the jaw members **222** toward radially inwardly collapsed condition in which the workpieces **150** may be readily applied thereover.

The jaw members **222** are forcefully radially expanded to lock a workpiece **150** to the work spindle **202** in the following manner. The radially inner faces of the jaws **222** are flat but tapered inwardly and downwardly as illustrated in Fig. 6, and received between these faces is the complementarily tapered wedge member **230**. The wedge member **230** is fixed to the upper end of a rod or shaft **232** which extends downwardly through the hollow interior of the work spindle **202** and into a vertically directed cylinder member **234** which is supported from and fixed with respect to the housing **154** by means of bolts **236**. Within the bore **237** of the cylinder member **234** the rod **232** is shouldered and receives against such shoulder a washer member **238** held in fixed position thereagainst by means of a nut **240** threaded on the lower end of the rod **232**. The washer **238** forms the central member of a dual thrust bearing assembly including a row of balls **242** on opposite sides of the washer **238** and cooperating axially outwardly spaced race members **244**. The race members **244** are suitably fixed within a piston member **248** vertically slidably received in the cylinder bore **237**. Accordingly, it will be appreciated that vertical movement of the piston **248** in the cylinder **237** will cause a corresponding axial movement of the rod **232** and wedge **230**, thereby to either force the jaw members **222** radially outwardly against the force of the springs **226** so as to lock the workpiece **150** to the work spindle **202**, or to render the springs **226** operative to move the jaw members **222** radially inwardly to release their grip upon the workpiece **150** and to permit its removal from the work spindle **202**. At the same time it will be appreciated that the rod **232** is freely rotatable

with respect to the piston 248 so that no wear is caused because of rotation of the piston 248 in the cylinder 237 during rotation of the work spindle 202 and the workpiece 150 mounted thereon during an operation on the workpiece by the rolls 86. The control of the axial position of the piston 248 in the cylinder 237 is accomplished by means of fluid pressure in a manner which will hereinafter be more clearly pointed out.

In order to provide means for braking the rotation of the work spindle 202 and the work carried thereby upon the completion of a rolling operation upon the workpiece by the rolls 86, the following mechanism is provided. Referring again to Figs. 6 and 7 it will be noted that the lower end of the housing 154 is closed by a plate-like end member 250 through which the bolts 236 project. On each bolt 236 below the member 250 is received a spacing washer or sleeve 252 and this is followed by an annular fixed brake plate 254. Below the brake plate 254 each bolt 236 receives thereon another spacing sleeve 256 which abuts against the upper face of the enlarged upper end of the cylinder member 234. The bolts 236 thus act between the housing 154 and the cylinder member 234 to secure all of these parts together in a rigid assembly.

The lower end of the work spindle 202 projects to a point slightly below the upper face of the cylinder 234 and such lower end is splined. This splined lower end of the work spindle 202 is received in the complementarily splined bore of the hub 260 of the rotatable brake disc 262 which has concentrically secured to its opposite faces rings 264 of friction material. The brake disc 262 which is thus mounted for rotation with the work spindle 202 and for axial movement with respect thereto because of its splined connection therewith is located immediately below the stationary brake plate 254. Between the disc 262 and the upper face of the cylinder 234 a non-rotatable but axially movable brake pressure plate member 266 is located. This pressure plate 266, as illustrated in Fig. 7, is centrally apertured for free reception of the hub 260 of the brake disc 262 therein, and its periphery is notched as at 268 in angular alignment with the spacing sleeves 256 which are freely received in the notches thereby to prevent rotation of the pressure plate 266 without restricting axial movement thereof. Between each adjacent pair of notches 268 the plate member 266 is provided with a radially outwardly projecting ear or lug 270 and the cylinder member 234 is provided with an opposed ear or lug 272 directly below each ear or lug 270, and between each cooperating pair of ears or lugs 270 and 272 a coil spring 274 is tensioned so as to constantly urge the pressure plate 266 downwardly away from the brake disc 262 and brake plate 254.

The cylinder member 234 is provided in its upper portion with a plurality, shown as six, cylindrical bores 280 arranged with their axes parallel to the axis of the cylinder 237 and arranged in equally angularly spaced relationship with respect to the axis of the cylinder 237 and with their axes in a circle concentric with the axis of theh cylinder 237. The bores 280 provide cylinders in each of which is slidably received a piston 282 having a sealing element 284 fixed to its lower face to prevent the escape of liquid between it and its corresponding bore 280. A coil spring 286 is maintained under compression between the lower end of each piston 282 and the lower end of the corresponding bore 280 so as to constantly urge the pistons 282 upwardly into contact with the pressure plate 266. The springs 274 exert a greater force than the springs 286 so that in the absence of fluid pressure in the lower end of the bores 280 the springs 274 overcome the force of the springs 286 and draw the pressure plate 266 downwardly into contact with the upper end of the cylinder member 234. A passage 288 extends downwardly from the bottom of each bore 280 and these passages are all connected together and communicate with a tube 290 through which fluid under pressure may be introduced to and discharged from the lower ends of the various bores 280.

It may be noted that the space between the member 250 and the brake plate 252 is open to the outside air through the space between the spacer sleeves 252, and the space between the brake plate 254 and the pressure plate 266 and in which the brake disc 262 is located is likewise open to the atmosphere between the spacer sleeves 256. The opening in the latter case permits air to freely circulate into contact with the brake disc 262 so as to enable heat generated by repeated braking action to be dissipated into the surrounding air. It might be noted that in the space between the plate 254 and the member 250 an oil throw ring 292 is fixed to the lower end of the work spindle 202 by means of a nut 294. The ring 292 is sealed to the work spindle 202 so that any lubricant working down the work spindle past the lower bearing assembly 200 is intercepted by the oil throw ring 292 and thrown outwardly so that it will not find its way to the surfaces of the brake disc 262. As a further aid in preventing such lubricant from finding its way to the braking surfaces the brake plate 254 is provided with an upwardly projecting hub portion 296 around its central bore which serves as a dam to prevent lubricant finding its way to the upper face of the brake plate 254 from the periphery of the oil throw ring 292 from working radially inwardly and down its central bore to the brake surfaces.

It may also be noted that although a suitable packing indicated generally at 298 is provided about the upwardly projecting sleeve 300 formed concentrically with the piston 248, should any liquid find its way upwardly from the cylinder 237 past the packing 298 it will be discharged below the upper face of the pressure plate 266 and, therefore, will not interfere with the proper action of the braking apparatus.

A tube or pipe 310 shown both in Figs. 1 and 6 connects into the cylinder 237 below the piston 248 and another tube or pipe 312, shown in Fig. 1, connects into the cylinder 237 above the piston 248. These two tubes together with the tube 290 connect into a suitable valve mechanism indicated generally at 314 in Fig. 1 and which may be of any suitable or conventional type and from which leads 316 and 318 lead to a suitable source of fluid under pressure and to a reservoir or other suitable point of discharge. Fluid under pressure may be supplied to the pipe 316 by means of a liquid pump 320 mounted upon and driven by an electric motor such as 322 shown mounted on the righthand end of the frame 14 in Fig. 1 and the discharge side of which is connected to the duct or tube 316 and provided with a tube 324 leading to a suitable source of liquid supply.

It will be appreciated from the foregoing and with reference to Fig. 6 that in the operation of the machine, when it is desired to operate upon

a workpiece the units 22 are withdrawn from each other by the piston and cylinder assemblies 44. The valve 314 is then actuated to apply fluid under pressure to the lower face of the piston 248 which raises the wedge 230 and permits the springs 226 to contract the effective diameter of the jaw members 220. The workpiece 150 and which, as previously described, may consist of either one or two discs such as 152, is then applied to the upper end of the work spindle with a central bore 218 of the workpiece received in surrounding relationship with respect to the pilot portions 216 on the upper end of the work spindle. The valve 314 is then operated to relieve the pressure on the lower face of the piston 248 and to apply pressure to the upper face thereof which causes the piston 240 to move downwardly, drawing the wedge 230 downwardly with it and forcing the jaw members 220 radially outwardly so that their serrated faces 224 grip the walls of the bore 218 in the workpiece thereby to lock the workpiece securely to the work spindle 202.

Under the above described conditions the lower ends of the bores 280 in which the pistons 282 are received are relieved of fluid pressure so that the springs 274 act to draw the pressure plate downwardly and free the brake disc 262 for substantially unrestricted rotation between the brake plate 254 and pressure plate 266. The piston and cylinder assemblies 44 are then actuated to move the unit 222 toward each other and to the limit of their movement in this direction, the pistons 112 then have fluid pressure applied to their outer ends to cause the rolls 86 to bear against the workpiece 252, the electric motors 110 are energized to start the rolls 86 into rotation and the cylinder and piston assemblies 44 are then actuated to slowly withdraw the units 22 away from each other, the rolls 86 imbedding themselves into the workpiece 152 to a depth as determined by the cams 182.

As soon as the rolls 86 pass radially outwardly beyond the workpiece 152 the pistons 112 are actuated to separate the rolls 86 and the valve 314 is actuated to apply pressure to the bottom faces of the pistons 282 which thus force the pressure plate 266 upwardly and causes the brake disc 262 to be frictionally engaged between the pressure plate 266 and brake plate 254, thus bringing it and the work spindle 202 together with the workpiece 150 supported thereby quickly to a stop. Pressure is then applied to the lower face of the piston 248 to release the jaw members 220 from the workpiece 150 and the work is removed and replaced by a new workpiece whereupon the above described operations are repeated. It may be noted and as, of course, will be appreciated that the motors 100 may be allowed to operate continuously during continued production and that the various valve mechanisms which are illustrated diagrammatically are preferably grouped either into a single unit or at least all arranged in associated relation with respect to each other so that all may be readily controlled by a single workman from a single point. As a matter of fact under these conditions the above described operations on a piece of work may be carried out in less time than it takes to explain them. It will also be appreciated that the work spindle brake and chuck will preferably be automatically controlled to operate in timed relation to the withdrawal of the units 22 from work engaging position, and that movement of the units 22 and the various movable parts thereof and the brake and chuck may be controlled by a conventional master time relay to obtain a completely automatic and timed operation of the various phases of movement of the machine.

Having thus described my invention, what I claim by Letters Patent is:

1. A mill capable of cold rolling steel plates comprising, in combination, a frame, a rotatable work supporting spindle fixed in position relative to said frame, a unit slidably mounted on said frame for movement toward and from the axis of rotation of said work spindle, a pair of roller carriers movably mounted on said unit, a roller rotatably supported by each of said carriers, means for rotating said rollers, fluid pressure means associated with each of said carriers operable to move said carriers in a direction to cause said rolls to approach each other to engage a piece of work carried by said work spindle between them, means in said unit and located directly below said fluid pressure means for offsetting the reaction forces of said fluid pressure means against each other independently of said frame, and means for shifting said unit on said frame.

2. A mill capable of cold rolling steel plates comprising, in combination, a main frame, a sub-frame mounted for sliding movement on said main frame, a work spindle rotatably supported in fixed relation with respect to said main frame and with its axis of rotation perpendicular to the plane of movement of said sub-frame on said main frame, a pair of roll carriers swivably supported by said sub-frame, a roll rotatably supported by each of said carriers and on opposite sides of the plane of rotation of work on said work spindle and in opposed relation with respect to each other, fluid pressure means operative to urge said carriers in a direction to cause said rolls to approach each other whereby to grip a piece of work between them, said fluid pressure means being carried by said such frame so that the force of said fluid pressure means is taken by said sub-frame independently of said main frame, means for rotating said rolls, and means for moving said sub-frame on said main frame.

3. A mill capable of cold rolling steel plates comprising, in combination, a frame, a rotatable work supporting spindle fixed in position relative to said frame, a unit slidably mounted on said frame for movement toward and from the axis of rotation of said work spindle, a pair of roller carriers movably mounted on said unit, a roller rotatably supported by each of said carriers, means for rotating said rollers, fluid pressure means associated with each of said carriers operable to move said carriers in a direction to cause said rolls to approach each other to engage a piece of work carried by said work spindle between them, means located directly below said fluid pressure means for limiting the approach of said rolls toward one another under the influence of said fluid pressure means, means in said unit for offsetting the reaction forces of said fluid pressure means against each other independently of said frame, and means for shifting said unit on said frame.

4. A mill capable of cold rolling steel plates comprising, in combination, a frame, a rotatable work supporting spindle fixed in position relative to said frame, a unit slidably mounted on said frame for movement toward and from the axis of rotation of said work spindle, a pair of roller carriers movably mounted on said

unit, a roller rotatably supported by each of said carriers, means for rotating said rollers, fluid pressure means associated with each of said carriers operable to move said carriers in a direction to cause said rolls to approach each other to engage a piece of work carried by said work spindle between them, means located directly below said fluid pressure means for limiting the approach of said rolls toward one another under the influence of said fluid pressure means operative to vary the spacing of said rolls in accordance with the position of said rolls radially of said work spindle, means in said unit for offsetting the reaction forces of said fluid pressure means against each other independently of said frame, and means for shifting said unit on said frame.

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