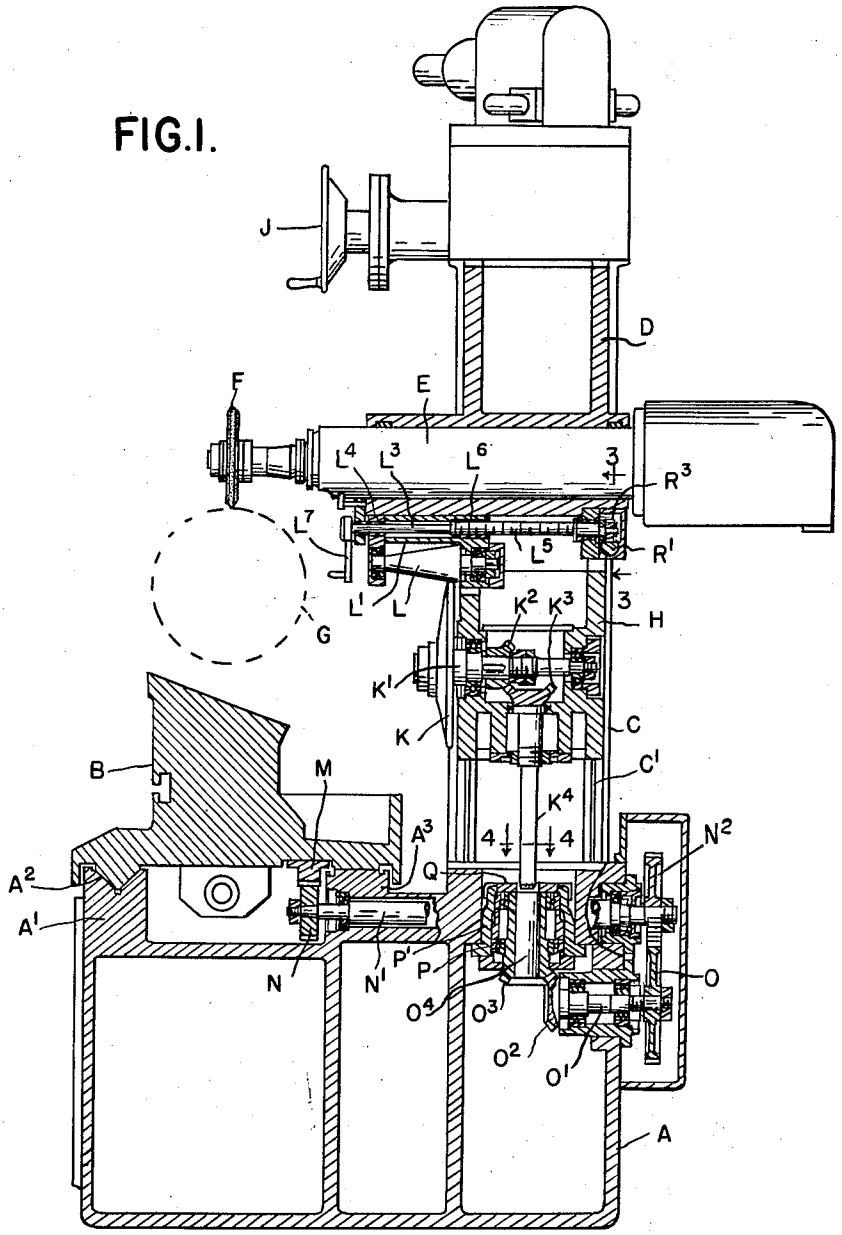
Oct. 23, 1956 I. M. RUDNICKI 2,767,520

FORM GRINDING MACHINE

Filed May 18, 1953 5 Sheets-Sheet 1

FIG.I.



INVENTOR.
IRENEUSZ M. RUDNICKI
BY
Whittemore Hulbert & Belknap
ATTORNEYS

Oct. 23, 1956 I. M. RUDNICKI 2,767,520

FORM GRINDING MACHINE

Filed May 18, 1953 5 Sheets-Sheet 2

FIG.3.

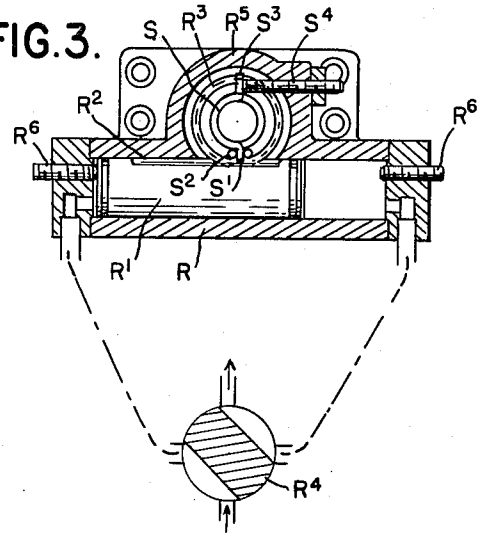


FIG.2.

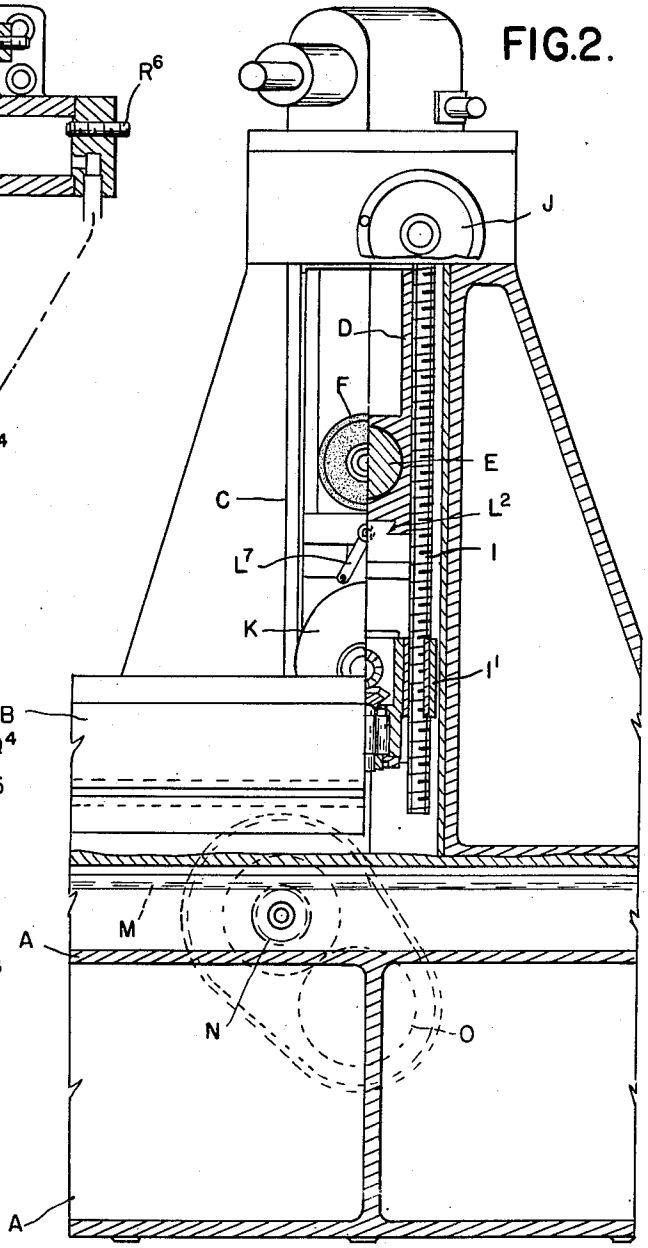
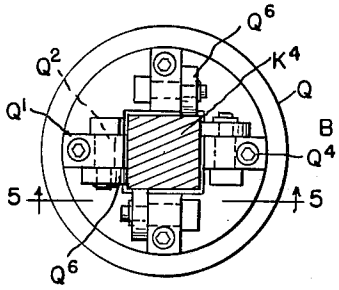


FIG.4.



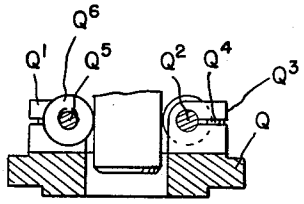


FIG.5.

INVENTOR.
IRENEUSZ M. RUDNICKI
BY
Whittemore Hulbert & Belknap
ATTORNEYS

Oct. 23, 1956 I. M. RUDNICKI 2,767,520

FORM GRINDING MACHINE

Filed May 18, 1953 5 Sheets-Sheet 3

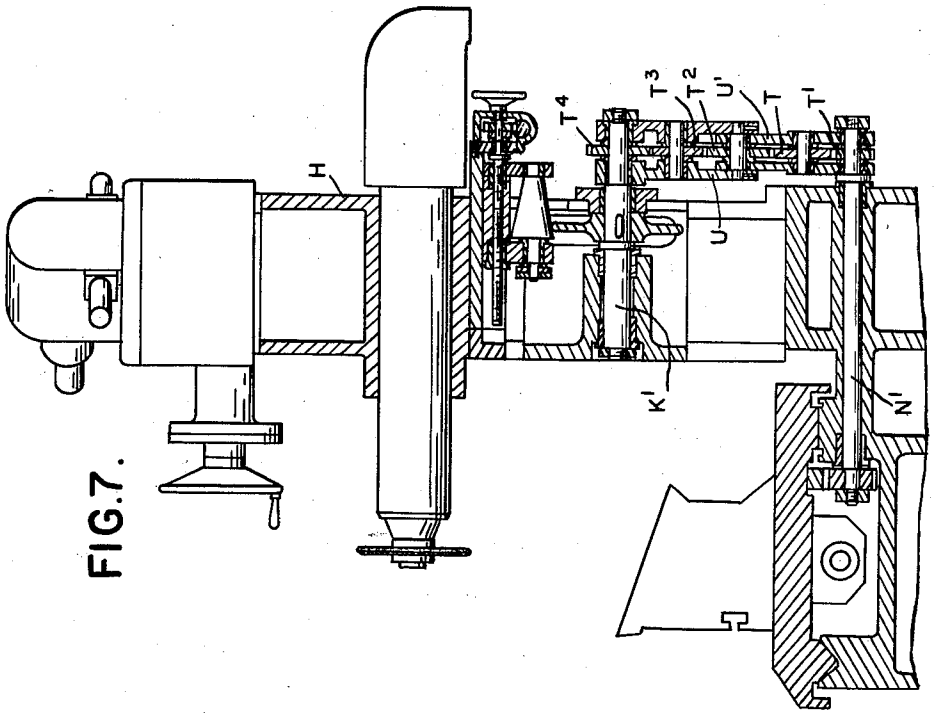


FIG.7.

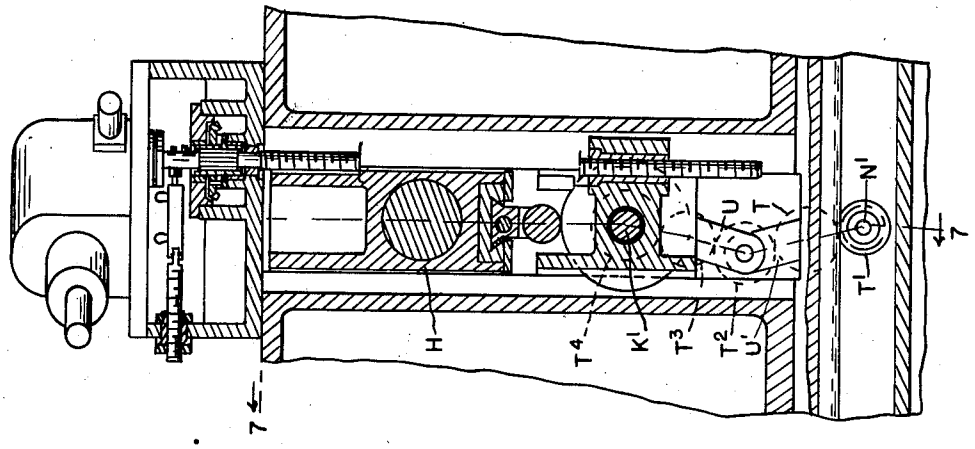


FIG.6.

INVENTOR.

IRENEUSZ M. RUDNICKI

BY

Whittemore Hulbert & Belknap

ATTORNEYS

Oct. 23, 1956 I. M. RUDNICKI 2,767,520

FORM GRINDING MACHINE

Filed May 18, 1953 5 Sheets-Sheet 4

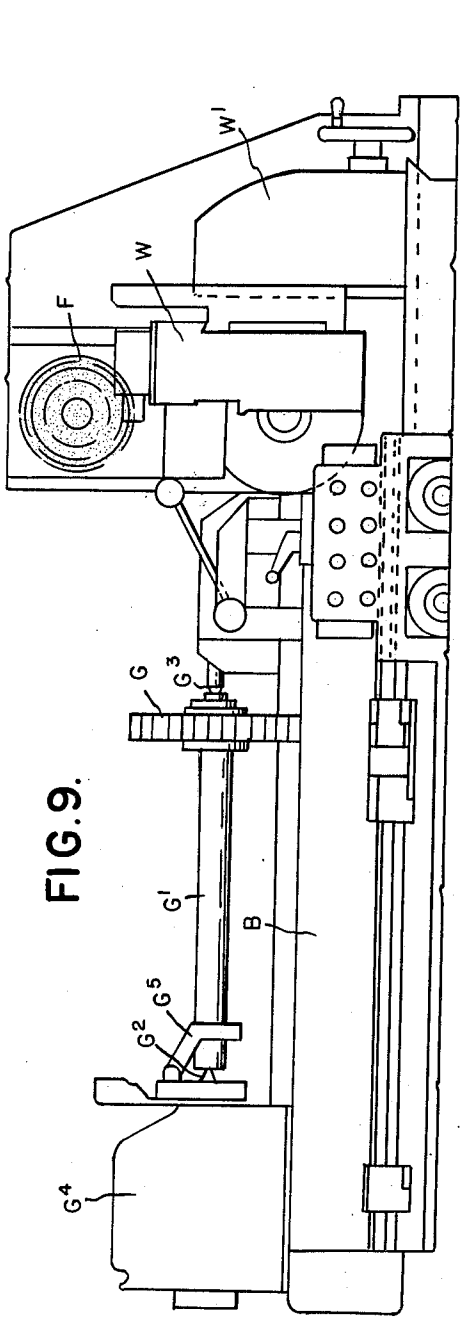


FIG. 9.

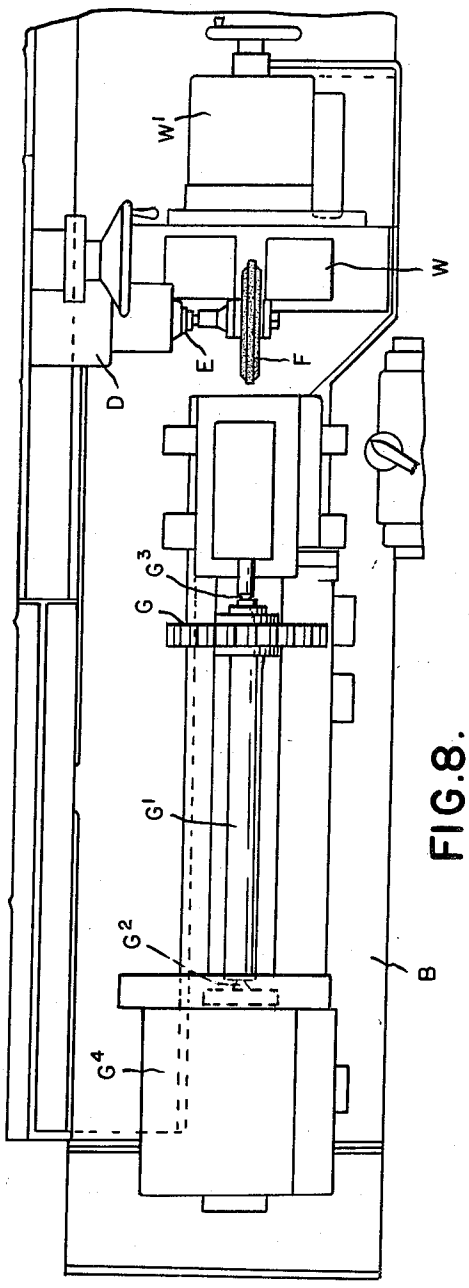


FIG. 8.

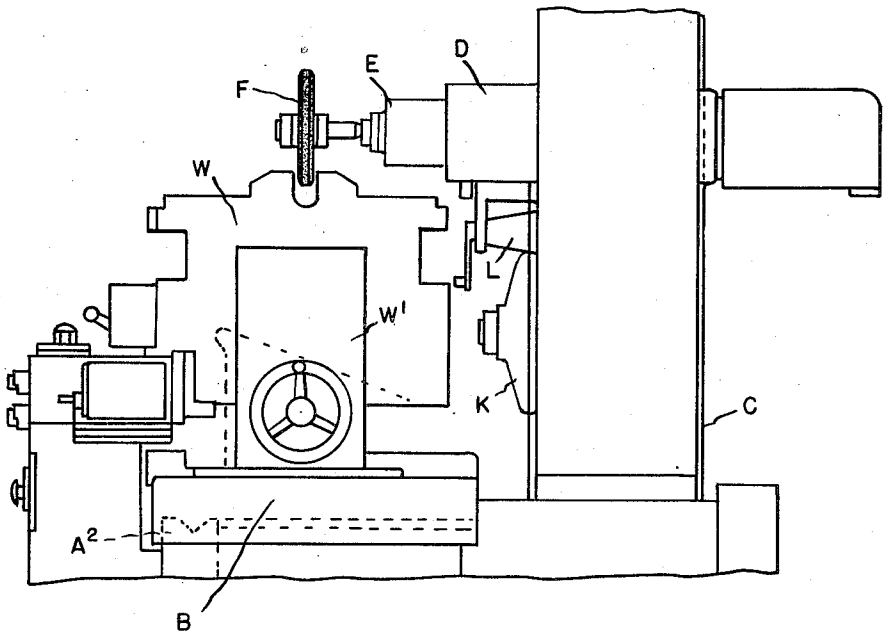
INVENTOR.
IRENEUSZ M. RUDNICKI
BY
Whittemore Hulbert & Belknap
ATTORNEYS

Oct. 23, 1956 I. M. RUDNICKI 2,767,520

FORM GRINDING MACHINE

Filed May 18, 1953 5 Sheets-Sheet 5

FIG. 10.



INVENTOR.
IRENEUSZ M. RUDNICKI
BY
Whittemore Hulbert & Belknap
ATTORNEYS

United States Patent Office 2,767,520 Patented Oct. 23, 1956

2,767,520

FORM GRINDING MACHINE

Ireneusz M. Rudnicki, Detroit, Mich., assignor to The Gear Grinding Machine Company, Detroit, Mich., a corporation of Delaware

Application May 18, 1953, Serial No. 355,511

6 Claims. (Cl. 51—45)

The invention relates to form grinding machines of the type comprising a frame, a reciprocating carriage thereon, a work holder and a grinder wheel mounted, the one on the carriage and the other on the frame, a trimming mechanism for periodically restoring the form of the grinder wheel and feed mechanism for advancing the grinder wheel into the work before successive passes of the one by the other. Machines of this type are used for the grinding of spur gears and other work in which the path of the grinder wheel is rectilinear.

It is the object of the invention to adapt this form of grinding machines to the grinding of surfaces which are non-rectilinear in contour. It is a further object to obtain this result with comparatively slight modification of the general structure of the machine. It is a further object to obtain substantially the same contour in the ground surface by the operation of grinder wheels of different diameters or one which is reduced in radius through trimming.

With these objects in view, the invention consists in the construction as hereinafter set forth.

In the drawings:

Fig. 1 is a vertical cross-section through the grinding machine with some parts shown in elevation;

Fig. 2 is a side elevation partly in vertical section;

Fig. 3 is an enlarged section on line 3—3, Fig. 1;

Fig. 4 is an enlarged cross-section on line 4—4, Fig. 1;

Fig. 5 is a section on line 5—5, Fig. 4;

Fig. 6 is a vertical section showing a modified construction of transmission mechanism between the carriage and the controlling cam;

Fig. 7 is a section on line 7—7, Fig. 6.

Fig. 8 is a plan view of a portion of the machine;

Fig. 9 is a front elevation thereof showing the grinder wheel registered with the trimming mechanism;

Fig. 10 is an end elevation.

Grinding machines of this type have the work holder and grinder alternatively mounted on the stationary frame and the reciprocatory carriage. I will however specifically illustrate and describe a construction in which the work is mounted on the carriage and the grinder wheel is mounted on a vertical column of the stationary frame. In detail A is the stationary frame which has a horizontally extending bed portion A′ provided with slideways A^2 and A^3 for a reciprocatory carriage B. C is a column rising from a central portion of the bed at one side of the carriage and which is provided with guideways C′ for a vertically movable head D. A grinder arbor E is journalled in a bearing in the head D and extends therefrom over the carriage B with the grinder wheel F mounted at its outer end. The carriage B is provided with suitable means (not shown) for reciprocating the same and is further provided with a mounting for the work, which in case the latter is a gear to be ground must also be in operative relation to an indexing mechanism. There is also a trimming mechanism W which is mounted on the carriage and in one position of the latter is placed in registration with the grinder wheel for operation in restoring the form of said wheel. However, as these elements form no part of the instant invention, I have merely indicated in Fig. 1 the position of the work on the carriage by the dotted circle G.

As heretofore constructed the head D has directly connected therewith a feed mechanism including a screw extending vertically of the column, a nut for the screw secured to the head and suitable mechanism for either manually or automatically rotating the screw to thereby raise or lower the head and the grinder carried thereby. With the instant construction the head D is free and the feeding mechanism is connected to a second head H located on the guideways beneath the head D and supporting the latter. Thus, as shown, the screw I extends through a channel in the head D and engages a nut I′ in the head H. The upper end of the screw is connected to an operating mechanism (not shown) but which includes the manually operable crank J. The head D is supported on the head H through the medium of an exchangeable rotary cam K mounted on the head H and a tapered roller L mounted on the head D and engaging the periphery of the cam. The cam K is actuated by the reciprocation of the carriage B through the medium of an intermediate transmission mechanism of the following construction: M is a rack mounted on the underside of the carriage to extend longitudinally thereof throughout its length. N is a pinion engaging the rack M and connected to a horizontal shaft N′ journalled in bearings in the bed and extending through the rear side thereof. N^2 is a gear wheel at the rear end of the shaft N′ which is in mesh with the gear wheel O on a shaft O′ connected by bevel gears O^2 and O^3 with a rotary member O^4 having a vertical axis. The member O^4 is hollow and is journalled in radial and end thrust roller bearings P in a stationary member P′, which latter is secured to the bed. On the head H the cam K is demountably secured to a horizontal shaft K′ journalled in said head and connected by bevel gear wheels K^2 and K^3 with a vertically extending shaft K^4 axially aligned with the rotary member O^4. The shaft K^4 is square in cross-section and of dimensions which would permit of its moving downward within the member O^4 when the head H is lowered by its feed mechanism. The shaft is rotatably coupled with the member O^4 preferably by the construction illustrated in Figs. 4 and 5. This includes a circular plate Q secured to the upper end of the member O^4 and having projecting upward therefrom lugs Q′ on each of the four sides of the square shaft K^4. Each of these lugs has a horizontal bore therethrough for receiving a pin Q^2, the lug being split on one side of this bore as indicated at Q^3, and a head screw Q^4 extending across the split forms the clamping means for said pin. At one end of the pin Q^2 is an eccentric journal Q^5 for a roller Q^6 which bears against the side of the shaft K^4. The construction just described forms a means for transmitting the rotation of the member O^4 to the shaft K^4 while at the same time permitting vertical movement of said shaft with respect to said member O^4. Also, this is accomplished without any lost motion as the rollers Q^6 may always be held in contact with the shaft K^4, being adjustable when necessary by rotation of the pins Q^2 with their eccentric journals Q^5.

In the operation of the mechanism as thus far described it will be understood that the cam K will be rotated in correspondence to the traverse of the carriage B so that the grinder wheel will be raised or lowered in accordance with the pattern of the cam. This will permit of imparting any desired contour to the work in the general direction of reciprocation of the carriage in place of a rectilinear contour which would be formed if the axis of the grinder wheel were stationary. One use of the machine thus modified would be to slightly crown spur gear wheels to compensate for slight non-parallelism of their axes or distortion through load. However, the

grinder machine is also capable of use for many other purposes and in fact for imparting any desired longitudinal contour to the article being ground.

As has been stated the trimming mechanism W for the grinder wheel is on a bracket W' mounted on the carriage B and may be placed in registration with the grinder wheel whenever the latter is to be trimmed. This operation however requires the lowering of the grinder wheel into intersecting relation with the diamonds of the trimmer and as a result of the trimming the grinder wheel is slightly reduced in radius. Instead of lowering the grinder wheel by rotation of the screw I, I have provided a separate mechanism independent of the regular feed mechanism. This comprises the tapering conical roller L above mentioned which is journalled in bearings in a transversely movable carriage L' engaging a guideway L^2 in the head D. A shaft L^3 passes through an aperture in the carriage and is journalled in bearings L^4 on the head D. A portion L^5 of this shaft is screw threaded and engages a nut L^6 secured to the carriage L'. At one end of the shaft L^3 is a crank handle L^7 for turning the same and at the opposite end there is located means for intermittently turning the shaft step by step in one direction only. The latter means comprises a hydraulic cylinder R mounted on the head D and containing a piston R' having a rack R^2 extending longitudinally at the top thereof. This rack is in mesh with the gear wheel R^3 which is sleeved upon the end portion of the shaft L^3. Hydraulic fluid is supplied to each end of the cylinder alternately through a valve R^4 by which means the piston and rack are reciprocated to impart rotation to the gear wheel R^3 alternately in opposite directions. Screw stops R^6 are arranged at opposite ends of the cylinder to accurately determine the length of stroke of the piston. Between the gear wheel R^3 and the shaft L^3 is a one-way clutch, which as shown comprises a helical coil S of resilient wire surrounding the shaft. One end of this coil has a radially extending portion S' which is secured to the gear wheel R^3 by pins S^2. The other end of the coil has a diametrically opposite radially extending portion S^3 which when the piston R' is at the left end of the cylinder, Fig. 3, will engage a stop rod S^4. This rod screw threadedly engages and extends outward through a housing R^5 enclosing the gear wheel R^3 and is adapted to be adjusted so as to expand the helical coil out of frictional engagement with the shaft L^3. However, when the piston R' moves towards the right, Fig. 3, its initial movement will withdraw the portion S^3 from the stop S^4, permitting the coil to contract into frictional engagement with the shaft and communicating rotation thereto. The initial movement of the piston R' in the opposite direction will expand the coil, releasing its frictional engagement with the shaft so that the latter will remain stationary. Thus, each operation of the valve R^4 which admits hydraulic fluid to the left end of the cylinder, Fig. 3, will cause the rotation of the shaft L^3 a predetermined amount, while adjustment of the valve to admit fluid to the right end of the cylinder will return the piston without moving the shaft. Rotation of the shaft L^3 will through the threaded portion L^5 and nut L^6 communicate an axial movement to the conical roller L so that a downward movement of the head D is permitted. This determines the amount of radial movement of the grinder wheel F into the path of the trimming cutters. If further radial movement of the grinder wheel is required the operation of the valve R^4 may be repeated. The length of the conical roller L and the angle of its taper will determine the amount of downward movement of the grinder wheel in successive trimming operations and is sufficient for reduction of the radius of said wheel to its minimum operative size.

In place of the transmission mechanism between the table and the cam K as illustrated in Figs. 1 and 2 I may substitute the construction shown in Figs. 6 and 7. In the latter the shaft N' is connected to the shaft K' through a train of spur gears. Inasmuch, however, as the distance between the axes of the shaft N' and K' will be varied during the vertical movement of the head H these gears are mounted on a jointed frame. As specifically shown a pair of links U on opposite sides of a gear wheel T and engaging the shaft thereof hold this gear wheel in mesh with a gear wheel T' on the shaft N' and also in mesh with a gear wheel T^2. A second pair of links U' hold the gear wheel T^2 in mesh with a gear wheel T^3 and the latter in mesh with a gear wheel T^4 on the shaft K'. The links U and U' extend at an angle to each other even at the highest point of adjustment of the head H and as said head is lowered this angle will be increased but in all positions the gear wheels of the train are held in successive mesh with each other.

In the operation of a rotary grinder wheel the circular grinding surface is necessarily tangent to the surface ground at each point therein, as otherwise the grinding of one portion would destroy another previously ground. By reason of this fact the contour of the ground surface is not the same as that of the path traversed by the axis of the grinder wheel or that formed by a grinding surface of a wheel which is of a different radius. This introduces a problem in the grinding of nonrectilinear contours by a grinder wheel which is changed in radius by successive trimming operations. If a cam of the same pattern is used for controlling the relative movement of the grinder wheel and the work, the contour ground by a wheel of one radius will not be the same as that produced by a wheel of larger or smaller radius. In fact, the only way in which the pattern of the cam could be exactly reproduced in the work would be through the use of an arcuate cam follower of exactly the same radius as the average grinding surface of the wheel.

I have overcome this difficulty by the use of a cam follower having arcuate portions varying in radius for alternatively contacting with the cam. Thus, by adjusting this follower, its cam contacting portion may be reduced in radius an equal amount to the reduction of radius of the grinding wheel through trimming. The simplest way of accomplishing this is by use of the conical roller which is axially adjusted to move the trimmer radially into the wheel. This while not completely compensating for the difference in path of the large and small diameter grinding wheels reduces the difference to a negligible amount.

As shown in Figs. 8 and 9 the table is in the position where the trimming mechanism W is in registration with the grinder wheel, the trimming points being in the vertical plane of the axis of said wheel. The work may be supported in any suitable way but as shown at G is mounted on an arbor G' which in turn is supported by centers G^2 and G^3. The indexing head G^4 is connected to the arbor G' by coupling means G^5.

What I claim as my invention is:

1. In a grinding machine of the type including a frame, a carriage mounted for rectilinear movement on said frame, means for reciprocating said carriage, a grinder wheel of formed cross sectional contour and a work holder, one mounted on said frame and the other on said carriage with the axis of the grinder wheel transverse to the direction of movement of the carriage, and a trimming mechanism registrable with said grinder wheel in one position of said carriage; mechanism actuated by the traverse of said carriage for moving said grinder wheel in a direction transverse to the cross sectional contour of the work in said work holder to form a nonrectilinear contour in the ground surface, said last mentioned mechanism including a cam and arcuate cam follower, and means automatically operating during relative adjustment of said trimming mechanism and grinder wheel preparatory to a trimming operation for contacting said cam with a portion of said arcuate follower the radius of which is less by an amount equal to the reduction in radius of said grinder wheel by said trimming

operation, thereby maintaining more nearly the same contour of ground surface with all diameters of the grinder wheel.

2. The construction as in claim 1 in which said follower is a conical roller and said cam is rotary in peripheral contact with said roller, said roller being adjusted axially by said relative adjustment of said trimming mechanism and grinder wheel to reduce the radius of the portion contacting with the cam.

3. The construction as in claim 2 in which the mounting for said grinder wheel includes a vertically extending guideway and an upper head slidable thereon, a lower head slidable on said guideway below and spaced from the upper head, said rotary cam and follower being respectively on said lower and upper heads and forming the supporting means for the upper head on the lower head, means for adjusting said lower head to bring the grinder wheel in operative relation to the work in said work holder, the portion of said grinder wheel moving mechanism between said carriage and cam being extensible and contractible to permit adjustment of said lower head.

4. The construction as in claim 3 in which said last mentioned mechanism includes a rack and an intermeshing pinion, one mounted for travel with said carriage and the other mounted on the frame.

5. The construction as in claim 3 in which said roller adjustment means includes a carriage on which said roller is mounted slidably movable on said upper head axially of the roller, a rotary screw threaded shaft for adjusting said last mentioned carriage, a cylinder, a piston therein, means for hydraulically reciprocating said piston in said cylinder, a rack extending longitudinally of said piston, a gear wheel in mesh with said rack rotatatively mounted on said shaft, and a one-way clutch between said gear wheel and shaft for rotating the latter step by step in successive reciprocations of said piston.

6. In a grinding machine of the type including a frame, a reciprocatory carriage on said frame, a grinder wheel and a work holder mounted one on said frame and the other on said carriage, and a trimming mechanism for periodically restoring the form of the grinding surface with a reduction in the average radius thereof; a mechanism including a cam for relatively moving said grinder wheel and work holder transversely of and during the reciprocation of said carriage to develop in the ground surface of the work a nonrectilinear contour, a cam follower having arcuate portions of different radii for alternatively engaging the cam and through which the transverse movement is transmitted, and means for adjusting said cam follower at each trimming operation to present a cam contacting portion thereof less in radius by an amount equal to the reduction in radius of the grinding surface.

References Cited in the file of this patent

UNITED STATES PATENTS

999,610	Virdin	Aug. 1, 1911
1,228,798	Maag	June 5, 1917
1,302,540	Hanson	May 6, 1919
2,030,907	Alfaro	Feb. 18, 1936
2,047,869	Harley	July 14, 1936
2,048,462	Orcutt	July 21, 1936
2,247,412	Rybicky	July 1, 1941
2,312,161	Hartman	Feb. 23, 1943
2,375,323	Pizzigoni	May 8, 1945
2,412,284	Orcutt	Dec. 10, 1946