

March 15, 1949.

A. E. SHORTER
METHOD OF SUCCESSIVELY CUTTING AND DIFFERENTIAL-
LY HARDENING A TOOTHED MEMBER

2,464,351

Filed April 19, 1944

4 Sheets-Sheet 1

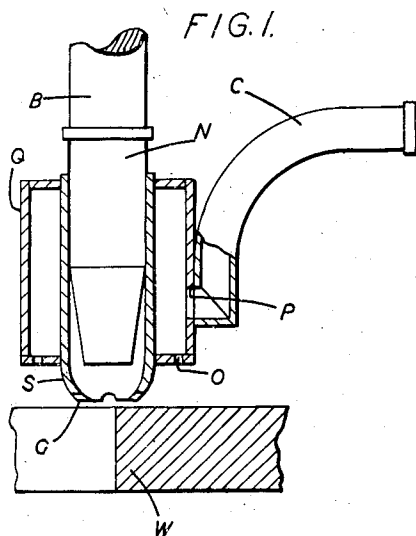


FIG. 3

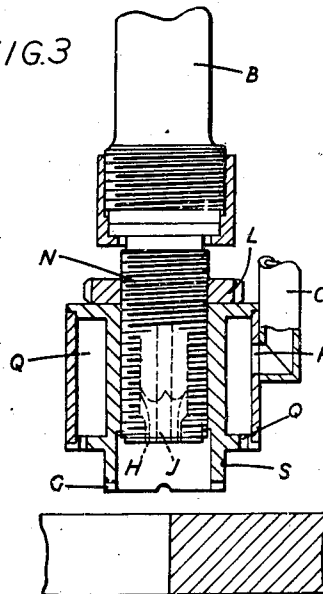


FIG. 2.

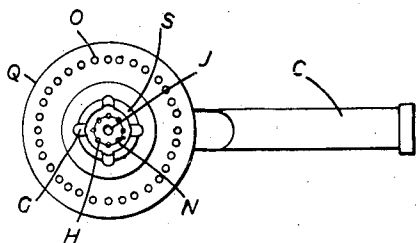
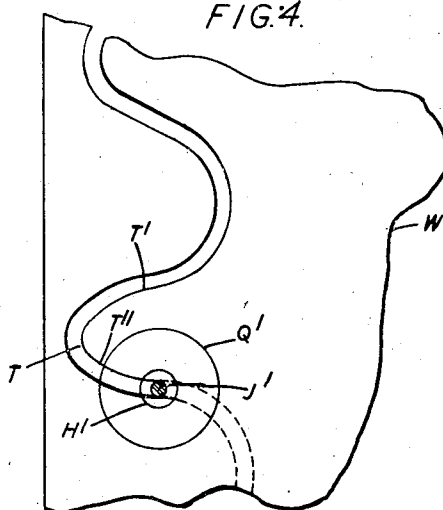


FIG. 4.



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FIG. 7

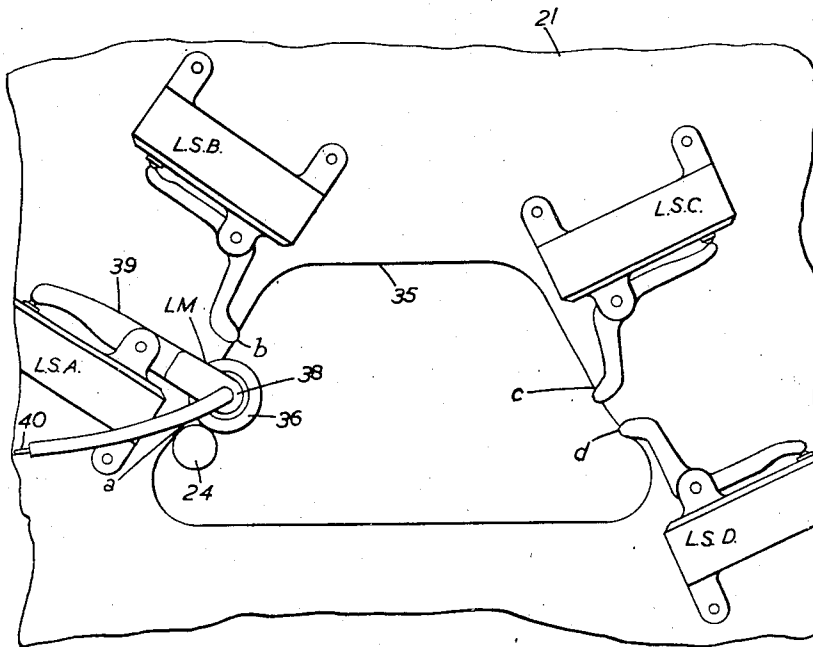
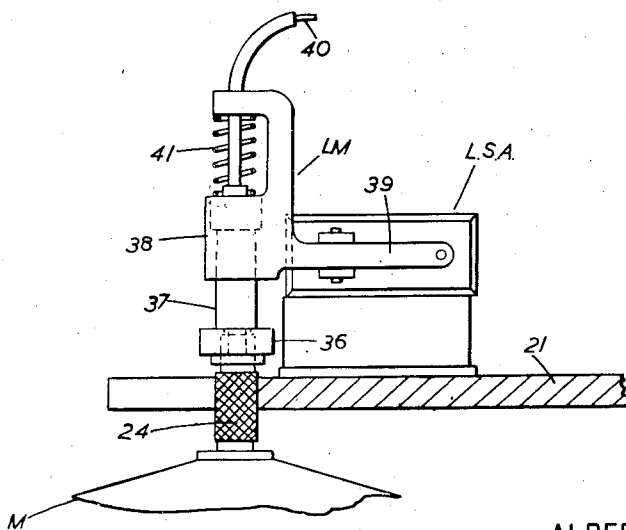


FIG. 8



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UNITED STATES PATENT OFFICE

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METHOD OF SUCCESSIVELY CUTTING
AND DIFFERENTIALLY HARDENING A
TOOTHED MEMBER

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4 Claims. (Cl. 148—9)

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The present invention relates to the produc-
tion of shaped ferrous metal parts having sur-
face hardened profiles.

It is common practice to produce shaped fer-
rous metal articles, such as templates, sprocket
wheels, gear wheels and other machine parts and
tools, by cutting the parts from metal blanks
using a high temperature severing procedure. It
is also known that the profiles of such shaped
articles or selected portions thereof may be sur-
face hardened by applying thereto high tempera-
ture heat to raise the surface to the critical point
or above and then rapidly cooling or quenching
the heated surface. The employment of two
separate heating operations, the first in the sever-
ing procedure, and the second in the hardening
process, is both time consuming and wasteful of
heat energy.

According to this invention a shaped ferrous
metal part having a surface hardened profile is
produced by subjecting a metal blank to a high
temperature severing procedure whereby the
blank is progressively cut to the required profile
and progressively quenching the profiled surface
before the temperature thereof has fallen below
the critical point, whereby a shaped metal part
having a surface hardened profile is obtained.

A preferred method of producing a shaped fer-
rous metal part having a surface hardened pro-
file in accordance with this invention comprises
progressively heating a metal blank, directing an
oxidising jet upon the heated surface to cut the
desired profile and progressively applying a
stream of quenching fluid to the profiled surface
before the temperature thereof has fallen below
the critical point.

The quench is preferably applied in the form
of an annular stream surrounding the cutting
point thereby ensuring the quenching of the
heated surface despite alterations in the direction
of relative progression between the metal blank
and the heating and oxidising jet.

According to another feature of this invention
apparatus for producing a shaped ferrous metal
part having a surface hardened profile, comprises
in combination high temperature oxidising
means for progressively cutting the metal to the
required profile and a quenching device adapted
to apply a stream of quenching fluid to the pro-
filed surface before the temperature thereof has
fallen below the critical point.

In accordance with a further feature of this
invention a machine for producing a shaped fer-
rous metal part having a surface hardened pro-
file comprises in combination a support uni-

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versally movable in a plane and bearing a tracer
mechanism and a cutting burner with associated
quenching device, the tracer mechanism com-
prising a mechanically driven tracing roller in
axial alignment with the cutting burner normal
to the plane of movement, and a template ar-
ranged to guide the tracing roller along a path
conforming to the desired profile. The machine
may be rendered substantially wholly automatic
by providing in association with the template an
electrical control system including limit switches
adapted to be actuated by the tracing roller as it
traverse the template to turn on and off in the
desired sequence the supply of the fluids to the
cutting burner and quenching device.

The invention will now be described in further
detail with reference to the accompanying draw-
ings in which:

Fig. 1 is a view in central longitudinal section
of a compound cutting burner and quenching
device;

Fig. 2 is an underside view of the apparatus
shown in Fig. 1;

Fig. 3 is a view in central longitudinal section
of a modified burner and quenching device;

Fig. 4 is a fragmentary plan view, somewhat
diagrammatic, illustrating the path of traverse
over the work of the apparatus shown in Figs. 2
and 3;

Fig. 5 is a view in side elevation of a machine
for the production of a surface hardened profile,
a portion being broken away to expose a part of
the mechanism;

Fig. 6 is a plan view of the machine shown in
Fig. 5;

Fig. 7 is a plan view of a detail of the machine
shown in Fig. 6, on an enlarged scale, and

Fig. 8 is a view in side elevation of another de-
tail of the machine, on an enlarged scale.

Referring to Figs. 1, 2 and 3, a cutting burner
B has a substantially cylindrical nozzle N pro-
vided in known manner with a central orifice J
delivering a jet of oxygen, the central orifice be-
ing surrounded by an annular row of preheating
orifices H delivering a combustible fuel such as an
oxy-acetylene mixture. Around the wall of the
nozzle N there is mounted a hollow walled cylin-
drical quenching device Q, the inner wall of
which is a sliding fit with the wall of the nozzle
N. The quenching device Q has an inlet port P
fitted with a conduit C for connection to a supply
of quenching fluid which, in most instances, will
be cold water and a series of discharge orifices O
for producing a ring of quenching jets arranged
to impinge upon the heated surface along the

circumference of a circle centred on the cutting point. Since the inner wall of the quenching device Q is in close contact with the nozzle N, the quenching liquid delivered to the quenching device serves also as coolant for the nozzle.

To prevent the quenching fluid discharged from orifices O from interfering with the heating and cutting jets, a shield S is provided between these jets and the quenching jets. The shield S may be constituted as an extension of the inner wall of the quenching device Q, the extension projecting forwardly of the nozzle N to terminate close to the surface of the work W being cut when the nozzle N is positioned at the correct distance from the surface. Gas escape slots G may be formed in the end surface of the shield S to permit the products of combustion to escape readily.

As the distance of the nozzle N from the surface will need to be varied with different thicknesses and composition of metal or alloy being cut, it is of advantage to arrange for the shield S to be adjustable with respect to the nozzle N, so that the shield may be maintained close to the work for all settings of the nozzle N. With the arrangement shown in Fig. 1, this is achieved by simply sliding the quenching device Q, of which the shield S forms an integral part up or down the nozzle N. In the modification shown in Fig. 3, which in all other respects is substantially identical with that shown in Figs. 1 and 2, the quenching device Q and shield S integral therewith threadedly engage the nozzle N. The requisite adjustment of the nozzle N with respect to the surface to be cut is effected by screwing the quenching device Q about the nozzle N. A locking nut L may be provided for securing the quenching device in the desired position.

The operation of cutting and hardening a profile using the apparatus shown in Figs. 1, 2 and 3 will be clear by reference to Fig. 4, where J' represents the cutting jet, H' the line of impingement of the preheating jets, and Q' the line of impingement of the quenching jets upon the surface of the work W. At the starting point, the preheating jets are lighted up and, after heating for the appropriate period as determined by the thickness of the material being cut, the oxidising jet is turned on. At the same instant the quenching jets are turned on and the apparatus is traversed over the material either by hand or by a machine, the line of traverse being either marked upon the surface beforehand or a template provided for guiding the cutting jet along the required path. The cutting operation raises the temperature of the metal along the line of cut above the critical point and the temperature will not have fallen below this point when, in the course of traverse, the cut profile comes under the influence of the quenching jets which rapidly cool the heated surface below the critical point and thereby produce a hardened surface. In Fig. 4 there is illustrated the cutting and hardening of a toothed profile T, where the direction of traverse is constantly changing. In advancing along the tooth flank T' already cut, the burner moved leftwardly but after passing the apex to cut the tooth flank T'' the burner moves rightwardly. By surrounding the cutting jet with an annular quenching jet, the quenching of the heated cut profile is ensured whatever the direction of traverse may be at any instant.

A machine for producing a shaped ferrous metal part having a surface-hardened profile in accordance with the invention is shown in Figs. 5 to 8 to which reference will now be made.

For purpose of illustration the set up and operation of the machine will be described in connection with the cutting from an annular blank with sequent hardening of a component having a number of identical profiles uniformly spaced around the periphery. An example of such a component is a sprocket wheel.

The machine comprises a massive four-sided base 10 having a transverse partition 11 on which is mounted a support 12 for the work W. Where, as in the present example, a number of profiles are to be produced arranged around the circumference of a circle, the work support 12 comprises a turntable; where the profiles are disposed linearly, a machine slide would replace the turntable. The partition 11 has a drain 13 leading to an outlet 14 for the quenching liquid. To one side of the base 10 there is secured a pedestal 15 supporting a vertical column 16 which carries an upper arm 17 and a lower arm 18 extending over the work support 12. The two arms 17, 18, are slidably mounted on the column 16 and are arranged to be clamped firmly thereto by means of clamps 19, 20, respectively.

At its end remote from column 16, the upper arm 17 carries a template 21 of ferro-magnetic material for propelling the cutting burner B and quenching device Q along the desired path. With the template 21 there is associated an electrical control system comprising four limit switches to be described in detail later, the switches being connected to a control cabinet 22 by current leads extending through a sheath 23.

The lower arm 18 is articulated so as to be universally movable in a plane and is known in the cutting machine art as a "folding gate arm." The arm 18 constitutes a support for a tracer mechanism M and a cutting burner B with associated quenching device Q. The tracer mechanism M comprises a mechanically driven magnetic tracing roller 24 arranged to bear against the template 21, the roller 24 being in axial alignment with the burner B normal to the plane of movement. The roller 24 is adapted to be energised by a magnet coil which causes the roller 24 to adhere to the edge of the template and is caused to travel around the template by means of a driving motor 25, which may be a variable speed electric motor, to which the roller 24 is coupled through a gear box. The construction and operation of such tracer mechanism is well known in the art and no detailed description thereof is deemed necessary. The burner B, which is secured to the arm 18 by a clamp 26, is furnished with a nozzle N on which the quenching device Q is mounted as described above with reference to Figs. 1 and 2 or Fig. 3.

The cutting oxygen is supplied to the burner B through a solenoid-operated valve 27 and flexible conduit 28, the gaseous fuel for preheating is supplied through a solenoid-operated valve 29 and flexible conduit 30; the quenching liquid is supplied to the quenching device Q through a solenoid-operated valve 31 and flexible conduit 32. A pilot light 33 supplied with a gaseous fuel through a flexible conduit 34 may be provided to ignite the preheating jets.

In the particular example taken to illustrate this invention, namely the production of a sprocket wheel, the guiding surface or edge 35 to which the roller 24 adheres is an internal boundary formed by an opening in the template 21 as will be clear from Fig. 7. The guiding edge 35 is mounted in vertical alignment with the work W and having been properly orientated radially and

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circumferentially with respect thereto, the burner B with the quenching device Q operates simultaneously through the same path as the roller 24 to produce a surface hardened profile in the manner described above with reference to Figs. 1 to 4.

In sprocket wheels and other toothed members, which in use are subject to wear and impact mainly along the flanks and root of each tooth, it is usually desirable for the apex to have a less hard but tougher structure than the flanks and root. The ensuing description shows how such differentially hardened teeth may be automatically produced in succession around the periphery of the work W.

The sequence of operations involved in the production of such a toothed member, starting at the apex of one tooth, moving along a flank and root and finally along the flank of an adjacent tooth to the apex thereof, is as follows:

- a. The turning on of the preheating jets and subsequently of the oxidising jet with sequent starting of the burner along the desired path;
- b. The turning on of the quenching jets as soon as the oxidising jet has moved a predetermined distance along a tooth flank from the apex;
- c. The turning off of the quenching jets as the burner approaches the apex of the second tooth;
- d. The turning off of the preheating and oxidising jets when the apex of the second tooth is reached.

On completion of this sequence of operations, the burner is returned to the starting position whilst the work is moved through one tooth space so that the apex of the second tooth becomes the starting point of the second sequence of operations. This is repeated round the whole circumference of the blank until the burner once again reaches the apex of the first tooth.

Reverting to Fig. 7, the aforementioned operations a, b, c, d are initiated in turn at the four similarly-lettered points shown on the guiding edge of the template 21 by an electrical control system now to be described.

At each of the four points a, b, c, d there is a limit switch LSA, LSB, LSC, LSD respectively, the four switches being secured to template 21 and connected to relays (not shown) housed in control cabinet 22, which cause the solenoid operated valves 27, 29, 31, to be turned on and off in the desired sequence. A main switch MS, which may be of the push button type, controls the starting of motor 25 and the energisation of the magnet coil associated with the tracing roller 24. Switch MS is mounted on a switch panel SP secured to the front of the base 10 (Figs. 5 and 6). A second push button switch OS is mounted on panel SP for breaking the circuit, together with three further switches QV, FV, and OV. Switch QV is arranged to complete the circuit through the solenoid of quench valve 31 independently of the control exercised by the limit switches on the template to permit of testing the supply of quenching medium; switches FV and OV perform analogous functions in the circuits through the solenoids of fuel gas valve 29 and oxygen valve 27 respectively.

Except that switch LSA is associated with a latch mechanism LM, the four limit switches are identical, being simple make-and-break contact switches which are closed in turn by the tracing roller 24 as it traverses the guiding edges 35. The latch mechanism LM serves the function of preventing the roller 24 from traversing the guid-

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ing edge 35 for a predetermined interval when starting so that the requisite preheat may be imparted to the work before the cutting oxygen is turned on. As will be clear by reference to Fig. 8, the latch mechanism LM comprises a roller 36 carried by a stem 37 slidably mounted in a guide 38 constituting an extension to the switch lever 39 of limit switch LSA. Stem 37 is secured to a flexible cable 40 by means of which it can be retracted to lift the roller 36 out of the path of the tracing roller 24. A helical spring 41 is provided to restore the roller 36 to its original position when the cable 40 is released.

The sequence of operation is as follows:

Prior to starting, the tracing roller 24 is moved round the guiding edge 35 till it is in the vicinity of the point a. On closure of the main switch MS, motor 25 starts to rotate the tracing roller 24 whilst simultaneously the magnet coil which magnetises roller 24 is energised. The roller 24 moves slightly around the guiding edge 35 in a clockwise direction to abut against the latch roller 36 causing switch 39 to close, further traverse of the tracing roller 24 around the guiding edge 35 being prevented by the latch roller 36 although the tracing roller 24 continues to rotate. Closure of switch 39 energises the solenoid-operated fuel gas valve 29 to turn on the preheating gas to burner B which is ignited at the nozzle N by the pilot light 33. After a preheating period, solenoid-operated valve 27 is energised to turn on the supply of cutting oxygen to the nozzle N which moves round the guiding edge 35 in a clockwise direction and the normal cutting operation proceeds along the tooth flank until the tracing roller 24 reaches the point b where it abuts against the lever of limit switch LSB to close this switch, thereby causing the energisation of the solenoid-operated quench valve 31 to turn on the supply of quenching medium to the quenching device Q. Tracing roller 24 continues to roll round the edge 35 until it reaches the point c where it closes limit switch LSC to turn off the supply of quenching medium as the cutting operation approaches the apex of the second tooth. Further movement of the tracing roller 24 brings it to the position d where it closes limit switch LSD to shut off both the preheating gas and the cutting oxygen supply. Tracing roller 24 continues to move round the edge 35 to return to the starting point whilst the work W is rotated to bring the apex of the second tooth immediately below the point a, whereupon switch MS is again closed and the cycle of operations is repeated.

I claim:

1. Method of successively cutting and differentially hardening a toothed member to cause the apex of each tooth to have a less hard but tougher structure than the flanks and root, which comprises directing a preheating jet and subsequently a cutting stream of oxygen against a blank at the apex of a tooth, relatively propelling said jet and cutting stream with respect to a blank to form a kerf along the flank and root of said tooth and the adjacent flank of the next tooth, directing a quenching jet against the kerf as soon as the oxidizing stream has moved relatively to the blank a predetermined distance along the flank of the first tooth and causing said quenching jet to follow said cutting stream, turning off the quenching jet as the cutting stream approaches the apex of the second tooth, and completing the cut to the apex of the second tooth.

2. Method of successively cutting and differentially hardening a toothed member to cause the

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apex of each tooth to have a less hard but tougher structure than the flanks and root, which comprises directing a preheating jet and subsequently a cutting stream of oxygen against a blank at the apex of a tooth, relatively propelling the blank and said jet and cutting stream along the flank and root of said tooth and the adjacent flank of the next tooth, directing quenching fluid against said blank in an annular stream concentric with the cutting stream as soon as the cutting stream has moved relatively to said blank a predetermined distance along the flank of the first tooth, causing said quenching stream to move with said cutting stream relatively to the blank while maintaining such concentric relation and thereby insuring quenching of the heated kerf despite change in direction of relative movement of the cutting stream, and turning off said quenching stream as the cutting stream approaches the apex of the second tooth.

3. Apparatus for successively cutting and differentially hardening a toothed member to cause the apex of each tooth to have a less hard but tougher structure than the flanks and root, which comprises a burner nozzle for directing a preheating jet and subsequently a cutting stream of oxygen against a blank at the apex of a tooth, a support for said burner nozzle universally movable in a plane and bearing a tracer mechanism for propelling said burner along the flank and root of said tooth and the adjacent flank of the next tooth, a quenching device surrounding said burner nozzle and constructed and arranged to project an annular stream surrounding said preheating jet and cutting oxygen stream, a limit switch actuated by said tracer mechanism for turning on said quenching device as soon as the cutting oxygen stream has left the apex and has moved a predetermined distance along the flank of the first tooth, and another limit switch actuated by said tracer mechanism for turning off said quenching device as the cutting stream approaches the apex of the second tooth.

4. Method of successively cutting and differen-

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tially hardening a toothed member to cause the apex of a tooth to have a less hard and tougher structure than the flanks, which comprises directing a cutting oxygen stream against a blank at the apex of a tooth, relatively propelling the blank and said cutting stream to form a kerf along the flank, directing a quenching jet against the kerf as soon as the cutting stream has moved relatively to the blank a predetermined distance along the flank and causing said quenching jet to follow said cutting stream, turning off the quenching jet before the cutting stream reaches the apex of the second tooth, and completing the cut to the apex of the second tooth.

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