June 24, 1930. A. E. SHORTER ET AL 1,768,159

APPARATUS FOR HARDENING METAL SURFACES

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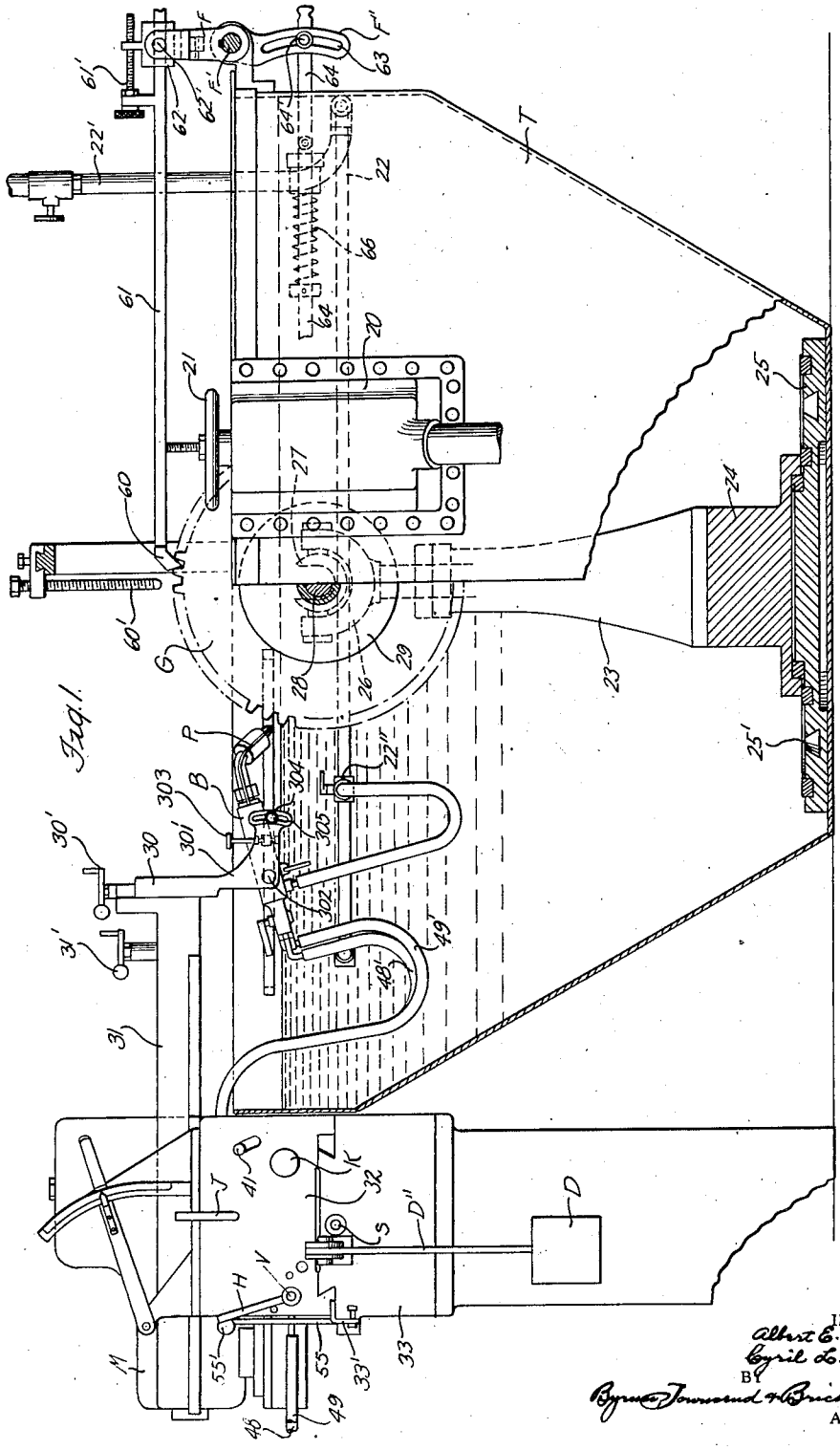


Fig. 1.

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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 2

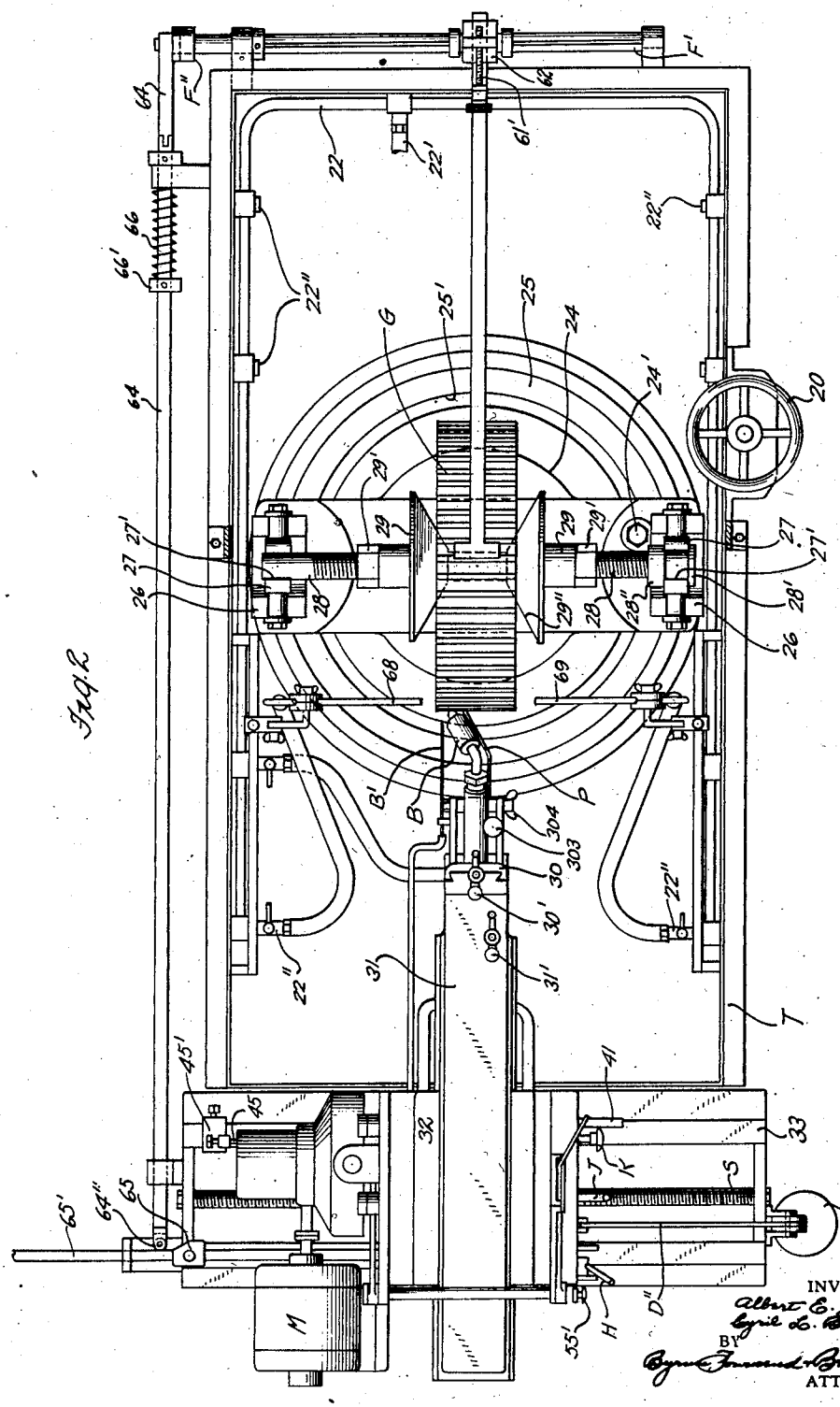


Fig. 2.

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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 3

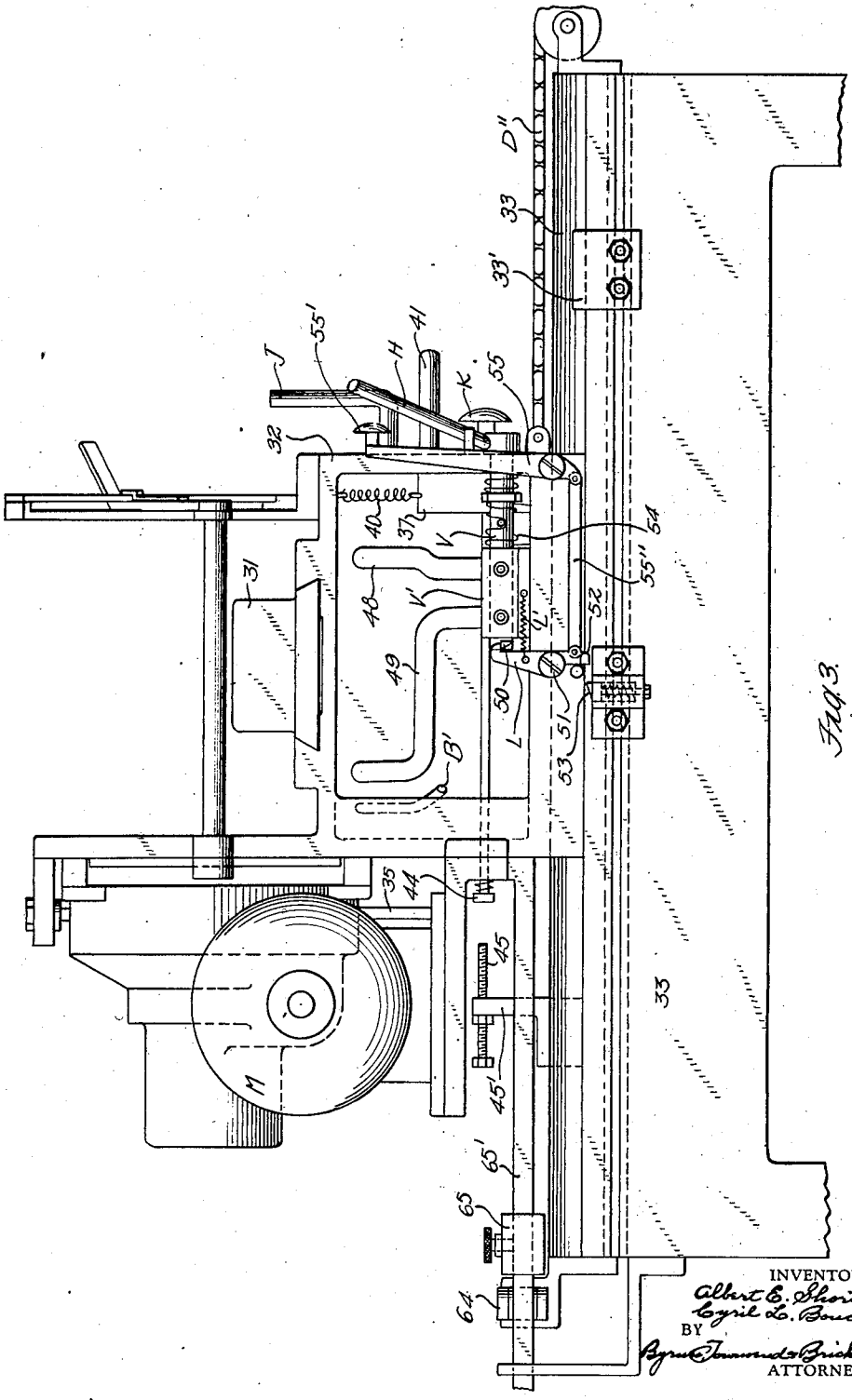


Fig 3.

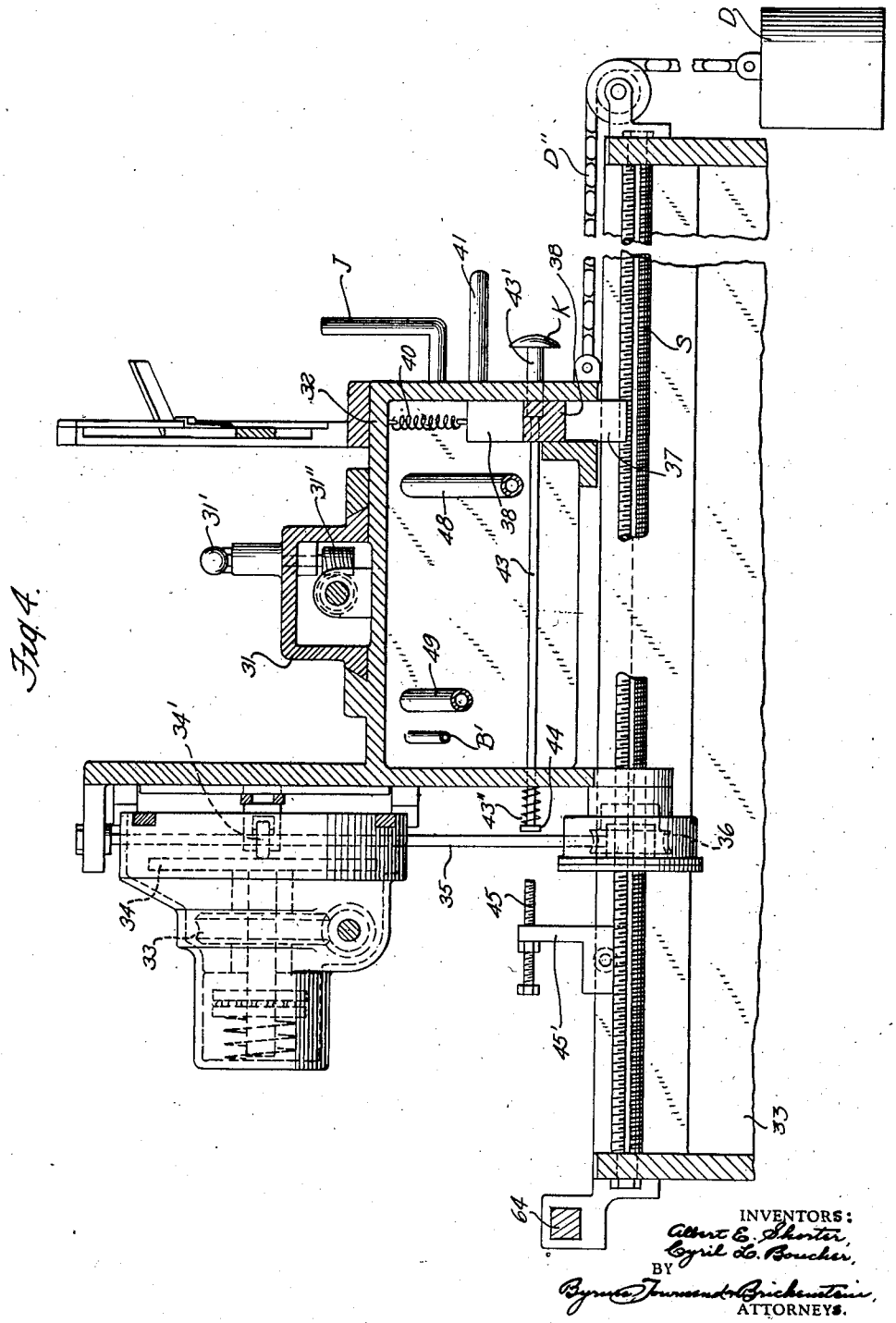
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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 4

Fig. 4.



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June 24, 1930. A. E. SHORTER ET AL 1,768,159

APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 5

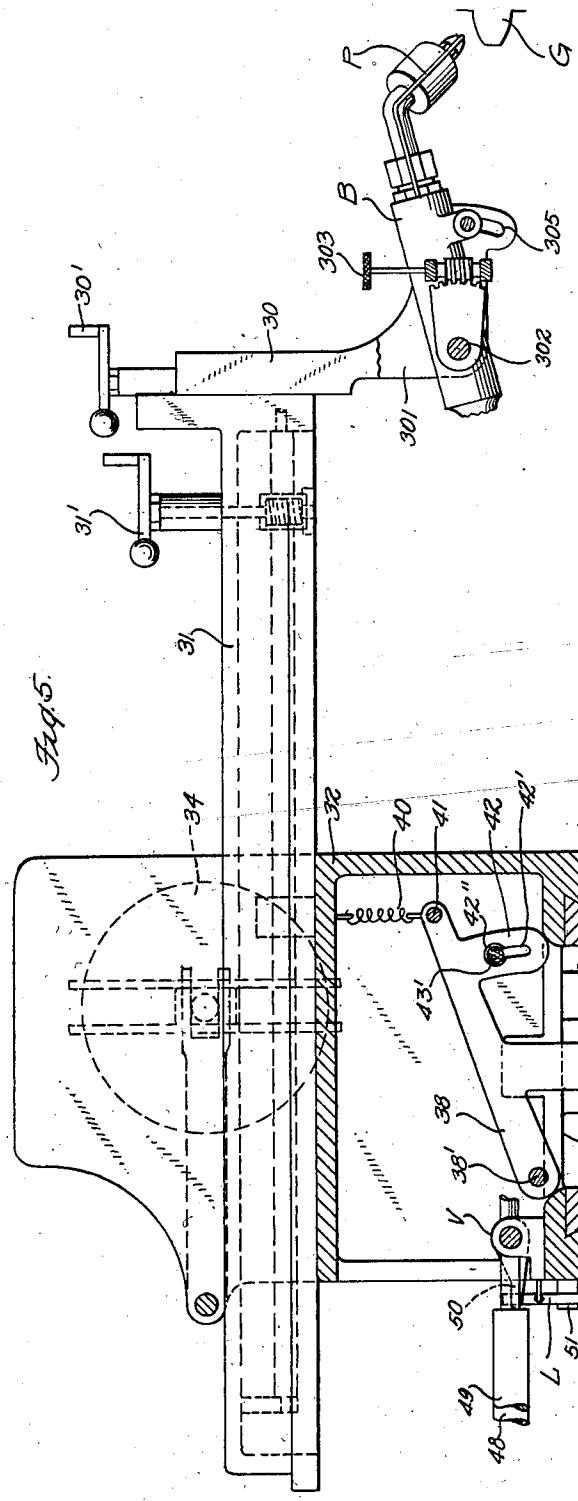


Fig. 5.

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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 6

Fig. 8.

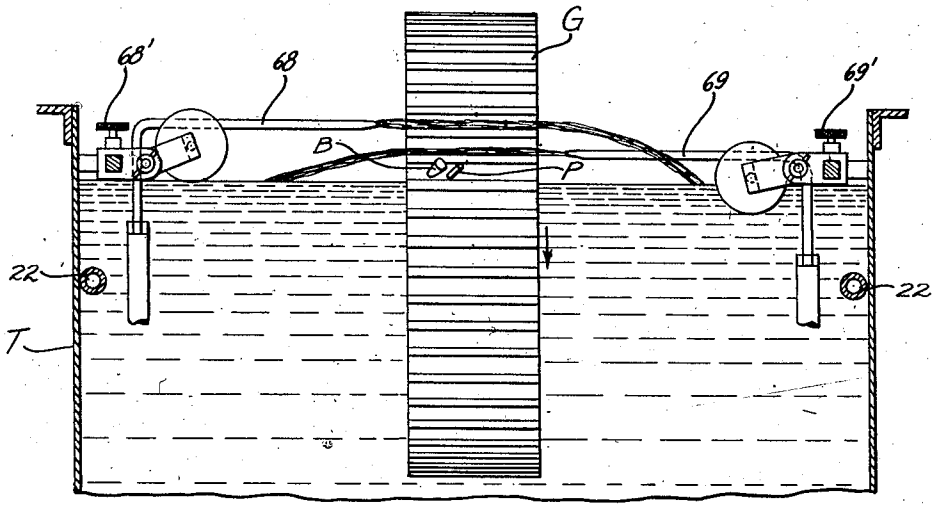


Fig. 6

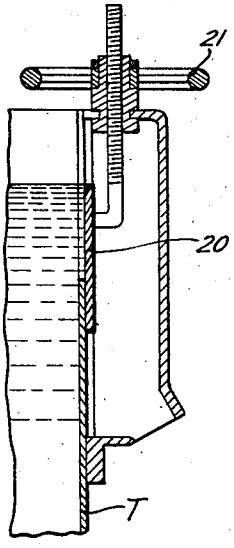
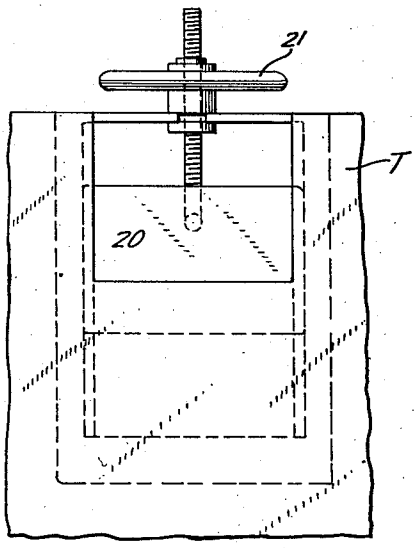


Fig. 7.



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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 7

Fig. 9.

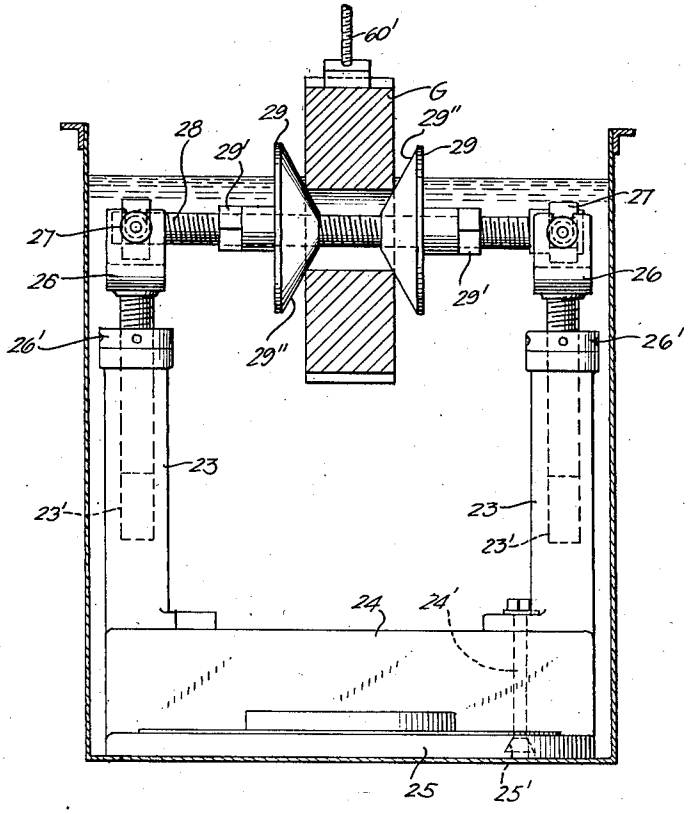
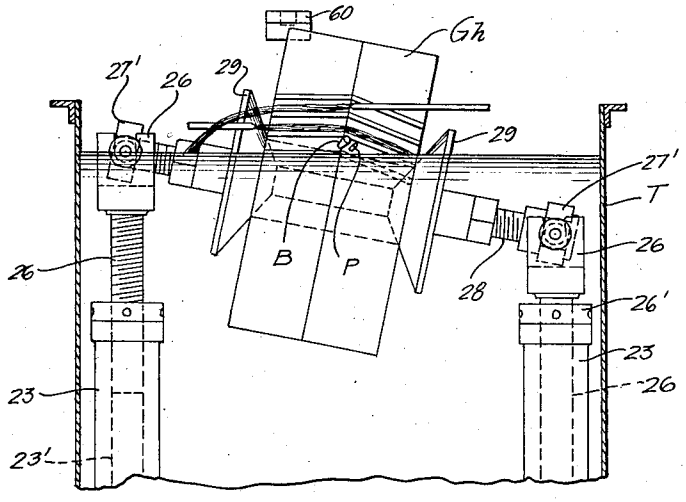


Fig. 10



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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 8

Fig. 11.

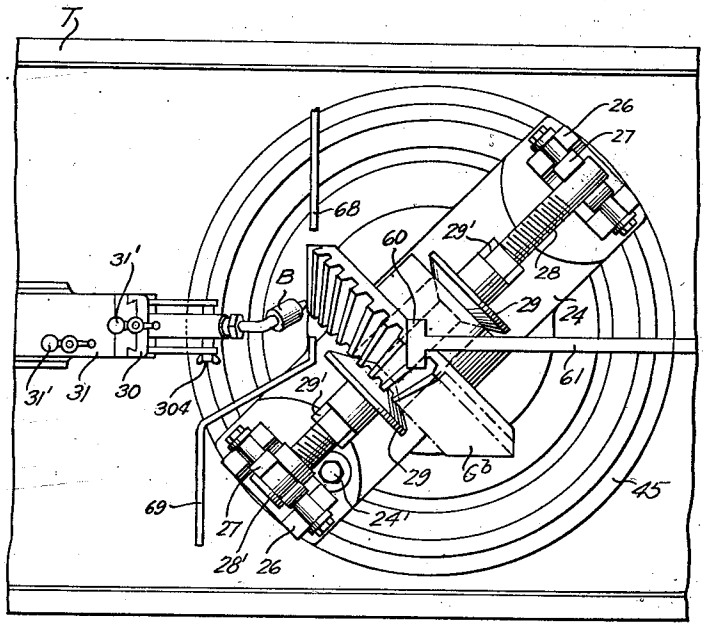
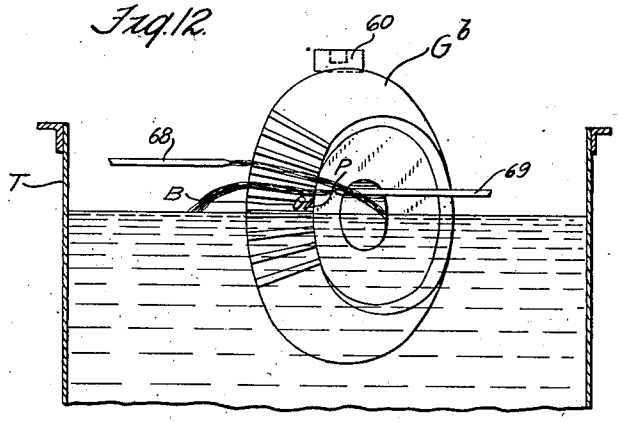


Fig. 12.



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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 9

Fig. 13.

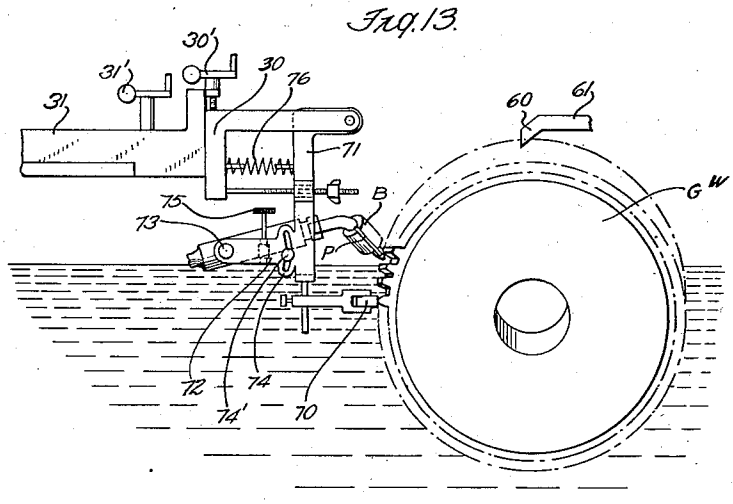


Fig. 14.

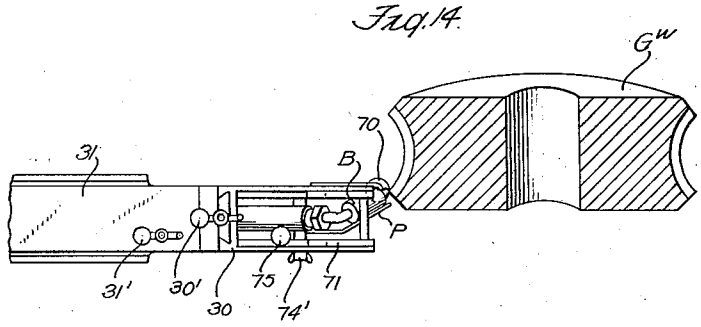
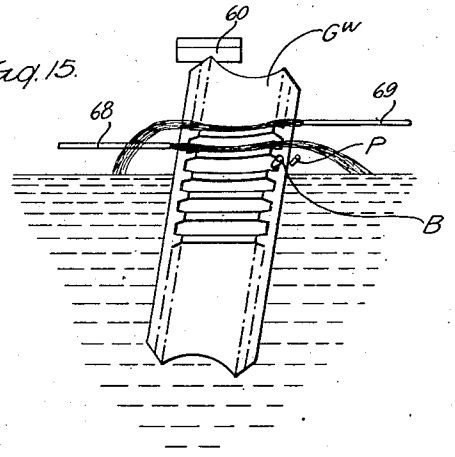


Fig. 15.



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APPARATUS FOR HARDENING METAL SURFACES

Filed Dec. 21, 1927 10 Sheets-Sheet 10

Fig. 16.

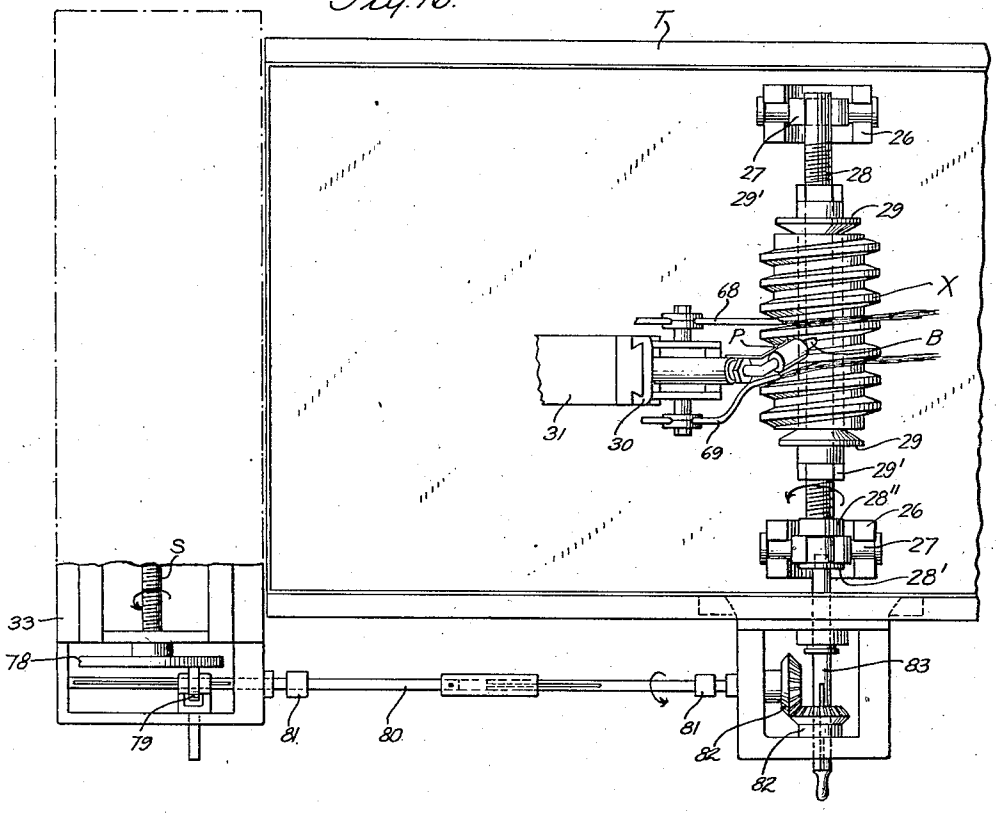
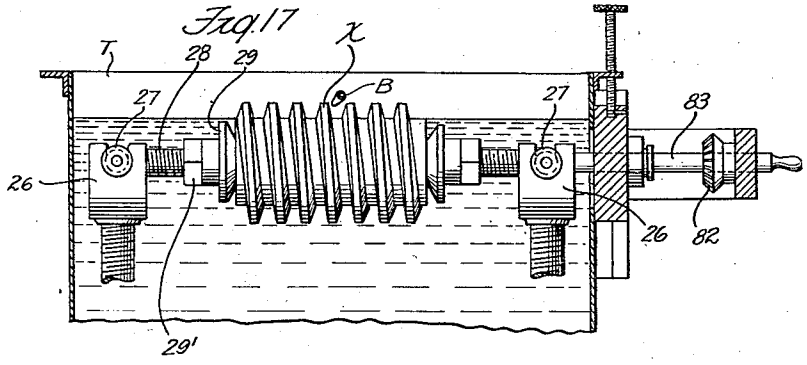


Fig. 17



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Patented June 24, 1930 1,768,159

UNITED STATES PATENT OFFICE

ALBERT EDWARD SHORTER, OF LONDON, AND CYRIL LETT BOUCHER, OF LITTLE BOOKHAM, ENGLAND, ASSIGNORS TO THE PATENT GEAR HARDENING COMPANY, LTD., OF LONDON, ENGLAND, A BRITISH CORPORATION

APPARATUS FOR HARDENING METAL SURFACES

Application filed December 21, 1927, Serial No. 241,632, and in Great Britain September 29, 1927.

This invention relates to the art of hardening the wearing surfaces of gear teeth, but certain features of the invention are of general application for hardening a variety of metal surfaces.

More particularly, this invention relates to improvements in the process and apparatus disclosed in British Patent No. 227,296, wherein the metal to be hardened is locally heated to the requisite high temperature by suitable high-temperature heating means, such as an oxy-acetylene flame, which is traversed slowly along the surface to be hardened, the intensely heated surface being then immediately quenched, as by directing thereon a jet of cold water. In the aforesaid apparatus, an oxy-acetylene blowpipe and a nozzle, or nozzles, (hereinafter referred to as the quenching nozzle) through which the quenching water is directed onto the heated surface are adjustably mounted on a reciprocable carrier which traverses the blowpipe tip and quenching nozzle accurately over the teeth of a gear wheel under treatment. The carrier is traversed in a path parallel to the axis of the gear wheel, back and forth across the face of said wheel, and means are provided for automatically reversing the movement of the carrier so as to harden the face of one tooth during the forward movement and the face of a succeeding tooth on the return movement. The arrangement is such that the uppermost face of the tooth under treatment lies in, or just below, the surface of the cooling liquid in a tank in which the gear wheel to be treated is rotatably supported. The heating flame directed upon the tooth locally disperses the liquid film over the tooth and heats a portion only of the tooth at a time, the remainder of the tooth and part of the gear wheel being kept cool by the liquid. As the flame is traversed along the tooth the successive portions of the latter are heated to the required degree and then immediately cooled by a jet of cold liquid directed thereon.

For practical purposes, it is more desirable to apply the heating flame while the blowpipe is moving across the face of the gear in only one direction, so as to avoid the complication of reversing the angular position of the blowpipe. One of the objects of the present invention is therefore to economize gas during the reverse movement of the blowpipe in a machine arranged to apply the heat only during the forward movement of the blowpipe. This is accomplished by mechanism which automatically shuts off both the oxygen and fuel gas at the end of the forward movement of the blowpipe.

Other objects of this inventon are to provide means for automatically turning the gear or other article to be surface hardened to present successive teeth in proper position to be operated on by the heating and quenching devices; to provide means for more completely cooling the parts of the article subjected to the high-temperature heat so as to further minimize liability of distortion; to provide an improved support that is adjustable to take work of varying shapes, and to generally improve such apparatus and adapt it for use in surface hardening various types of gears and other articles.

The above and other objects and the novel features of this invention will be apparent from the following description and the accompanying drawings in which:

Fig. 1 is a view of a machine embodying this invention, parts beng shown in section and part in side elevation;

Fig. 2 is a top plan view of the same;

Figs. 3, 4, 5, 6 and 7 are detail views of the same;

Fig. 8 is a view, partly diagrammatic, illustrating the use of additional cooling jets to prevent distortion;

Figs. 9 and 10 are detail views of the improved gear support, the first adjusted to carry a spur gear and the second to carry a double spiral or herringbone gear for treatment;

Figs. 11 and 12 illustrate the support and associated appliances adjusted to treat bevel gears;

Figs. 13, 14 and 15 illustrate the principles of this invention employed in surface hardening worm wheels; and

Figs. 16 and 17 illustrate the principles of

this invention applied to the surface hardening of worms.

A machine embodying the principles of this invention is illustrated in Figs. 1 to 9 inclusive, being here employed for surface hardening the teeth of a spur gear G which may be rotatably mounted to be turned step-by-step for presenting successive teeth to a high-temperature heating device, such as a blowpipe B adapted to produce an intense flame, an oxy-acetylene blowpipe being advantageous for this purpose.

The suporting means for the gear to be treated is disposed in a suitable water tank T which may be provided with an overflow weir 20 adjustable by means of a hand wheel 21 to vary the water level in the tank, as indicated in Figs. 6 and 7. Suitable means may be provided for supplying and distributing water to the several parts of the apparatus, and as shown a water pipe 22 is secured to and extends along three sides of the inside wall of the tank. This pipe is provided with an inlet 22′ and at various points with plugged outlets 22″, any one of which may be opened to couple a hose connection thereto.

The improved work support constitutes an important feature of the present machine since it is designed to be adjusted to rotatably support various types of gears so that their teeth may be presented successively to the heating blowpipe and quenching jet. As here shown, the improved support consists of a pair of standards rising from a base 24 which is turnable along suitable bearing surfaces concentric with the turntable 25 at the bottom of the tank. The base 24 may be secured in any one of its various rotary adjustments by bolts 24′ which have tapered heads adapted to be tightened in a correspondingly tapered groove 25′ of the turntable 25, as more clearly shown in Fig. 9. The standards are made of two telescopically adjustable sections, upper ends of the lower sections 23 being provided with central sockets 23′ to receive the threaded stems of yokes 26 which are vertically adjustable by means of the nuts 26′ bearing against the upper ends of the lower sections. The gear G or any other type of gear, as will be hereinafter explained, is rotatably supported by the pair of yokes 26. The upper end of each yoke carries a rockable trunnion 27′ to rotatably support an end of the threaded gear-carrying shaft 28. At one end the shaft 28 has a collar 28′ and a nut 28″ which are disposed on opposite sides of one of the trunnions 27 to prevent endwise movement of the shaft 28. A pair of clamp plates 29 are adjustable toward each other by nuts 29′ in the shaft 28 to grip a gear between them. The plates 29 desirably have opposed conical faces 29″ adapted to fit into the hub opening of a gear. These conical faces may thus be accommodated to gears of different sizes and securely clamp the gear in position. Either yoke and its trunnion may be either raised or lowered, as desired, the trunnions 27 turning in the upper forked ends of the yokes to maintain the bearings 27′ in line to properly support the rotatable shaft 28 and the gear thereon in any desired angular position. This support is therefore universally applicable for mounting spur gears as well as beveled gears, herringbone gears, and other types of work in proper position to present their teeth or other parts to the high-temperature heating means and its associated quenching means.

The heat blowpipe and its associated pipe P for delivering a quenching jet of cold water or other suitable liquid immediately behind the blowpipe are mounted on a slide 30 that is vertically adjustable as by a handle 30′ and an associated screw, along suitable ways on the front end of a slide 31 which is horizontally adjustable by a handle 31′ and associated gear 31″. The slide 31 is adjustable along suitable ways on a carriage 32, to move the blowpipe toward or away from the work. Further adjustment of the blowpipe may be obtained by pivoting it, as at 302 on a bracket 301′ of the slide 30, raising or lowering the free end by an adjusting screw 303, and securing it in any adjusted position by a wing nut 304 on the blowpipe which engages a slotted arm 305 on the bracket 301. The carriage 32 is propelled by a lead screw S along suitable ways on a frame 33 parallel to the tooth or other surface to be treated. It will thus be seen that the blowpipe and its associated quenching jet may be adjusted vertically and horizontally in various directions to set these devices in proper position to treat gears of any diameter or to treat other surfaces of varying shapes.

The lead screw S is rotatably mounted in the frame 33 and may be driven at different speeds by a motor M which may be connected through a worm gear 33, a friction gear 34, a shaft 35 and worm gearing 36 to the lead screw S. By manipulating the disc 34′ of the friction gearing 34 an infinite number of speed changes may be obtained and the lead screw S may be driven in either direction. As shown in Fig. 4 and 5, the carriage 32 may be coupled to the lead screw S by a nut or block 37 which has a recess at its lower end threaded to fit the threads of the lead screw S. The nut 37 may be a projection on the lever 38 which is pivoted on the carriage at 38′ and is normally held in an elevated position by a spring 40 connected to its free end and to the carriage 32, so that normally the connecting nut 37 is disengaged from the lead screw S. In order to set the nut 37 in engagement with the lead screw, the free end of the

lever is depressed by pushing down a handle 41 on the lever which extends through a slot in the carriage 32. Suitable means may be provided to releasably lock the connecting nut 37 in engagement with the lead screw S to feed the carriage. As shown the lever 38 may be provided with an arm 42 which has a curved slot 42′ of uniform width except at its upper end where it is formed with an enlargement 42″. The enlargement 42″ is designed to receive the enlarged end 43′, of a releasing rod 43 which is slidable in opposite side walls of the carriage 32, the enlargement 43 being held in the recess 42′ by a spring 43″ that bears against a collar 44 on the rod 43 and against the side of the carriage 32.

The distance that the carriage 32 travels along the screw S may be limited by an abutment screw 45 which is carried by a bracket 45′ adjustable to various positions along the frame 33 lengthwise of the screw S. The adjustable abutment screw 45 is disposed in line with the rod 43 to be engaged by the collar 44 on the later when the carriage 32 has reached the limit of its movement in one direction. This engagement depresses the rod 43 against the spring 43′ and moves the enlargement 43′ out of the recess 42″, whereupon the tension of the spring 40 acts to lift the lever 38 and disengages the nut 37 from the lead screw S stopping the travel of the carriage 32. It will thus be seen that the length of travel of the blowpipe B and its associated quenching jet along the surface to be treated may be predetermined and the blowpipe travel may be stopped at any desired point by setting the abutment screw 45 as desired. Moreover the carriage 32 and the movement of the blowpipe B may be manually stopped at any point in their travel by pulling downwardly on a knob K secured to the outer end of the control rod 43. After the carriage 32 has reached the limit of its movement in one direction and the nut 37 is disengaged, the carriage may be returned to its initial position manually as by a handle J, or automatically, and again set in motion to repeat its operation by depressing the handle 41. A suitable weight D suspended over a pulley D′ and connected by a chain D″ to the carriage 32 may be employed to automatically return the carriage to its initial position against the stop 33′ when the nut 37 is released by the control rod 43.

When the carriage 32 reaches the end of its movement and the blowpipe has finished hardening one tooth or a given zone on a surface to be treated, it is desirable to automatically shut off the oxygen and acetylene supply which produces the heating flame of the blowpipe, in order to prevent waste of gas while the blowpipe is being returned to its initial position to perform a succeeding operation. The oxygen and the acetylene or other fuel gas may be supplied by pipes 48 and 49, respectively to flexible hose connections 48′ and 49′, respectively, which lead to the blowpipe B. The supply of acetylene or gas mixture to a pilot light B′ is not disturbed. The supply of oxygen and acetylene to the pipes 48 and 49 may be derived from suitable cylinders of compressed gases, and may be controlled by a plug valve V which operates in a valve casing V′. The outer end of the stem of the valve V carries a handle H by means of which the valve may be manually turned to admit to the pipes 48 and 49. As so adjusted, the valve V may be held in open position by a latch L which has a catch to engage a right angle extension 50 rigidly connected to the valve-plug V, a spring L′ being provided to hold the latch in this position. The latch L is pivoted at 51 on the carriage 32 and has a depending arm 52 arranged to be engaged by a spring-pressed trip pawl 53 which may be adjustably secured to a bar on the frame 33 at any point lengthwise of the lead screw S. A torsion spring 54 surrounds the stem of the valve V and normally tends to close this valve which is, during the operation of the blowpipe, held open by the latch L. However, the trip 53 is so adjusted that it will engage the depending arm 52 and disengage the latch L from the projection 50 at the limit of the operating movement of the blowpipe, whereupon the torsion spring 54 rotates the valve V to shut off both the oxygen and the acetylene. A manually operable lever 55, having a button 55′ connected to its free end, is connected by a link 55″ to the latch arm 52 so that the gas may be manually shut off whenever desired, by depressing the button 55′.

Means may be provided to turn the gear sufficiently after each tooth-hardening operation to bring the next tooth in position to be hardened. For this purpose indexing means or step-by-step mechanism may be employed. As illustrative of such mechanism, a pawl 60 may be provided at the outer end of a rod 61 which is secured by an adjusting screw 61′ to a block 62 pivoted at 62′ in the forked upper end of a lever F pivoted at F′ on the rear end of the tank T. The depending end F″ of this lever is provided with a curved slot 63 whereby a rod 64 carrying a pin 64′ may be adjustably secured to the arm F″ at any point in the slot 63 at a variable distance from the pivoted F′. This connection permits a variable movement for the pawl 60, depending upon the diameter of or the number of teeth on the gear wheel that is being treated. The pawl 60 has inclined faces so that it may be withdrawn from the space between any tooth without exerting a return movement on the gear, and the forward movement of the pawl 60 is limited by an

adjustable set screw 60′ mounted in a bracket on the tank T. The feeding movement of the pawl 60 is applied by the rod 64 which extends lengthwise of the machine and has its free end 64″ disposed in the path of a cam 65 mounted on and adjustable lengthwise of an operating rod 65′ that is fixed to the carriage 32. Accordingly, with the cam 65 properly adjusted, when the carriage 32 reaches the end of its movement, the cam 65 engages the end of the rod 64 which actuates the lever F to push the pawl 60 forwardly to index or turn the gear sufficiently to set the succeeding tooth in position with its top surface at or just below the water level in the tank T so that a thin film of water will cover the surface to be hardened. A spring 66 surrounding the rod 64 and bearing against the collar 66′ operates automatically to return the feed mechanism to its initial position, withdrawing the pawl 60 and dropping it in the space between the succeeding teeth in position for the next forward feed of the gear.

In applying the intense heat to the surfaces to be hardened the major portion of the gear or the surface is immersed in the water in the tank T, thus reducing the possibility of distortion and localizing the heat. In order to further localize the heat and eliminate possibility of distorting the portion of the article above the water level, it is desirable to apply cooling means to the article above the surface being treated. As best shown in Figs. 2 and 8, jets of cooling liquid, such as cold water or water atomized by compressed gases, are directed by nozzles 68 and 69 across the face of the gear just above the blowpipe. The cooling nozzles are adjustably mounted on brackets 68′ and 69′ and receive water from suitable outlets 22′, and desirably direct their jets from opposite sides of the gear through the channels and along surfaces between the teeth just above the one being treated. Heat conducted upwardly into the article is thus carried away by these cooling jets and distortion from this source is minimized.

While Figs. 1 to 9 inclusive illustrate the invention as applied to the surface hardening of spur gear teeth, it will be understood that the machine herein shown is equally well adapted to be used for surface hardening the teeth of other types of gears and similar articles. For example, Fig. 10 diagrammatically illustrates the machine arranged to harden the surfaces of one set of teeth of the herringbone gear Gh. Here one of the yokes 26 is raised and the other lowered to set the gear so that the teeth of one-half of its face will be parallel to the water level in the tank T. Should any adjustment of the water level be necessary this may be accomplished by raising or lowering the weir 20. With the gear in position as indicated in Fig. 10, the blowpipe B and its associated quenching jet pipe P may be traversed lengthwise of the tooth at or just below the water level to treat this tooth in the same manner as in the case of spur gear teeth. Part of the gear above the tooth being treated may be cooled as already set forth, by discharging one or more jets of cooling fluid through the channels and along the surfaces between the teeth. The gear indexing device 60, the automatic gas shut off mechanism, and other features of the machine shown in Figs. 1 to 9 are similarly applicable to the mechanism shown in Fig. 10.

Figs. 11 and 12 illustrate the machine adjusted so as to be capable of surface hardening the teeth of bevel gears or similar articles. To accomplish this, the supporting base 24 is turned about the vertical axis of the turntable 25 and secured in such a position that the teeth of the gear Gb will be presented to the blowpipe B in a flame coinciding with the water level. The blowpipe B and its associated quenching pipe then traverse the successive teeth of the beveled gear as each is automatically moved into operating position. Otherwise the mechanism and operation for hardening bevel gear teeth and similar surfaces as the same as already described.

Figs. 13, 14 and 15 illustrate a slight modification in the machine to adapt it for surface hardening curved teeth such as those of the worm wheel gear Gw. After the worm wheel has been properly mounted between the clamp plates 29 of a support in all respects similar to the one shown in Fig. 9, the teeth at the water level are traversed by a blowpipe and its associated quenching jet to successively harden them and the wheel is advanced tooth-by-tooth as already described. In order to give the necessary motion to the blowpipe and quenching means, a follower wheel 70 is mounted on a depending lever 71 which has an arm 72 that supports the blowpipe and the pipe P. As indicated the blowpipe is secured to the arm 72 by pivot 73 and a slotted extension 74 which receives a pin 74′ securing the blowpipe to the arm in any position to which it is adjusted by the thumb screw 75. The blowpipe supporting lever 71 is carried by the vertical slide 30 and a spring 76 presses the arm 71 toward the gear to hold the roller 70 against the periphery of a guiding tooth on the gear wheel Gw. Accordingly, when the carriage 32 moves transversely of the face of the gear, the roller 70 will engage and be guided by the tooth and guide the blowpipe correspondingly along the face of the tooth being treated. Otherwise the mechanism and arrangement for surface hardening this gear wheel is the same as that already described.

In Figs. 16 and 17 the invention is shown as applied to the surface hardening of worms and similar spiral metal surfaces. The worm X may be supported by the turntable and standards, as already described, but in the present instance the worm is continuously rotated to present successive portions of the tooth face to the blowpipe and its associated quenching jet. For this purpose one end of the lead screw S may be extended and provided with a suitable driving disc 78 to drive an adjustable disc 79 that is splined on a shaft 80 connected to suitable universal joints 81 and beveled gearing 82 for driving the shaft 83 which is coupled to the worm supporting shaft. While the worm is being rotated, the blowpipe flame and quenching jet are applied to the tooth face to harden the latter, and suitable jets of cooling fluid are discharged through the channels and along surfaces on opposite sides of the surface and under treatment to confine the heat and minimize distortion. The major portion of the worm is desirably submerged in the water in the tank T, leaving only a small section of the worm exposed.

It will be obvious that the improved machine may be modified so as to treat both faces of the teeth of a gear in one setting. For example, a carriage and its associated mechanism similar to that shown at the left end of the tank T in Fig. 1 may be provided at the opposite end of the tank, so that one face of each tooth will be treated by a blowpipe and its associated quenching jet operating across one side of the gear, and the other face of each tooth will be treated by a similarly arranged blowpipe and its quenching jet operating across the opposite face of the gear. Thus the teeth of the gear may be finished on both faces without removing it from the machine. With this double arrangement, only a single indexing mechanism is employed, which may be similar to that herein disclosed but mounted on the side instead of the end of the tank. Numerous other details of the herein-disclosed machine may be changed without departing from the principles of the invention, and therefore the invention is not intended to be limited to the exact construction shown and described.

What is claimed is:

1. A machine for surface hardening gear teeth, comprising a blowpipe for applying intense heat to a tooth, means for traversing said blowpipe relatively to said tooth, means whereby the tooth is progressively quenched immediately after intensely heating it, means operative to automatically turn the gear after a tooth has been treated to present a succeeding tooth for treatment, and means operative to shut off the gas supply for the heating flame of said blowpipe after each tooth has been treated.

2. A machine for surface hardening a wheel having gear teeth; comprising a device for applying intense heat to a tooth; means for progressively quenching each tooth immediately after intensely heating it; a water tank in which said wheel is partially submerged with the tooth undergoing treatment disposed substantially at the water level in said tank; and means for applying cooling medium to said wheel above the tooth being treated, such cooling medium applying means comprising a jet of cooling fluid flowing lengthwise of an adjoining tooth above the water level.

3. A machine for surface hardening a wheel having gear teeth; comprising a device for applying intense heat to a tooth; means for progressively quenching each tooth immediately after intensely heating it; a water tank in which said wheel is partially submerged with the tooth undergoing treatment disposed substantially at the water level in said tank; and means for applying cooling medium to said wheel above the tooth being treated, such cooling medium being discharged lengthwise of channels between teeth of said gear above the water level.

4. A machine for surface hardening metals comprising a support for the article to be treated, such support having vertically adjustable standards and horizontally adjustable article clamping means carried by said standards.

5. A machine according to claim 4, wherein said support also comprises means whereby said article may be mounted at an angle to the horizontal.

6. A machine for surface hardening metals comprising a support for the article to be treated, such support being turnable about a vertical axis and having means supporting said article for rotation about an axis disposed at an angle to said vertical axis.

7. A machine according to claim 4, wherein said support is turnable about a vertical axis.

8. A machine for surface hardening gears comprising a water tank, a turntable therein, vertically adjustable standards mounted on and adjustable about the vertical axis of said turntable, a rotatable gear support mounted on said standards, a blowpipe, mechanism for traversing a blowpipe along the tooth of a gear on said support, and means for discharging quenching fluid onto the tooth after the same has been intensely heated.

9. A machine according to claim 8, in combination with means operative to automatically shut off the gas supply for the

heating flame of said blowpipe after each tooth is treated.

10. A machine according to claim 8, in combination with mechanism automatically operative to present the gear teeth in succession to said blowpipe and quenching means.

11. A machine for surface hardening articles comprising means for applying intense heat to the surface of an article and immediately quenching such intensely heated surface; means for traversing the aforesaid means along the surface to be treated; means for automatically interrupting the movement of such aforesaid means; means operative to automatically interrupt the application of heat when said movement is interrupted and means for automatically returning such aforesaid means to its initial position while said heat is interrupted.

12. A machine for surface hardening gear teeth, comprising a blowpipe for applying intense heat to a tooth, means for transversing said blowpipe relatively to said tooth, means operative to shut off the gas supply for the heating flame of said blowpipe, at a predetermined point in such movement, means whereby the tooth is progressively quenched immediately after heating it and means operative to automatically turn the gear after the tooth has been treated to present a succeeding tooth for treatment.

In testimony whereof we affix our signatures.

ALBERT EDWARD SHORTER.
CYRIL LETT BOUCHER.