The invention relates to a method for rolling bevel gears and to a device for carrying out this method. According to the invention the bevel gear wheel is clamped and thereafter is heated to the working temperature in the ready clamped condition in the region in which the teeth are to be rolled, whereas the teeth are rolled into the blank without unclamping in a rolling process by means of at least one bevel gear tool, the bevel gear being then unclamped and removed. In this way it is possible to prepare by rolling a bevel gear in a complete working process, without the necessity for an after treatment. The precision of the toothing and the quality of the surface depends essentially on the precision and the surface quality of the bevel gear tool used. For the invention it is of decisive importance that the bevel gear blank be first clamped and then warmed up to the temperature in the region provided for the toothing. Finally it is also foreseen to effect the rolling in several, in particular, two steps, an intermediate heating stage being arranged between the two rolling steps. Moreover it is recommendable especially with large bevel gears to provide for heating in a plurality of successive steps. Finally it is also foreseen to effect the rolling in several, in particular, two, steps, an intermediate heating stage being arranged between the two rolling steps.

The device for carrying out the invention is simple and relatively inexpensive considering the great improvement in working obtained. An especially simple device for carrying out the method includes a working table rotatably mounted on a machine upright and rotatable in steps, on which a plurality of bevel gear blanks can be clamped in a circle; moreover it is possible to orient the upright in the axis of the individual clamping devices of the working table a clamping or a loading station, heating stations, rolling stations and an unclamping or delivery station are arranged in a series corresponding to the desired steps of the process. A device is thus provided which is in a position to produce bevel gears from bevel gear blanks, in which the bevel gear blank is introduced at one position of the machine and the prepared rolled bevel gear is removed at another position. Essentially it is also possible, to construct the device so that a working table has so many stations that several bevel gears are rolled in a single cycle.

The bevel gear tools are advantageously driven in a form-closed manner about their own axes, whilst the bevel gear blanks are driven for the purpose of rolling on the bevel gear tools about their axes lying centrally of the clamping device. However it is essentially also possible to effect the whole rolling movement by the tool or the work piece, as is known in teething machines.

The forces which appear during the rolling of the teeth and which must be taken up by the supports of the tool and work piece are very great. For this reason it is recommended that the part of the upright supporting the roller working tools, which is described subsequently as the upper part, be connected by a tie rod lying in the axis of the working table to the part of the upright receiving the working table, which is designated subsequently as the lower part. In this way it is effected that the mounting of the tool and the work piece are balanced so that no deformation under the influence of the high rolling pressures takes place. This however is assuming that the bevel gear blank is rolled so that it requires no subsequent treatment. Attention is expressly drawn to the fact that the invention can be carried out with great advantages if the flanks of the bevel gear rolled in accordance with the invention are after-treated for example by grinding.

The clamping devices, in which the bevel gear blanks are clamped are also driven for rotation about their own axes. Moreover these clamping devices are arranged on the working table which turns in steps about its own axis, as soon as a working step at the individual clamping devices ends. According to the invention is hereby provided that each clamping device is axially displaceable and supported by means of a mushroom head rotatably mounted on the upright. This head takes the axial forces applied to the clamping device. At each station where the bevel gear is rolled a special difficulty arises from the high rolling pressures to be taken up. At the remaining stations of the working table, where the bevel gear blank is heated or where it is clamped in the clamping device or unclamped and removed from the clamping device, these mushroom heads can be of a smaller size because here the axial forces are substantially less.

Preferably the support of the clamping devices and the clamping and unclamping and ejection of the bevel gear blank or the prepared rolled bevel gear are effected hydraulically or pneumatically, without electric or mechanical performance of these subsidiary tasks being excluded.

Further improvements and advantageous features of the invention are explained with reference to the accompanying drawings in which the embodiment of the inven-
tion in the form of an example is shown in a simple way in that the drawing is restricted to parts essential to the invention.

In the drawings:

FIGURE 1 is a side view of a machine embodying the invention;

FIGURE 2 is a view of the machine of FIGURE 1 in the direction of the arrows A—B of FIGURE 1;

FIGURE 3 is a section through the work table of the machine of FIGURES 1 and 2 along the line III—III of FIGURES 1 and 5;

FIGURE 4 is a partial view of the right-hand upper section of FIGURE 3 in a larger scale for showing a clamping device in detail;

FIGURE 5 is a horizontal section through the machine along the line V—V of FIGURES 1—3 and 6, in which a part of the figure a section the line Voa—Voa of FIGURE 3 is detailed in chain-dotted line;

FIGURE 6 is a vertical non-linear partial section through the machine, the upper part of FIGURE 6 representing a section along the line Vla—Vlb—Vlc of FIGURE 5. The lower part of FIGURE 6 represents part of a section along the line Vle—Vib—Vid of FIGURE 5. In addition a section along the line Vlea—Vlbe—Vlc of FIGURE 5 is shown in the lower part of FIGURE 6 in broken lines. The upper part of FIGURE 6 also shows a section along the line VI—VI of FIGURES 2 and 9;

FIGURE 7 is a view of the upper part of FIGURE 6 on a larger scale for showing in detail the drive of the rolling tool (bevel gear rolling wheel);

FIGURE 8 is a view of the middle part of FIGURE 6 on a larger scale for showing in detail the rolling tool operation;

FIGURE 9 is a partial section through the upper part of the machine on the line IX—IX of FIGURES 1 and 6;

and

FIGURE 10 is a distance-time diagram for schematically showing the movement of the clamping devices and of the work piece to be rolled therewith, in dependence on time.

The machine has an upright especially of cast steel or of welded construction designated generally by the reference numeral 1. At its lower part 2 a machine table 3 is rotatably mounted on vertical axle 4. At its upper part 5 all tools and in particular the bevel gear rolling wheels are mounted. This upper part 5 is connected to the lower part 2 by means of a tie rod 7 arranged in the axle 4. This tie rod 7 engages with its bolt-like end 8 in a housing 9 provided in the lower part 2 and is secured by a strong wedge 10. For accommodating the tie rod, the upper part 5 of the machine is provided with a long barrel-shaped housing 32, of which the bore 11 receives the tie rod 7. At its upper end the tie rod 7 is provided with a threaded extension 12 on which are screwed the nut and counter-nut 13 which engage on a surface 14 of the upper part 5 of the upright.

Within the upright 1, in fact, in its lower part 2, an electric motor is arranged in a manner not shown which drives a V-belt pulley 16 through a multi-belt V-belt drive 15 (see FIGURE 9) which is keyed onto a shaft 17 rotatably mounted in the upper part 5 of the upright. On the shaft 17 a bevel gear 18 is keyed which drives a bevel gear 19 secured to a vertical shaft 20. The motor for driving the bevel gear 16 runs continuously during the operation of the machine.

The lower end of the shaft 20 (see FIGURES 5—6) is provided with a bevel gear 21 which meshes with a bevel gear 22 arranged on a shaft 23 rotatably mounted in the lower part 2 of the upright 1. To the shaft 23 is secured a bevelled pinion 24 which meshes with bevelled teeth 25 (see FIGURE 3) provided on an intermediate wheel 26 (sun wheel). This intermediate wheel 26 (sun wheel) is mounted for free rotation on the tie rod 7 with the help of roller bearings 30. The outer periphery of the wheel 26 is provided with frontal teeth 27 which mesh with a plurality of spur wheels 28. The frontal teeth 27 extend to such an extent in the direction of the axis of the tie rod 7, that the spur wheels 28 (planet wheels) are movable to a desired extent axially without losing engagement with the frontal teeth 27.

The rotatably mounted work table 3 is provided with a ring of teeth 29 which mesh with a toothed pistons 166 which is not shown and which is driven by an electric motor not shown or by a hydraulically operated piston. In this way the working table 3 can be turned step by step or intermittently about an axis 4.

On the work table 3 a plurality of clamping devices are arranged uniformly spaced from one another about a circle. These clamping devices are designated 31 in general and are uniformly with one another. At the upper part 5 of the upright machine tools are arranged which will be described later for working on the bevel gear blanks which are secured in the individual clamping devices 31. In this way the working table provides a number of different stations, a station being formed at which a bevel gear blank is secured to a clamping device and also a further station at which a bevel gear is unclamped and removed from a clamping device. In the illustrative example, eight such stations are provided, which are designated A, B, C, D, E, F, G and H (see FIGURE 5). All these stations have like clamping devices 31 arranged on the work table. In the station A the bevel gear blank is introduced into the machine and secured to a clamping device. From this position it is provided at the upper part 5 of the upright, namely at the barrel shaped housing 32, in which the bore 11 is provided for receiving the tie rod 7, a holder 33 which has a magazine 34 in which the bevel gear blanks 35 are arranged one above the other.

After the loading station A there follow for example three heating or prewarming stations B, C, D. Here the previously clamped bevel gear blank is heated to the working temperature in the zone which is to be toothed. The heating takes place in one or more steps so that for example the working temperature is first reached at the outer surface in the third step D, the temperature at the interior of the zone to be toothed being generally lower, and the bevel gear in the region of its bore or its bushing where it is clamped remains substantially below the working temperature. The work piece 35 clamped in a clamping device at station A is transported by the corresponding rotation of the work table 3 to the station B where by means of an inductor 36 it is heated by induction middle-frequency heating. Thereafter the working table 3 carries the blank through a corresponding rotation to the step C, where with the help of a second inductor 37 it is further heated, whilst at the same time a bevel gear blank which has been introduced at step A and clamped is moved to the first heating station B.

The first-mentioned bevel gear blank is then after its further heating by means of the inductor 37 conveyed through a further rotation of the work table 3 to the station D, where the heating of the region of the first blank to be toothed to the temperature for deformation is completed by means of the inductor 38. The three inductors 36, 37 and 38 are connected to one another by a busbar 39 or by individual transformers in a way not shown. The busbar 39 is secured to the upper part of the upright by means of bolts 40.

In the next following station E takes place a pre-rolling of the teeth on the bevel wheel blank in a way to be further described below, whereas the already pre-rolled blank is again heated in the next following station F, this heating being again preferably effectuated by middle-frequency induction heating. At the station F connection is made to the station E, i.e. the final rolling of the bevel wheel blank takes place. The ready rolled bevel gear is then transported from the station G to the station H by means of a further rotation of the work table, where the prepared bevel gear is released and removed.
Thus there accordingly takes place the production of bevel gears by warm rolling continuously in that at each working step of the working table a blank is introduced at the station A and there secured and a completed rolled bevel gear is removed at the station H.

The working table 3 is provided at its periphery with stop indentations 167 which are arranged for co-operation with a stop catch 160 on the machine upright 1 so that at each engagement of the catch in an indentation 167 the number of which corresponds to the number of stations A to H the working table 3 is secured in one of its working positions. The stop catch 160 can be spring loaded but can however also be controlled hydraulically, for example.

All the working parts connected with the support, clamping and unclamping of the bevel gear blanks to be rolled are operated hydraulically. For this purpose—as is shown especially in FIGURES 3 and 4—a clamping device housing 41 is provided which has at its lower end a cylindrical space 42 in which an ejector piston 43 and a clamping piston 44 are mounted for axial displacement. The clamping device housing 41 is connected rigidly through the above-mentioned tooth wheel 28, so that the clamping device housing is arranged rotatably in the table 3 about its axis 45 and axially displaceable.

In the axis 45 of the clamping device a clamping piston rod 46 is arranged which is securely connected to the clamping piston 44. In the axis 45 region of the clamping device space 42 the rod 46 is surrounded by a bush 47 on which the ejector piston 43 is displaceably arranged by means of corresponding packing 169. This bush 47 connected is at its upper part with the clamping device housing 41 and at its lower part with an intermediate cover 48 through which the rod 46 projects. At its lower side of this intermediate cover 48 engages the outer periphery of the upper end of a bushing 49, which at its upper end projects against a shoulder 50 of the toothed wheel 28 connected fast to the clamping device housing 41. In this way the intermediate cover 48 is held securely in its axial position and separates the lower working space 51 of the ejection piston 43 from the upper working space 52 of the clamping piston 44; whilst the lower working space of the piston 44 is designated with 53, the upper working space of the ejection piston 43 is provided with the reference numeral 54.

The lower working space 53 is not actuated and connected in any way with the interior of the lower part 2.

As is seen especially in FIGURES 3, 4 and 6, the toothed wheel 28 is provided at its lower side with a pressure relief bush 55 which is suitable for supporting the pressure mushroom head 56. This mushroom head 56 is rotatably mounted with the help of radial bearings 57 and thrust bearings 58 on the plug 59 of a stepped or differential piston, which carries the general reference number 60 and comprises the step 61 of smaller diameter (see FIGURE 6). In this way a working space 63 of greater cross-section and an annular working space 64 of smaller cross-section is provided. The cylinder 65 receiving the piston 60 is connected securely to the lower part 2 of the upright 1.

At the cover 179 of the cylinder 65 an abutment 125 is provided against which the ledge 171 formed between the two piston steps 61 and 62 lies in the upper position of the piston 60.

In FIGURE 6 a specially large construction of this supporting head 56 with the stepped piston 60 is shown. This is provided only at the stations of E and G where the rolling of the teeth takes place. At the remaining stations correspondingly smaller support mushroom heads are arranged as is shown in FIGURES 3 and 4, of which the construction corresponds with that of FIGURE 6.

The clamping device housing 41 projects a projector 66 in the form of a rod, which in the withdrawn position, as is shown in FIGURES 3 and 4 projects at one end into the upper working space 54 of the ejector piston 43.

The clamping device housing 41 is at its upper end provided with a swaged or narrowed down projection 67 which forms a horizontal surface 68 on which lies which is connected securely for example by means of screws with the clamping device housing 41. The outer diameter of this disc 69 is somewhat greater than the largest diameter of the underlying parts of the clamping device housing 41. In the work table in a corresponding way a shoulder surface 70 is provided on which lies on a shoulder ring 71 which is made from a material of good frictional properties for example bronze.

At the upper surface of this shoulder ring 71 is supported the outer part of the intermediate disc 69. Beneath the shoulder ring 71 in the clamping device housing 41 is provided a ring shaped working space 72 which is sealed at the shoulder ring 71 by a packing ring 73.

The ejecting rod 66 projects through the disc 69 and engages with its upper end against the adjustable work piece support 74 which is connected by a spring and groove connection 75 for axial displacement to the clamping device 31 and for rotation therewith for effecting the ejection. For exact transfer of turning force from the clamping device 31 to the work piece 35 moreover a further spring and groove assembly 76 is arranged between the piston rod 46 and the projection 67 of the clamping device 31.

At the upper end of the piston rod a conical body 78 is releasably connected by means of a screw 77 connected thereto. This conical body acts in a known way with its conical surface on the upper conical surface 79 of a split spring chuck or collet 80 of which the lower conical surface 81 lies against a conical surface 82 which is provided at the outer end of the abutment 67 of the clamping device housing 41. The split collet 80 is cylindrical at its outer periphery and is pushed into the bore of a bevel wheel blank 35 for the purpose of securing this. If now the conical body 78 is further secured to the piston rod 46 and the piston rod is moved downward, the spring collet 80 is pressed outwardly whereby the bevel gear blank 35 is securely fastened and clamped to the upper surface 84 of the closure disc 74 (tool support 74).

In the closure disc 74 (tool surface support 74) a series of uniform borings 85 divided by a diameter are provided, through which in forming a shoulder 85 a threaded bolt 86 projects, which is screwed into the intermediate disc 69. A coil spring 87 is arranged between the head of the bolt 86 and the shoulder 85.

The working table 3 is rotatably mounted by means of a hub 88 on the tie rod 7, in that it is supported uniformly over the pressure and roller support 89 of the intermediate wheel 96 (sun wheel), and therewith the housing 9 of the lower part 2 of the upright.

Before going into the method of working of the clamping device 31, the roller tools and their drive will be explained. Over the shaft 17 which is rotatably mounted in the upper part 5 of the machine upright (see FIGURES 6, 7 and 9) and which is driven by the common driving roller motor, a shaft 95 is mounted parallel to it. This shaft 95 is driven from the shaft 17 through a gear changing device 91 of which the input wheel is designated by 92 and the output wheel by 93. The gear change can be adjusted in known way to alter the speed reduction ratios. To this purpose a closable door 94 is provided in the upper part 5 of the upright.

From the shaft 90 two shafts 95 extending parallel to one another are driven in a completely similar way. The axis of the one shaft 95 is designated by 96 and that of the other shaft 95 by 97. The shaft 95 with the axis 96 is driven through a pair of bevel gears 98, 99, whilst the shaft 95 with the axis 97 is driven through a pair of bevel gears 100, 101.

The two shafts 95 each serve to drive a tool attachment in that each of the tool attachments is mounted in
a hub-like housing 103 which forms a part of the top of the upright. As can be seen from FIGURE 1, two housings 102, 103 of this kind and therefore two roller tool attachments are provided, which correspond to stations E and G. It is however clearly to be understood that a single roller tool station or more than two roller tool stations can be provided. As will be subsequently seen separately there relates to each rolling tool station E, G, three bevel gear rolling tools 6. It is however also possible at each station to increase or reduce the number of such tools.

In the following only one gear cover of a shaft 95 is spoken about and it is emphasized that the gear covers of both drive shafts 95 and the associated roller tools are constructed in completely similar ways.

The shaft 95 drives a bevel gear pinion 104 which meshes with a pinion 105 (bevel gear), the bevel gear pinions 104, 105 being arranged in a special housing 106. The two bevels above the housing 103 or 102, which is securely connected to the housing 103, 102 and thus with the upper part of the machine upright. The bevel gear 105 is securely connected to a toothed member (hollow shaft) 107, although the centre of which a shank 108 extends. The toothed body 107 (hollow shaft) is rotatably mounted on the housing 106 or the cover 109 associated therewith. The shaft 108 is turnbually mounted in a drum-shaped support housing or body 110, by means of two support bodies (roller supports) 111, 112, in that axial displacement between the shaft 108 and the support body 110 is prevented by means of shoulders 113, 114 (mut with counter nut). The support body 110 is secured against rotation but is however axially displaceable in a bore 115 of the housing 103 of the machine upright 1. At the upper part of the outer periphery of the support body 110 is cut a square section trapezoidal or buttress type thread 116 on which is threaded a nut 117 which is made from material with good frictional properties, for example bronze, and which is provided on its outer periphery with worn teeth 118. In this worm thread 118 engages a worm gear 119 which is mounted for rotation in the housing 103 or 102 and can be turned manually by means of a hand wheel 120 which is secured on the shaft of the worm gear 119. By turning the hand wheel the axial position as regards height of the support body 110 and therewith of the shaft 108 can be precisely adjusted to a fraction of a millimeter. Instead of the hand wheel 120 a positioning motor can of course be provided for adjusting the axial height of the shaft 108.

In this connection the upper part of the shaft 108 is provided with a spline 121 which engages in a correspondingly long constructed spline 122 in the bore of the bevel wheel body 107. In this way the axial position of the shaft can be altered without influencing the working engagement between the body 107 and the shaft 108. At the lower end of shaft 108 is secured a bevel gear 123 which centers with a bevel gear 124. The two bevel gears are connected below two cover housings 125, 126 which are secured to the support body 110. The bevel gear 124 is connected by a spring and groove connection 127 for rotation with a tool reception head 128 which is rotatably attached to the housing 129, 130 and axial roller supports 131, 132 in a cover support body 125, 126, which unifies the assemblies. Tool reception body 128 has a central bore through which a threaded bolt 133 projects. The threaded end 134 of this bolt engages in a corresponding threaded bore which is provided at the far end of the tool attachment 6. This tool attachment is at its outer end provided with bores 135 and moreover has a bevel seating surface 136, which is able to co-operate with a corresponding seating surface of the tool reception 128. At the conical seating surface 136 is attached a cylindrical projection 137 in which the threaded boring for receiving the threaded end 134 of the bolt 133 is provided. At the threaded bore is connected a bore 172 which reaches to engage at the teeth 135 of tool attachment 6.

In that the bolt 133 can be screwed up from outside, the bevel gear tool 6 with its seating 136 and its cylindrical projection 137 can be inserted within the tool reception head 138 and secured thereto.

The threaded bolt 133 has a central bore 138 which stands in connection with a water connection 139 through a transverse boring and is sealed to the base of the bore 172 by means of an extension tube 140 and therewith continued to be sealed under the teeth 135 of the tool 6. The tube 140 dips with a great deal of play or intermediate space into the bore 172 of the tool attachment 6. A cylindrical space 141 is left free around the bolt 133 and is in connection with a water connection 145 through a transverse bore 16 and is also connected with the bore 172 of the tool inset 6 through longitudinal bores, not shown, which are provided in the tool inset 6 outside its axis. Cooling water enters for example at the connection 145 flows through the annular space 141 to the bore 172 within the tool 6, there cooling the tool, and travels then in a more or less warmed condition through the tube 140 and the water connection 139 and the cooling medium can then be recycled and it is possible to use another cooling liquid instead of water.

As is clear especially from FIGURES 1 and 2, but also from FIGURES 6 and 8, each shaft 108 drives by means of the bevel gear 133, 134 the three of this kind of bevel gear roll working tool 6 which are arranged uniformly about its periphery. The number of rolling tools at each station is however—as already emphasized above—dependent in particular on the shape and size of the work piece.

The clamping device 31 and the working spaces 63, 64 of the mushroom support head 56, are hydraulically actuated and controlled. The lower working space 53 of the clamping piston remains unactuated whilst the upper working space 52 of the clamping piston is actuated for the purpose of clamping a bevel gear blank 35, by pressure fluid which flows in through ducts 146 provided in the working table 3 and a long annular space 147 (grooved canal) in the clamping device housing 41. In the corresponding way the lower ejector working space is actuated by pressure fluid through a long annular space 148 (grooved canal) and ducts 149. The upper working space 54 of the ejector piston is actuated by pressure fluid through grooved ducts 150 and conduits 151. The return space 72, which is provided in the clamping device housing 41 is actuated by pressure means through ducts 152 whilst through a circlip 153, leaking oil is led from the outer peripheries of the differential rings 154 and from this connection packing collars 154 are provided for sealing this outer periphery. The in- and out-flow of the oils takes place in a manner not shown by bores 174 which are provided in the tie rod 7 (see FIGURE 5).

The working table is cooled by means of wants from within. To this purpose the individual clamping devices are located in a barrel-like housing 156 which forms a part of the working table 3 (see in this connection the chain dotted line of FIGURE 5). This barrel-like housing is compensated with the interior bore 157 of the working table by links 158 in which the oil ducts 147, 149, 151, 152 and 153 are arranged. In these links, moreover, are provided windows 159, so that the single chambers 160 formed in this way are in connection with one another. Each of these chambers 160 has an inlet and outlet duct in that for example a bore 161 serves as the outlet duct for cooling water and the bore 162 is provided for the inlet. A cap 162 transfers the force of the two nuts 163 to the table 3 and provides two annular spaces 164, 165 which are sealed by packing rings 143, 144 and from which the inflow and outflow of the water for cooling the working table takes place through the bores 161, 162.

The clamping devices 31 are adjusted by means of a master wheel, a stencil or template, or by normal means.
In this way the support head 56 is moved against the abutment 155 in FIGURE 6. This abutment 155 secures all the clamping devices in the highest position whereby each clamping device provided at the roller stations E and G reaches the highest position first at the end of the rolling or forming process.

In the distance-time diagram of FIGURE 10 the distance covered by the clamping devices 31 and therefore by the workpieces to be rolled are set out in dependence on time (the distance as ordinate and the time as abscissa). The solid line drawn shows the circumstances at heating at one of the stations A, B, C, D, and F, the chain dotted line those in rolling or forming at the stations E and G.

On heating, according to the displacement-time diagram of FIGURE 10, the mushroom support head is quickly moved into its upper position against the abutment 155 (trend line c) and remain during the whole heating process in their upper position (trend line d). Whilst the support head for the heating station is acted upon by means of a low pressure pump only, the same low pressure pump and in addition a high pressure pump of low pressure pump of low operating the support head for the two rolling stations. Both pumps operate also the working space 63 of FIGURE 6. If however the clamping device 31 in a rolling station E, G accelerates according to trend line e of FIGURE 10 and the roller tool enters into engagement at the corner point F of the trend line, then according to the displacement-time diagram of FIGURE 10, the support shoulder 56 is not in its upper position. The resistance increases so that the low pressure pump is no longer in the position to overcome the operating resistance and at this time only the high pressure pump is supplying with a corresponding retardation of the lifting of the lever 56 and therewith of the clamping device 31 and the work piece during the rolling (see trend line g). The delivery quantity of the high pressure pump is proportioned to the working velocity of the rollers. In both the working stations E and G the support head again reaches the abutment 115 at the end of the rolling process in that during the rolling process the profile is only roughly rolled out, whilst the completion rolling produces the final profile. The pressure of the pump however then increases in order quickly to reduce after reaching the highest pressure of an adjustable over-pressure valve or in dependence on the possible adjustment of a time meter (trend line h), whereafter the annealed work piece is quickly moved away from the working tool, in order to prevent excessive heat transfer.

All the clamping devices of the working table are positioned at this height. After a bevel gear blank 35 is clamped in the station A by actuation of the working space 52, this working space remains under pressure during the whole cycle, so that the bevel gear blank remains clamped. Shortly before the further movement of the working table 3 through one division however the working space 63 of the support pillar 56 is discharged and the annular return space 64 is charged. About the same time pressure fluid enters into the return space 72 of the housing 41 of the clamping device. Then the support head 56 moves back into its lower position. At the same time the whole housing of the clamping device, which consists of parts 41, 69 and 74, is moved back into the position shown in FIGURE 3, in which the disc 71 mounted resting in the work table 3 serves as an abutment. The rotation of the whole clamping device about the axis 46 is thus permanently carried on so that the unclamped face of the disc 69 is slidingly supported on the upper surface of the disc 71. In this return position a sufficient clearance of for example five millimeters between the lower surface of the support head 56 must be allowed to remain. At this time the table 3 can be returned to a further position, whereon the return working space 72 and the working space 64 are discharged whilst the working space 63 loads the support head, whereon the whole clamping device 31 with the bevel wheel blank 35 clamped thereon is raised to the desired position, whereafter this blank is heated by means of inductor 36 in the first step and is turned about its own axis 45.

This cycle is continued in the stations C, D, E, F, and G, the blank not being heated in stations E and G, but by means of the toothed wheel tool 6 is provided by a rolling process with teeth by rolling. If then after the ending of the preliminary rolling at the station G the ready rolled bevel wheel is transported to the station H, then moreover in the described way the support shoulder 56 is disengaged and the whole housing 41, 69, 74 is returned by actuation of the return working space 72. However now the work space 52 is also discharged so that the collet 80 is no longer under pressure. At this time the lower re- jector space 51 is actuated by the pressure fluid, so that the rejection piston 43 moves upwards and pushes upward the rejection rod 66. The rejection rod 66 at this time lifts the closure disc 74 (work piece support 74) against the resistance of the spring 87, on which rests the wheel blank 35 now provided with teeth. In this way the gear wheel is lifted out of the region of the collect 80 and can be ejected at the station H in a known and not shown way, for example with a single stripper. The work space 51 is now discharged and the work space 54 is actuated by the pressure means, so that the rejection piston 43 is returned to its lower initial position.

At the same time the disc 74 moves back under the influence of the spring 87 into its initial position, the ejector rod 66 being pushed further downward. The clamping device is now ready for receiving and for clamping a new bevel gear blank, the table having already moved to this purpose from position at the end station H to the initial station A.

What I claim is:

1. Apparatus for rolling bevel gears comprising a machine having a base, a work table rotatably mounted on said base, means intermittently rotatably indexing said work table, a plurality of rotatable bevel gear blank clamping means mounted on said work table at equal distances from the axis thereof, gear blank loading means comprising a loading station mounted on said base above said work table adapted to place a gear blank in said clamping means as the clamping means are positioned thereunder, at least one heating means comprising a heating station mounted on said base above said work table adapted to heat the clamped gear blank after leaving the loading station, at least one bevel gear rolling tool mounted on said base above said work table, a rolling station forming gears teeth on the blank after the clamped blank leaves the heating station, and means unclamping and removing the formed gear from the clamping means comprising an unloading station mounted on said base after gear leaves the rolling station.

2. Apparatus for rolling bevel gears as in claim 1, wherein a plurality of heating stations are mounted on said base successively heating the gear blank prior to indexing the work table to move the blank to the rolling station.

3. Apparatus for rolling bevel gears as in claim 1, wherein a plurality of rolling stations are mounted on said base, wherein the rolling of the blank is accomplished in stages and a heating station interposed between the adjacent rolling stations, to reheat the blank between rolling stages.

4. Apparatus for rolling bevel gears, comprising a machine having a base, a work table rotatably mounted on said base, means intermittently rotatably indexing said work table, a plurality of rotatable bevel gear blank clamping means mounted on said work table at equal distances from the axis thereof, clamping means comprising a loading station mounted on said base above said work table, means supporting said clamping means within said work table for axial movement thereto, gear blank loading means comprising a loading station mounted on said base above
said work table adapted to place a gear blank in said clamping means as the clamping means are positioned thereunder, at least one heating means comprising a heating station mounted on said base above said work table adapted to heat the clamped gear blank after leaving the loading station, at least one bevel gear rolling tool mounted on said base above said work table comprising a rolling station forming gear teeth on the blank after the clamped blank leaves the heating station, means unlamping and removing the finished bevel gear from the clamping means comprising an unloading station mounted on said base above said work table and means indexing and moving the finished bevel gear toward and away from said stations after each indexing of said work table.

5. Apparatus for rolling bevel gears comprising a machine having a base, a work table rotatably mounted on said base, means intermittently rotatably indexing said work table, a plurality of rotatable bevel gear blank clamping means mounted on said work table at equal distances from the axis thereof, gear blank loading means comprising a loading station mounted on said base above said work table adapted to place a gear blank in said clamping means as the clamping means are positioned thereunder, at least one heating means comprising a heating station mounted on said base above said work table adapted to heat the clamped gear blank after leaving the loading station, at least one bevel gear rolling tool mounted on said base above said work table comprising a rolling station forming gear teeth on the blank after the clamped blank leaves the heating station, said rolling station including a tubular support body mounted for axial movement on said base coaxial with the axis of the clamping means and gear blank located at the rolling station, a gear shaft concentrically supported within said tubular body, said rolling tool rotatably mounted on said body having an axis obliquely disposed to the axis thereof, gear means establishing a driving connection between said drive shaft and said rolling tool, and means mounted on said base selectively axially positioning said support body thereto.

6. The method of producing bevel gear wheels by hot rolling, comprising the sequential steps of clamping a cold bevel gear blank in a holder and rotating the holder and gear blank, induction heating the clamped rotating bevel gear blank in several predetermined graduated temperature stages allowing a predetermined time to elapse between each of said heating stages to allow the heat to be conducted inwardly of the material thus evenly heating said bevel gear blank to a predetermined temperature and depth in the localized area in which the teeth are to be formed, prerolling the teeth of the clamped rotating bevel gear blank by means of at least one preliminary bevel gear tool, intermediate induction heating the prerolled teeth in the localized area thereof to compensate the loss of heat during prerolling, finish-rolling the teeth of the clamped rotating blank by means of at least one finish bevel gear tool and unlamping and removing said finished bevel gear wheel from the holder.

7. A machine for rolling bevel gears comprising a machine base, a work table rotatably mounted on said base, means intermittently rotatably indexing said work table, a plurality of rotatable bevel gear blank clamping means mounted on said work table at equal distances from the axis thereof, gear blank loading means mounted on said base above said work table forming a loading station adapted to place a gear blank in said clamping means as the clamping means are positioned thereunder, induction heating means comprising a plurality of heating stations mounted on said base above said work table, said heating means being adapted to heat the clamped rotating gear blank indexed from the loading station through said heating stations in the localized zone of the teeth to be rolled in a graduated predetermined manner with an even temperature to a predetermined depth, at least one bevel gear prerolling tool mounted on said base above said work table comprising a prerolling station for rolling preliminary teeth on the rotating blank after the clamped blank is indexed from said intermediate heating station to said finish-rolling station, and means unlamping and removing the finished bevel gear from the clamping means comprising an unloading station mounted on said base after the bevel gear leaves the finish-rolling station.

8. A machine for rolling bevel gears, comprising a machine base, a work table rotatably mounted on said base, means intermittently rotatably indexing said work table, a plurality of rotatable bevel gear blank clamping means mounted on said work table at equal distances from the axis thereof, gear blank loading means with respect to said work table, means supporting said clamping means within said work table movement thereby, gear blank loading means mounted on said base above said work table forming a loading station adapted to place a gear blank in said clamping means as the clamping means are positioned thereunder, induction heating means comprising a plurality of heating stations mounted on said base above said work table, said heating means being adapted to heat the clamped rotating bevel gear blank indexed from the loading station through said heating stations in the localized zone of the teeth to be rolled in a graduated predetermined manner with an even temperature to a predetermined depth, at least one bevel gear prerolling tool mounted on said base above said work table forming a prerolling station for rolling preliminary teeth on the rotating blank after the clamped blank is indexed from said intermediate heating station to said finish-rolling station, and means unlamping and removing the finished bevel gear from the clamping means comprising an unloading station mounted on said base after the bevel gear leaves the finish-rolling station.

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