June 15, 1943. J. O. BISHOP ET AL 2,321,645

APPARATUS FOR FLAME HARDENING OF ARTICLES

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Fig. 1

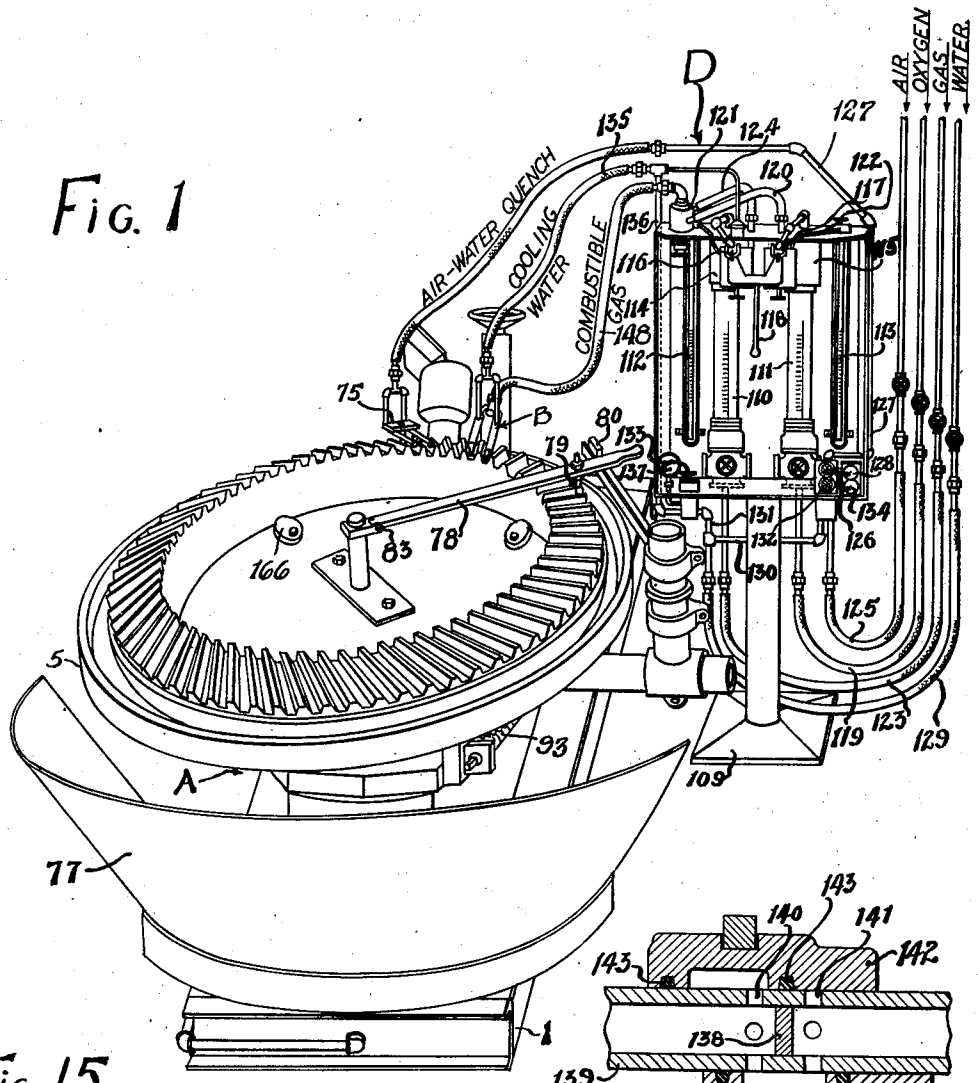


Fig. 15

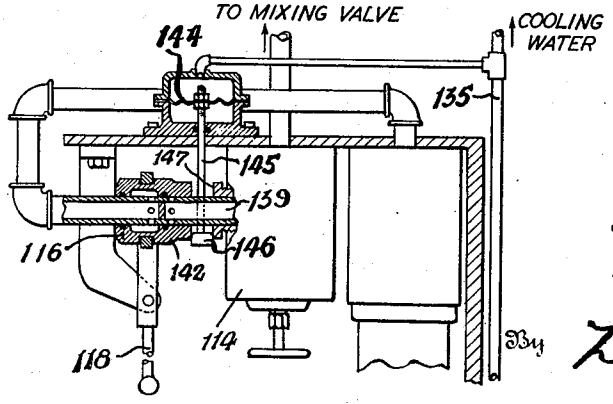


Fig. 16

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APPARATUS FOR FLAME HARDENING OF ARTICLES

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Fig. 2

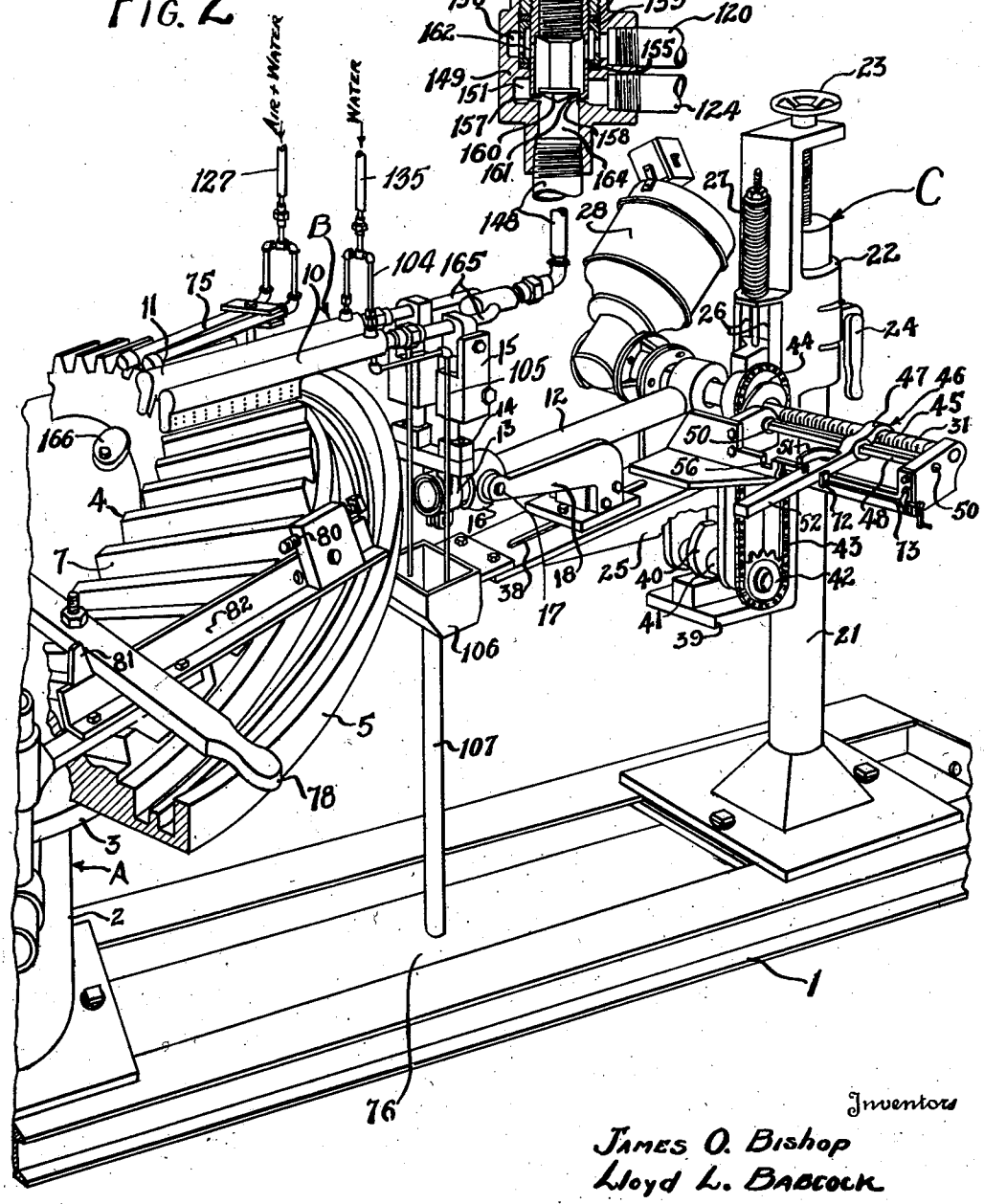


Fig 3

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APPARATUS FOR FLAME HARDENING OF ARTICLES

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Fig. 6

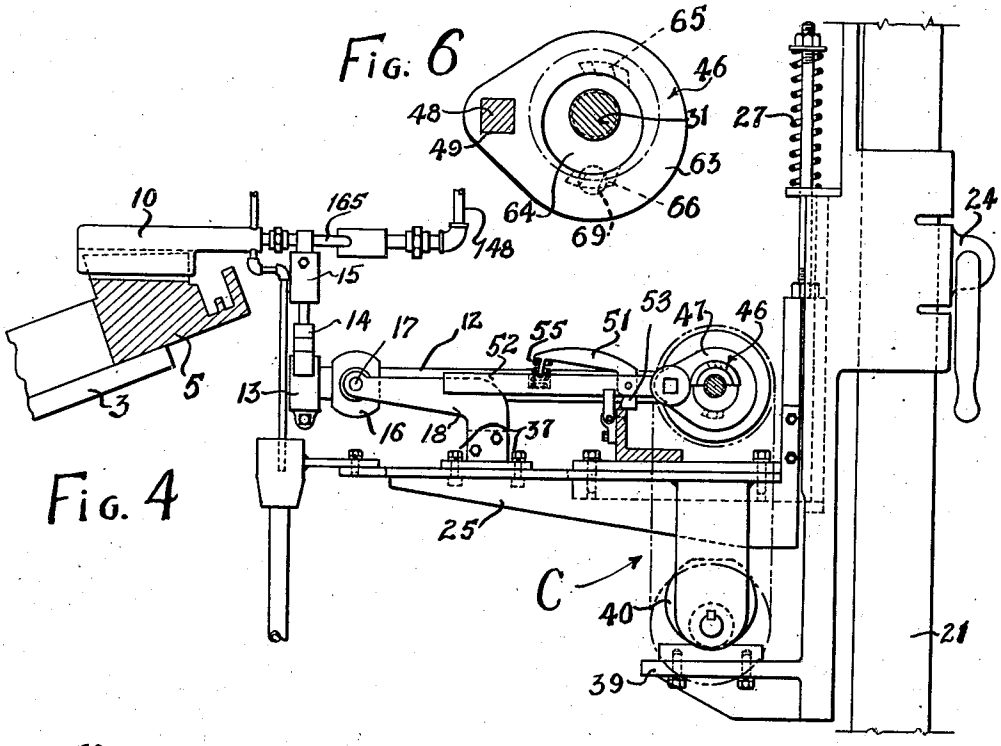


Fig. 4

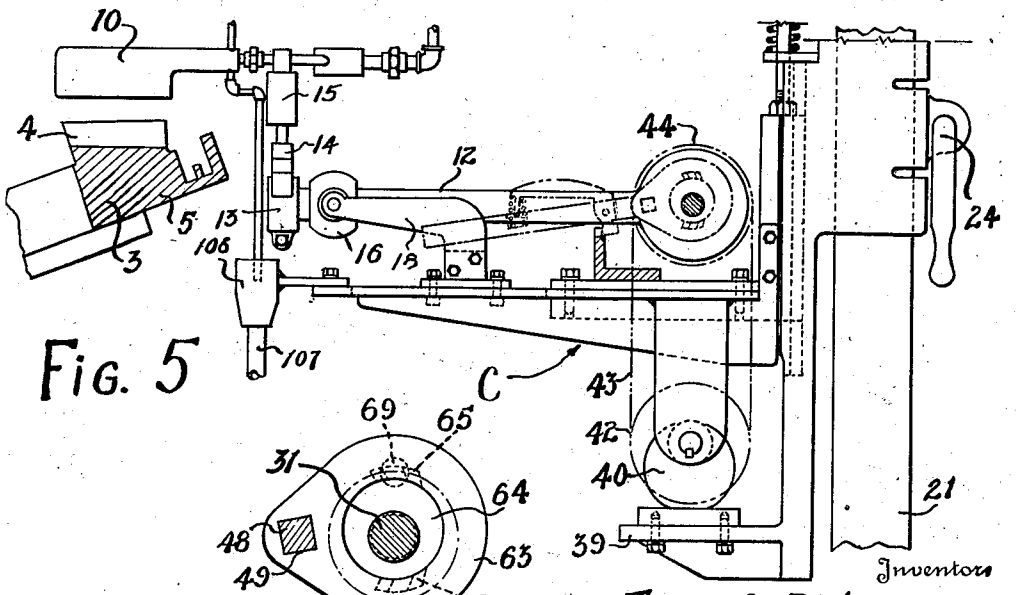


Fig. 5

Fig. 7

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APPARATUS FOR FLAME HARDENING OF ARTICLES

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Fig. 8

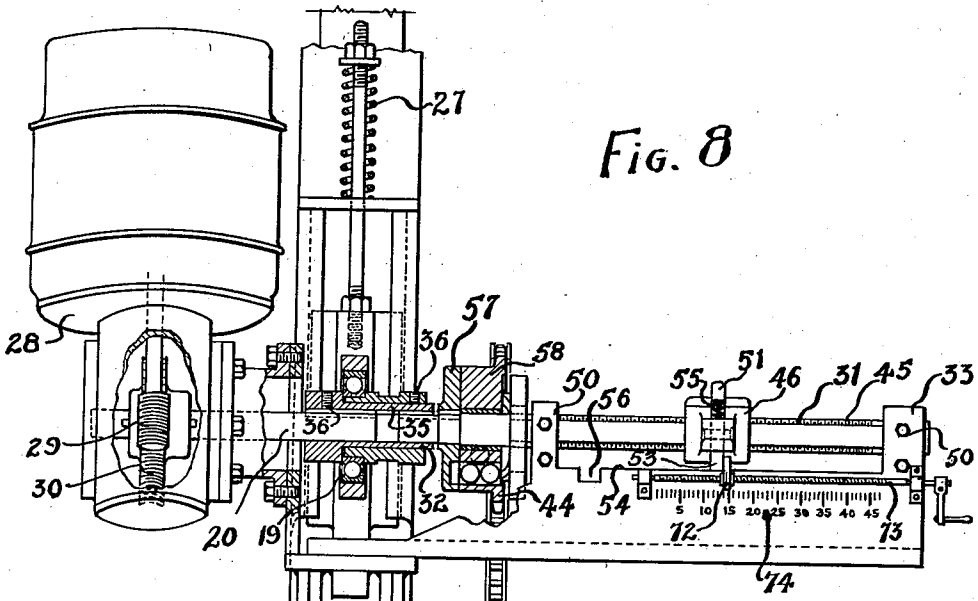


Fig. 9

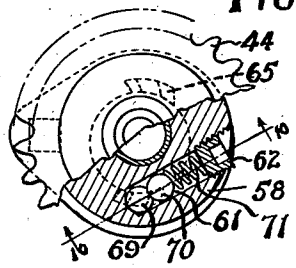


Fig. 11

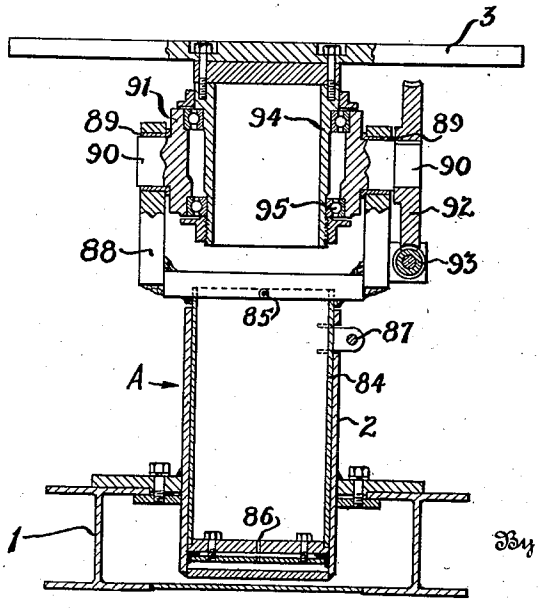
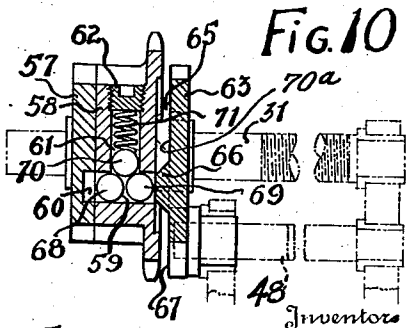


Fig. 10



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APPARATUS FOR FLAME HARDENING OF ARTICLES

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Fig. 12

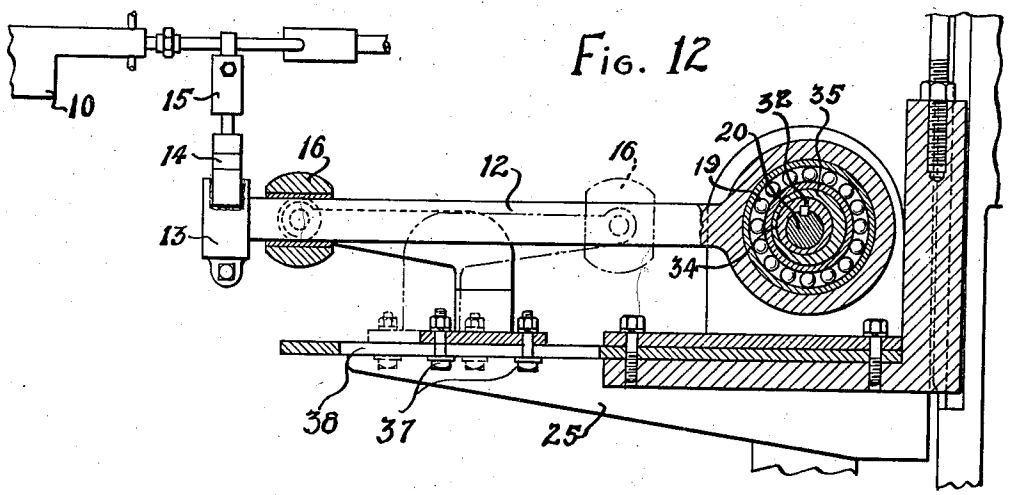


Fig. 13

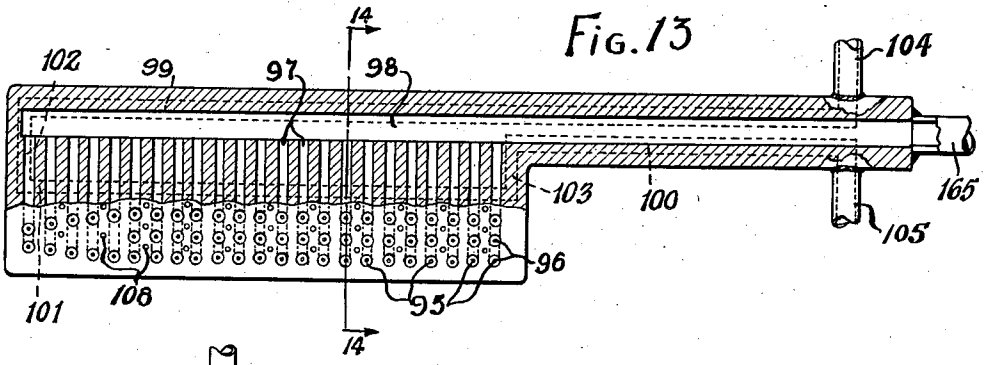
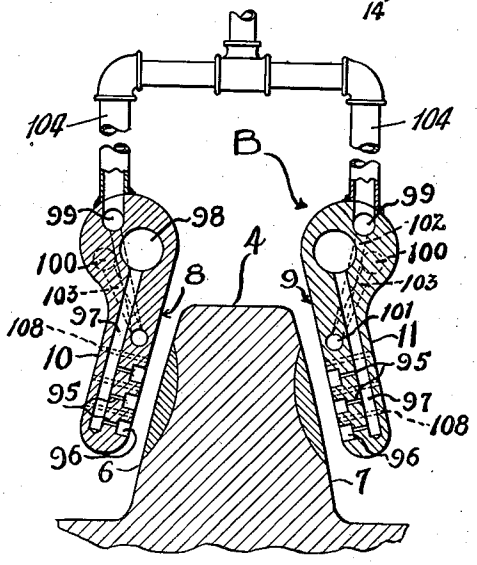


Fig. 14



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Patented June 15, 1943 2,321,645

UNITED STATES PATENT OFFICE

2,321,645

APPARATUS FOR FLAME HARDENING OF ARTICLES

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Application August 3, 1940, Serial No. 350,196

11 Claims. (Cl. 266—4)

This invention relates to a method of and apparatus for the treating of metallic surfaces to flame-harden the same and is more particularly directed toward the provision of a method and apparatus for flame-hardening the teeth of a gear.

In the flame-hardening of a metallic surface, it is essential to provide a method of producing uniform flame distribution and heating over the surface to be hardened and in such manner as to avoid the building up of stresses within the body so treated and the localization of the heat as applied to the surface.

It is also essential to provide a method and apparatus which makes possible very accurate control of the time of the treatment, as well as to insure the even distribution of the flame and heating over the entire surface during the said time interval.

In the particular problem of flame-hardening a gear tooth, it is desirable that the method and apparatus be susceptible of producing a uniform heat treatment of the gear tooth from its opposed or opposite flanks simultaneously and over the entire area of such flanks.

It is therefore an object of this invention to provide a method for the flame-hardening of the opposed flanks of the gear by simultaneous directing of flames over the entire surface of the flanks in a direction substantially normal to the flanks and oscillating the flames as directed in a curved path substantially parallel with the said flanks.

Another object of this invention is to provide an apparatus for the flame-hardening of the gear tooth, which apparatus includes a pair of oppositely disposed and directed torches having a multiplicity of flame-directing apertures extending substantially the length of the flanks of the gear tooth, and a means for supporting the torches in a position parallel with the flanks, and means for imparting an oscillatory motion to the supporting means to move the torches in a curved path substantially parallel with the flanks to obtain distribution of the flames evenly over the flanks and from the opposed sides of the gear tooth.

Another object of this invention is to provide a method and apparatus for heat-treating the entire length of the flanks of the gear tooth simultaneously without the necessity of traversing the tooth or flanks with the heating element.

Another object of this invention is to provide a method and apparatus for directing a mat type flame against a surface to be hardened from a torch which oscillates in a substantially elliptical path.

Another object of this invention is to provide a method and apparatus for directing flame against a surface to be hardened, including flame distribution members including a plurality of flame producing apertures, and a means for increasing the heat intensity in the fuel as burned at the point of application of the flame to the to the surface to be hardened.

Another object of this invention is to produce a method and apparatus wherein the time of heat or flame application to a surface may be accurately regulated and whereby the heat-directing means is maintained during such period of time adjacent the surface to be heat-treated.

Another object of this invention is to produce a flame-hardening method and apparatus which embodies the provision of a means operable to maintain a wide range of mixtures of heat producing fuel and gas required for combustion thereof and which is operable over a wide range of flow rates to maintain such efficiency.

Another object of this invention is to provide a flame-hardening method and apparatus which includes safety means operable to prevent accidental over-heating of the apparatus by controlling the flow of the combustible gas utilized until circulation of the required cooling medium is established.

Other objects and advantages of this invention it is believed will be apparent from the following detailed description of a preferred embodiment thereof as illustrated in the accompanying drawings.

In the drawings:

Figure 1 is a perspective view of the apparatus embodying this invention and diagrammatically illustrating the method of operation thereof.

Figure 2 is a fragmental perspective view thereof upon an enlarged scale.

Figure 3 is a longitudinal sectional view of the mixing valve embodied in our invention.

Figure 4 is a diagrammatic side elevation partly in section illustrating the flame-applying or torch means in operable position with respect to the surface to be flame-hardened.

Figure 5 is a view similar to Figure 4 illustrating the position of the parts with the flame-directing or torch means raised to inoperable position.

Figure 6 is a detached detail view illustrating the clutch shifter element with the parts in the position of Figure 4.

Figure 7 is a view similar to Figure 6 illustrating

the clutch shifter elements in the positions corresponding with Figure 5.

Figure 8 is a front elevation partly in vertical section of the timing mechanism and associated parts.

Figure 9 is a fragmental view partly in section illustrating the construction of the half-revolution clutch embodied in our invention.

Figure 10 is a sectional view taken substantially on the line 10—10 of Figure 9.

Figure 11 is a sectional view illustrating the construction of the adjustable supporting standard for the article to be flame-hardened.

Figure 12 is a sectional side view illustrating the details of construction and operation of the means provided for imparting an oscillatory motion to the torches.

Figure 13 is an enlarged sectional elevation of one of the torches embodied in our invention.

Figure 14 is a sectional view taken substantially on the line 14—14 of Figure 13 and illustrating the position of the torches with relation to a section of a gear tooth.

Figure 15 is a diagrammatic view partly in section illustrating the safety device provided to prevent the flow of combustible gas to the torches until flow of the cooling medium for the torches has been established.

Figure 16 is a fragmentary sectional view illustrating the arrangement of the parts of the valve of Figure 15.

In carrying out the method embodying our invention, we prefer to utilize the apparatus as illustrated in the accompanying drawings, which apparatus includes generally a universal work supporting unit A, a flame or torch unit B, a torch unit timing and oscillating unit C which also functions to support the torch unit B, and a fuel and cooling medium supplying unit D for supplying fuel, gas necessary for supporting combustion of the fuel, cooling means for the torch unit, and the cooling medium required for quenching the flame-hardened teeth or surface after the flame treatment.

The method embodying our invention comprises the supporting of the surface to be hardened, as illustrated, the opposed flanks of a gear tooth, the providing and directing of flames over the entire surfaces of the opposed flanks of the gear tooth in a direction substantially normal to the surfaces and parallel therewith, and the distribution of the flames as supplied evenly over the surfaces of the tooth by oscillating the flames in a curved path substantially parallel with the plane of the surface to be flame-hardened, and then the proper quenching of the flame-treated surfaces in order to obtain the desired surface hardening thereof.

In order to effectively carry out this method, the apparatus as illustrated in its preferred form includes a base frame 1 upon which there is supported a standard 2, upon which there is supported the universally mounted work head or table 3 of the unit A. As will hereinafter be set forth, this table 3 is mounted so as to permit rotation in a horizontal plane, adjustment vertically to position the work, and supporting of the work illustrated as the gear teeth 4 of a rotary table 5 in position so that the teeth, or the opposed flanks 6 and 7 of the teeth, are parallel with the flame-emitting surfaces 8 and 9 of the torches 10 and 11 of the flame-producing unit B.

As illustrated, the gear table 5 may be provided with spiral gear teeth requiring that the torches 10 and 11 be slightly curved to permit each torch to fit in the recess or space between the teeth so as to be substantially parallel thereto and uniformly spaced throughout the entire length of the flanks 6 and 7 of the gear teeth 4.

Means are provided for supporting the torches 10 and 11 upon a supporting means so that the torches may be oscillated in a direction parallel with the flanks 6 and 7 and in a curved path in the parallel plane defined by the flanks 6 and 7 so as to provide for and insure uniform distribution of the flame over the said flanks 6 and 7 and to avoid all possibility of concentration of any single flame upon a point upon such flank surfaces.

In order to accomplish this result, the torches 10 and 11 are supported upon an oscillating bar 12 of the supporting and timing unit C. Secured to the forward end of the bar 12 are a plurality of adjustable adapters 13, 14 and 15, through the medium of which the torch unit B is adjustably secured to the oscillating bar 12 to permit aligning the torch surfaces 8 and 9 with the flanks 6 and 7. Means are provided for reciprocating the bar 12 and hence the torch unit B parallel with the flanks 6 and 7, which means include a bearing support 16 for the bar 12, which bearing support is carried upon trunnions 17 of a bracket 18. The opposed end of the bar 12 is enlarged to receive a bearing 19 which is mounted eccentrically with relation to the axis of the power shaft 20 so that rotation of the shaft 20 imparts an oscillatory movement to the bar 12.

The torch supporting, timing and oscillating unit C includes a standard 21, likewise supported upon the frame 1, upon which standard there is mounted for vertical adjustment the torch supporting head 22.

Vertical adjusting means are provided between the standard 21 and the head 22 through the medium of adjusting screw and wheel 23 and a clamping unit 24.

Carried by the head 22 is a carriage 25 which is slidably supported in ways 26 for vertical reciprocation. A spring 27 is provided for counterbalancing the weight of the carriage 25 and its attendant parts so that the same may be raised or lowered with a minimum of effort. The carriage 25 supports the motor 28 which provides the source of power for driving the power shaft 20 through a worm 29 and worm wheel 30 drive. An extension shaft 31 is positioned in axial alignment with the power shaft 20 and is rigidly coupled thereto by means of a sleeve 32 which has a key connection with each of the shafts 20 and 31. An outboard bearing 33 is provided for the outer end of the extension shaft 31.

Means are provided for varying the intensity or magnitude of the oscillatory movement imparted to the bar 12, providing both a fine adjustment and an adjustment which permits of a wide variation in intensity and in the path of oscillation given to the torches 10 and 11. This adjustment is particularly important to enable the changing of the torches 10 and 11 to vary the type and characteristics of the flame utilized for the flame-hardening as well as to permit adjustment of the eccentric means so that the flames as emitted from the torches 10 and 11 are uniformly directed over the surfaces to be flame-hardened without concentration of the effect of the flame at any particular point or region during the flame-hardening operation.

In order to provide for these adjustments, the sleeve 32 has an outer periphery which provides a cylindrical surface 34 which is not coaxial with

the axes of the shafts 20 and 31. Mounted on this eccentric surface 34 is an outer sleeve 35 which may be rotated to any desired angular position relative to the inner sleeve 32 and may be maintained in such desired position of adjustment by means of a set screw 36. The outer surface of the outer sleeve 35 is also cylindrical but not concentric with the surface 34. By this arrangement the magnitude of the eccentric mounting for the bearing 19 is capable of fine adjustment to enable adjustment of the oscillatory motion imparted to the torches 10 and 11. It will be apparent that by turning the outer sleeve 35 relatively to the inner sleeve 32, that any desired degree of eccentricity may be obtained ranging from zero to the sum of the individual eccentricities provided for by the sleeves 32 and 35.

Means are also provided for obtaining a much greater degree of adjustment of oscillation than is permitted through the variation of the eccentricities as hereinabove set forth. This additional adjustment is accomplished through the medium of the bracket 18 which supports the bearing 16 through which the bar 12 is reciprocated and by mounting this bracket upon the carriage 25 so that it may be reversed end for end as illustrated in the dotted lines in Figure 12 to vary the position of the bearing 16 along the length of the bar 12, and also by reason of the fact that the bracket 18 is secured to the carriage 25 by means of bolts 37 positioned within the slot 38.

Means are provided for raising and lowering the carriage 25 to enable the torches 10 and 11 to be moved to or from operative position with relation to the work to be flame-hardened and as illustrated, this means includes a forwardly projecting foot-piece 39 of the head 22 which is adapted to be engaged by a cam 40 mounted upon a shaft 41 carried by the carriage 25. The shaft 41 carries a sprocket 42 over which a chain 43 is trained and the chain 43 is also trained over a sprocket 44 mounted through the medium of a half-revolution clutch upon the power shaft 20.

As the half-revolution clutch is engaged to rotate the sprocket 44, it will be apparent that the cam 40 is rotated to lift the carriage 25 upward and thereby raise the torches 10 and 11 from the operative position as illustrated in Figure 4 to the inoperative position illustrated in Figure 5.

Means are provided for timing the operation of raising and lowering the torches 10 and 11 so that the same are maintained in the operative position of Figure 4 for a definite predetermined period of time before the half-revolution clutch is engaged to discontinue the flame-heating operation of the work. This means includes the formation of the threads 45 upon the extension shaft 31 and a cooperating half nut or follower element 46. The head portion 47 of the follower 46 is provided with threads (not shown) which mate with the threads 45 and cause the follower 46 to move axially along the threads 45 when the extension shaft 31 is rotated.

Means are provided for slidably supporting the follower 46, which means include a square bar 48 which passes through a square hole 49 formed in the follower element 46. The bar 48 is supported in bearings 50 on the carriage 25.

A trigger 51 is pivotally connected with the handle 52 of the follower 46 and is provided with a lug 53 which is adapted to slide in contact with a guideway 54 formed on the carriage 25. A spring 55 normally maintains the lug 53 in contact with the guideway 54 and thereby holds the follower 46 in engagement with the threads 45. A notch 56 is provided in the guideway 54 into which the lug 53 drops when it reaches the position of the notch 56. When the lug 53 drops into the notch 56, the weight of the handle 52 overbalances the head 47 of the follower element 46, thereby turning the square bar 48 in its bearings 50 and disengages the head 47 from the threads 45.

The turning of the square bar 48 not only serves to disconnect the follower element 46 from the threads 45, but also acts to cause engagement of the half-revolution clutch and thereby cause the sprocket 44 to rotate the cam 40 and raise the carriage 25 and the torches 10 and 11.

As herein illustrated, the half-revolution clutch (Figures 9 and 10) includes the hub 57 secured to the extension shaft 31 and the rotatably mounted driven member 58 which carries the sprocket 44. The rotatably mounted member 58 is provided with a longitudinal bore 59 extending therethrough and adapted to register with a pocket 60 formed in the lateral face of the hub member 57.

A transverse passage 61, closed at its outer end by means of a plug 62 intersects the longitudinal bore 59 at a point between its ends.

A clutch shifter plate 63 is secured and supported upon the square bar 48 and is located adjacent the rotatable member 58.

A central opening 64 is provided in the shifter member 63 large enough to provide for clearance around the extension shaft 31. Adjacent this opening and on opposite sides thereof are a pair of like projections 65 and 66 which extend beyond the end surface 67 of the plate 63. The projection 65 is adapted to register with the longitudinal bore 59 when the follower element 46 is in the engaged position shown in Figure 4. Similarly the projection 66 registers with the longitudinal bore 59 when the lug 53 enters the notch 56 and the follower element 46 is disengaged as shown in Figure 5. Balls 68 and 69 are positioned in the longitudinal bore 59 and a ball 70 is positioned in the transverse passage 61. The ball 70 is urged to advanced position by means of a spring 71 interposed between the ball 70 and the plug 62. When the projection 66 lies adjacent the bore 59, it contacts the ball 69 and crowds the ball 70 back into the passage 61 against the action of the spring 71. The ball 68 therefore has considerable looseness in the bore 59 and accordingly does not enter the pocket 60 of the hub 57. This permits the hub 57 to rotate while the member 58 remains stationary. However, when the square shaft 48 tilts the shifter plate 63 to bring the lug 66 out of engagement with the ball 69, the ball 69 moves against the surface 70^a as the spring 71 crowds the ball 70 between the balls 68 and 69, and this forces the ball 68 into the pocket 60 when the rotating hub 57 moves the pocket 60 into registry with the bore 59. As the pocket 60 is too shallow to receive the full diameter of the ball 68, the ball 68 is caught between the walls of the pocket 60 and the wall of the longitudinal bore 59, and thereby forms a positive driving connection between the hub 57 and the member 58. The member 58 thereby rotates the sprocket 44, causing the cam 40 to turn and the carriage 25 drops of its own weight.

The member 58 and sprocket 44 continue to revolve only until the longitudinal bore 59 comes into alignment with the projection 66 and the

parts are arranged so that this travel amounts to one-half revolution. At this point of movement the sloping side of the projection **66** engages the ball **69** and forces it back into the longitudinal bore **59** which in turn raises the ball **70** permitting the ball **68** to move out of the pocket **60**, disrupting the driving connection. When the clutch shifter **63** is tilted back to the position illustrated in Figure 7, the clutch is again engaged for a half revolution and consequently the carriage **25** is again raised to the position shown in Figure 5.

As the extension shaft **31** is rotated at substantially constant speed, the distance travelled by the follower **46** on the threads **45** determines the time that the carriage remains in its lowered position and until the lug **53** drops into the recess **56**. Therefore the act of engaging the head **47** of the follower element at any pre-selected point along the threads **45** determines the time interval which must elapse before the torches are raised from the work. We utilize this relationship for accurately regulating the time interval by providing an adjustable stop member **72** adapted to contact the lug **53**.

The adjustable stop member **72** is carried upon a screw **73** carried by the carriage **25** and the position of this lug **72** is calibrated to indicate the number of seconds which will elapse as the follower element **46** moves from the pre-selected point to the notch **56**. Thus as illustrated in Figure 8, the follower element **46** is positioned by the stop member **72** to require 14½ seconds to reach the notch **56**. The time scale **74** is provided upon the carriage adjacent the stop member **72** to enable an easy determination of this time element as the screw **73** is rotated to adjust the position of the stop member **72**.

Means are provided for rotating the particular tooth which has been flame-treated away from the position of the torches **10** and **11** and into a position under a quenching bath. This quenching bath is conveniently provided by a pair of cooling nozzles **75** which direct fluid against the flanks **6** and **7** of the tooth which has been heated. The quenching fluid flows off the tooth **4** across the table **5** and falls into a sump **76**. A shield **77** may be provided to direct excess fluid into the sump.

Indexing means are provided to facilitate the rapid and accurate movement of the heated tooth to the proper position beneath the cooling nozzles **75** and also to position a second tooth in position with relation to the heating torches **10** and **11**. As herein illustrated, this indexing means includes a radial lever **78** which carries a projection **79** adapted to drop between adjacent teeth of the gear. Arcuate movement of the lever **78** is limited by a pair of stops **80** and **81** positioned upon a stationary arm **82** mounted in the work support **2**. These stops **80** and **81** are so positioned that when the lever is swung by the operator from the position shown in Figure 2 to the position shown in Figure 1, the heated tooth is brought into position beneath the cooling nozzle **75**. The lever **78** is provided with a pivoted joint **83** which enables the operator to lift the projecting lug **79** from between the gear teeth and to swing the lever **78** back against the stop **81** and reengage the projecting lug **79** between a pair of new teeth.

As heretofore set forth, the work supporting means provides a rotatable support for the work and the preferred form of this construction is illustrated in Figure 11. Here it is illustrated that the standard **2** forms a hydraulic cylinder for the reception of a piston **84** which may be raised or lowered in the cylinder by the introduction of fluid under pressure into the interior of the piston **84** through the inlet **85**. Ports **86** communicate through the piston **84** with the lower end of the cylnder **2** and owing to the difference in area between the inside and outside of the piston **84**, the fluid pressure acts to raise the piston in the cylinder.

A clamping device **87** is provided for maintaining the piston at any desired height. Carried on the piston **84** is a crosshead **88** which has bearings **89** for reception of the trunnions **90** of the ring **91**. A worm gear wheel **92** is fixed upon one of the trunnions **90** and may be rotated to any desired angle by means of a cooperating worm **93**. A barrel **94** is journaled upon spaced bearings **95** carried on the ring **91** and the work-suppporting table **3** is secured to the barrel **94**. It will thus be apparent that a universal mounting is provided for the table **3** which permits raising or lowering the table **3**, its rotation or its tilting to any desired angle.

The torch means herein illustrated are preferably of the following construction and are substantially duplicates except that they are right and left-handed. Each torch is proportioned so that it may be inserted adjacent the gear teeth. The broad sides of the torch from which the flame is directed are designated as the active faces **8** and **9**. Formed in the active faces **8** and **9** are a large number of orifices **95**, each of which has a counterbore **96** forming an enlarged chamber upon the faces **8** and **9**. The large number of orifices **95** are distributed over the area of the active faces and hence the large number of individual flame jets combine to function as a single "mat" of flame. The orifices **95** communicate with one of a plurality of lateral fuel passages **97** which in turn lead from a main header passage **98**. Cooling passages are also formed in the torch to permit a cooling fluid to be circulated through the torches to prevent overheating during the flame-hardening operation. As illustrated, these cooling passages are the passages **99**, **100**, and **101**, connected by lateral passages **102** and **103**. Cooling fluid, such as water, enters through the inlet **104**, circulates through the passages **99**, **102**, **101**, **103**, and **100**, in the order named, and then discharges through the outlet **105**. Hot water from the outlet **105** is delivered to the cooling trough **106** mounted on the carriage **25** and is then carried away through the discharge pipe **107**.

The torches **10** and **11** are provided with through-bores **108** interposed between the fuel orifices **95**. These orifices extend completely through the torches and provide air delivery apertures through which air is delivered into the flames upon the faces **8** and **9** of the torches **10** and **11**, respectively. The torches as herein illustrated are particularly adapted for use with natural gas, although their use is not limited thereto. Natural gas is used as a source of the fuel to produce the flame because it has been found to be less expensive than acetylene and because it has been found that the results accomplished through the use of this less expensive fuel are just as satisfactory. Just as when acetylene is used, the natural gas is mixed with oxygen through the medium of a mixing means, as will hereinafter be described.

It has been found that when using natural gas, it is necessary to obtain a reduction in velocity

of the gas mixture to prevent the flame produced on the surface of the torch from being blown out. This reduction in velocity we have accomplished by forming the enlarged counterbores 94. We have further found that we are enabled to reduce the time required for heat-treating the flanks of the gear teeth by the intensification of the heat produced at the surface by the use of the through-bores 108. As an example, before the through-bores were formed through the torches, it required approximately 70 seconds to heat the flanks 6 and 7 of the teeth 4 to the desired depth. After the through-bores 108 were formed, the same depth of heating was attained in approximately 20 seconds. The apparent reason for this is that secondary air is delivered into the flames produced at the point where the intense heat was required and the intense heat was acquired by insuring sufficient oxygen or air at this point to produce a mixture which burned completely and burned in a manner to give the hottest type of flame.

Means are provided for regulating the supply of natural gas, oxygen, and the cooling fluid or water for the torches 10 and 11 and for controlling the type and amount of quenching fluid delivered to the nozzles 75. This means as herein illustrated includes a control stand 109 which supports a pair of flow meters 110 and 111, a pair of manometers 112 and 113, and a pair of pressure regulators or governors 114 and 115, and a pair of main control mixing valves 116 and 117 operated from a main control lever 118. Oxygen under pressure is supplied through the line 119 and passes through the flow meter 111, the control valve 117, governor 115 and through the piping 120 to the mixing valve 121. The pressure in the governor 115 is indicated by the manometer 113, there being a connecting pipe 122.

Similarly, natural gas is supplied through a line 123 and passes through the flow meter 110 and control valve 116 and governor 114 through the piping 124 to the mixing valve 121. The manometer 112 indicates the gas pressure in the governor 114.

Air under pressure passes from the supply line 125 through the valve 126 to the supply line 127 for the cooling nozzles 75 when it is desired to cool with air alone or with a mixture of air and water. A gauge 128 may be provided to indicate the pressure of the air delivered into the supply line 127.

Water is supplied through the water supply line 129 to the branch pipes 130 and 131 which lead to the valves 132 and 133, respectively. From the valve 132 water may be admitted into the quenching line 127 and its pressure may be indicated by the gauge 134. From the valve 133 the water enters the cooling line 135 by way of the connecting pipe 136. A gauge 137 is provided for indicating the water pressure in the line 136.

The control valves 116 and 117 for the natural gas and oxygen are substantial duplicates and therefore a description of one such valve will suffice. These valves are preferably constructed to include a plug 138 (Figure 16) which is positioned in the pipe 139 leading from the flow meter 110 to the governor 114.

Ports 140 and 141 are formed in the wall of the pipe 139 on opposed sides of the plug 138. A shiftable sleeve 142 is slidably mounted upon the pipe 139 and is adapted to permit flow into the governor 114 or to prevent such flow when desired. The sleeve 142 is provided with a pair of spaced annular flanges which carry packing 143 adapted to seal off around the pipe 139. When the sleeve is positioned as shown in the upper half of Figure 16, no flow is permitted, but when the sleeve is located as shown in the lower half of Figure 16, flow takes place outwardly through the ports 140 bore of the sleeve 142 and back through ports 141. Both valves 116 and 117 are shifted simultaneously by the lever 118.

Means are provided for preventing flow of combustible mixture through the control valve 116 until water under pressure is made available for circulation through the cooling passages of the torches 10 and 11, respectively. This safety device thus prevents accidental overheating of the torches through failure to circulate cooling water. As this means is illustrated (Figure 15) it includes a diaphragm 144 connected by a rod 145 to actuate an interference lug 146 when sufficient water pressure exists in the cooling line 135. This pressure forces the diaphragm 144 down, moving the interference lug 146 out of the way so that the valve 116 may be opened. If for any reason the water pressure is too low, the diaphragm 144 remains in the upper position, thereby holding the interference lug 146 between the valve sleeve 142 and the abutment 147 preventing opening of the valve 116 and as the valves 116 and 117 are connected by a common shifting lever 118, neither valve 116 nor 117 may be open when this interference is met.

Means are provided for mixing the combustible mixture of natural gas and oxygen which means as herein illustrated include the mixing valve 121 (Figure 3). In Figure 3 the mixing valve 121 is illustrated inverted from its actual operating position for the reasons of clarity of description. This mixing valve has an oxygen inlet from the connecting pipe 120 and a natural gas inlet from the connecting pipe 124 and a common outlet 148, both of which inlets and outlets lead to and from the body 149. Within the body 149 are formed a pair of annular chambers 150 and 151 communicating with the inlet pipes 120 and 124, respectively. An adapter 152 is threaded into the body 149 and maintains a lantern ring 153 in contact with spaced packings 154 and 155 which seal about a sleeve 156. The sleeve 156 is threaded into the adapter 152 and is provided at its lower end with an inwardly directed flange 157. The lower end of the flange 157 cooperates with the body 149 to define an annular orifice 158 leading from the chamber 151 to the outlet 148.

A plunger 159 is threaded into the sleeve 156 and has a tapered valve head 160 adapted to cooperate with the annular flange 157 to form an annular port 161. This port establishes communication between the annular chamber 150 and the outlet 148 by way of the windows 162 in the sleeve 156 and the lantern ring 153. The plunger 159 is provided with a micrometer scale 163 which permits of very accurate setting of the size of the annular port 161. Similarly, a micrometer scale (not shown) is provided for regulating the size of the port 158. These port openings may therefore be accurately regulated to meet the requirements of the particular torch in use, and may be independently varied to change the proportions of the mixture as desired.

It will also be noted from the foregoing that the annular ports 158 and 161 are separated only by the relatively thin annular flange 157, and that therefore the oxygen and natural gas are intimately mixed on a circular periphery near the upper end of the valve chamber 164. It has been

found that this form of mixing valve 121 operates very satisfactorily over a very wide range of port openings.

Branch pipes 165 connect the outlet pipe 148 with the torches 10 and 11.

The operation of the apparatus embodying our invention to carry out the method thereof is as follows:

A gear 5 is placed on the table 3. It is held in place by means of locking members 166. The table 3 is elevated to the proper height and tilted enough to bring the flanks of the gear tooth 4 adjacent and parallel with, and axially spaced from, the faces 8 and 9 of the torches 10 and 11. With the carriage 25 in its upper position as illustrated in Figure 5, and with the lug 53 in the notch 56, the motor 28 is started. If the observed path of oscillation of the torches 10 and 11 is not the desired one, the sleeve 35 and the bracket 18 may be adjusted until the proper path is obtained. In any event, the path of the torches is a closed, curved path which is not circular but more closely approximates an elliptical path, though perhaps not an elliptical path in the true, precise mathematical sense. It will however be hereinafter referred to as an elliptical path.

The proper valve settings are made on the control stand to insure proper delivery of combustible gas, oxygen and cooling water to the torches 10 and 11 and the cooling fluid to the quenching nozzle 75.

Either air or water, or any combination thereof, may be used as a quenching medium, depending upon the particular steel employed and the depth of hardening desired. The lever 118 is then actuated and the torches lighted.

The trigger 51 of the follower element 46 is then actuated to release the lug 53 from the notch 56 and the follower element 46 is manually moved along the guideway until the lug 53 strikes the adjustable stop 72 which has previously been set at the desired point.

The handle 52 is then raised to bring the head 47 of the follower element 46 into cooperative engagement with the screw threads 45. The lug 53 contacts the guideway 54 to prevent disengagement of the follower element 46 and screw threads 45 while the follower element 46 is moved along the guideway 54 by the screw threads 45.

The act of raising the handle 52 turns the square bar 48 and thereby moves the shifter plate 63. This in turn effects engagement of the half-revolution clutch and causes the cam 40 to revolve and permit the carriage to gravitate to its lowermost position, thus bringing the torches 10 and 11 into operative position adjacent the flanks 6 and 7 of the tooth 4.

The torches are continuously oscillated in the curved, closed, substantially elliptical path by means of the rod or bar 12 and this oscillation prevents overheating at points on the flanks. At the end of the selected time interval, the lug 53 drops into the slot 56. This automatically releases the follower 46 from the screw threads 45, effects engagement of the half-revolution clutch, rotates the cam 40 to lift the carriage 25, and hence raises the torches away from the heated tooth 4. The operator promptly swings the radial lever 78 until it engages the stop 80, thereby rotating the gear 5 to bring the heated tooth 4 into position under the cooling nozzle 75 and also presents a new tooth for the flame treatment under the torches 10 and 11. The operator then lifts the lever 78 to clear the projection 79, swings the lever 78 back against the stop 81, and releases the lever. This brings the projection 79 into position between two teeth ready for the next indexing movement. The handle 52 is again moved to its starting position by the operator and the cycle is repeated until all of the teeth in the gear table 5 have been heat- or flame-treated as desired.

Having fully described our invention, it is to be understood that we do not wish to be limited to the details herein set forth, but our invention is of the full scope of the appended claims.

We claim:

1. In a device for heat treating the teeth of a gear, the combination of, a torch positioned adjacent the flank of a tooth and extending along the flank for substantially the full length thereof, means on the torch for directing a mat flame at right angles against the entire flank surface which is to be heat treated, and means for imparting an oscillatory movement to the torch, both laterally and longitudinally of the flank surface.

2. In a device for heat treating the teeth of a gear, the combination of a torch insertable into the gap between two teeth and extending along the flank of one of them for substantially the full length thereof, means emitting a mat flame from the torch adapted to simultaneously heat the entire flank surface which is to be heat treated, the flame being directed substantially at right angles to the flank surface, and means for imparting an elliptical movement to the torch.

3. In a device for flame hardening the teeth of a gear, the combination of, a torch positioned adjacent the flank of a tooth and extending along the flank for substantially the full length thereof, means on the torch for directing flame simultaneously against the entire flank surface which is to be hardened, means for imparting an oscillatory movement to the torch, means for automatically removing the torch from the proximity of the flank after a predetermined time interval, and means for quenching the heated surface of the flank.

4. In a device of the class described for flame hardening the teeth of a gear, the combination of, a power shaft provided with an eccentric, means to rotate the power shaft, a member having a rotatable connection with said eccentric, a relatively stationary support having a slidable engagement with said member, a torch supported on said member and adapted to be positioned adjacent one of the teeth of the gear, the torch being provided with means for directing flame against the flank of said tooth, and a time controlled device for removing the torch from the vicinity of the heated tooth flank after a predetermined interval.

5. In a device for imparting an oscillatory motion to a torch, the combination of, a relatively stationary member having a shaft rotatably mounted thereon, means to rotate the shaft, an eccentric carried on said shaft and arranged to be radially adjusted relative thereto to vary the degree of eccentricity, a bar having a rotatable connection with said eccentric, a relatively stationary support adjustably positioned upon said member, a bearing element pivotally carried on said support and adapted to receive said bar in sliding engagement, and means mounted on the bar adapted to support a torch.

6. Apparatus for hardening gear teeth, comprising in combination, a torch adapted to be

positioned in the gap between adjacent teeth of the gear, the torch having an active face adapted to lie in relatively close proximity to the flank of one of the teeth, a plurality of openings in the active face of the torch adapted to direct flame jets against the flank of the tooth, a plurality of air ducts passing laterally through the torch and communicating with said active face adjacent said openings, and passage means in the torch adapted to supply a combustible fluid to each of said openings.

7. In a device for flame hardening the teeth of a gear, the combination of, a torch adapted to be positioned in the gap between adjacent teeth of the gear, means on the torch for directing flame at right angles simultaneously against the entire flank of one of said teeth, means including a carriage for supporting the torch in operative position relative to said flank, means mounted on the carriage adapted to impart an oscillatory movement to the torch, and means for shifting the position of the carriage whereby the torch may be moved out of said gap and away from the flank of said tooth.

8. In a heat treating device of the class described, the combination of, a torch having means means for directing flame against an adjacent surface, means including a carriage for supporting the torch in operative position with relation to said surface, a power shaft rotatably mounted on the carriage, drive means for rotating the power shaft, operative connections between the power shaft and the torch whereby rotation of the power shaft serves to impart an oscillatory movement to said torch, and means driven from said power shaft selectively operable to shift the position of the carriage.

9. In a device of the class described, the combination of, a rotatably mounted power shaft, drive means adapted to rotate the power shaft, a torch adapted to be positioned adjacent a gear tooth, means associated with the power shaft adapted to impart an oscillatory movement to the torch, means for regulating the length of time the torch is maintained adjacent the tooth flank, including a screw associated with the power shaft and a cooperating follower element adapted to move axially of the screw, mechanical means for shifting the torch to a position remote from said flank, and means including a clutch automatically operable to effect a driving connection between said drive means and said mechanical means upon the follower element reaching a predetermined position axially of the screw.

10. In a heat treating device of the class described, the combination of, a torch having means for directing flame against an adjacent surface, means including a carriage for supporting the torch in operative position with relation to said surface, an externally threaded lead screw rotatably mounted on said carriage, a power source adapted to rotate said lead screw, a follower element selectively engageable with said lead screw and adapted to be translated along the carriage in a direction axially of the lead screw, mechanical means for shifting the position of the carriage whereby the torch may be moved away from said surface, and means including a clutch automatically operable to effect a driving connection between said power source and said mechanical means, upon the follower element reaching a predetermined position upon the carriage.

11. In a device for flame hardening a gear tooth, a pair of substantially oppositely directed torches having a multipilcity of flame directing apertures extending substantially the length of the flanks of the gear tooth, means for supporting the torches in a position parallel with the said flanks, and means for imparting an oscillatory movement to the supporting means to move the torches in a curved path substantially parallel with the said flanks to distribute the flames evenly over the said flanks and obtain uniform flame heating thereof.

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