266-126. OR 2,461,734 SR

SEARCH ROOM

Feb. 15, 1949. A. L. HARTLEY ET AL. 2,461,734

FLAME HARDENING APPARATUS

Original Filed June 19, 1945 2 Sheets-Sheet 1

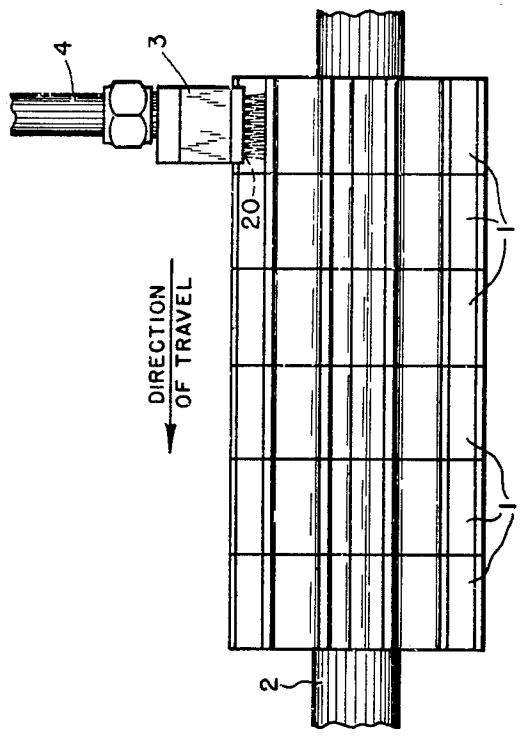


FIG. II

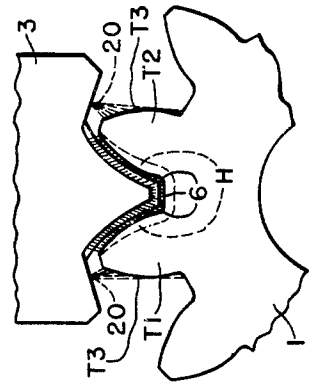


FIG. IIIb

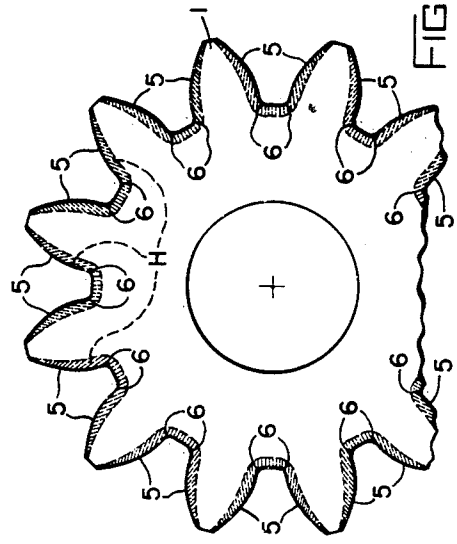


FIG. III

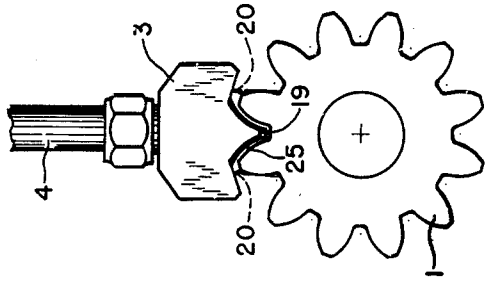


FIG. I

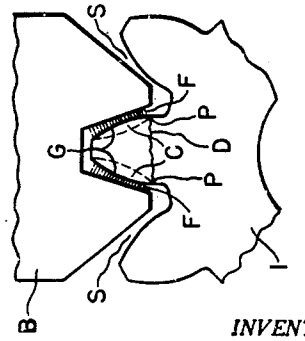


FIG. IIIa

T2035

X2042

X203

INVENTORS.
ALBERT L. HARTLEY
AND ADOLPH H. DAVIS

BY Taulmin & Taulmin

ATTORNEYS.

SEARCH ROOM

Feb. 15, 1949. A. L. HARTLEY ET AL 2,461,734

FLAME HARDENING APPARATUS

Original Filed June 19, 1945 2 Sheets-Sheet 2

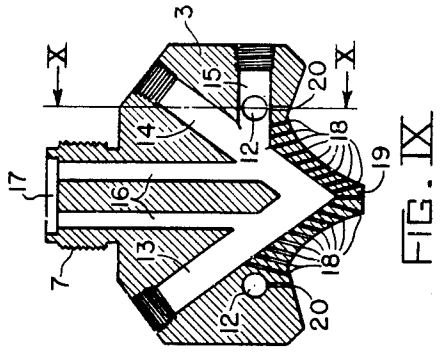


FIG. IX

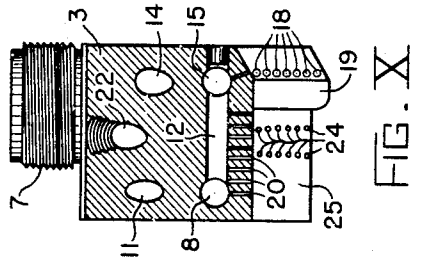


FIG. X

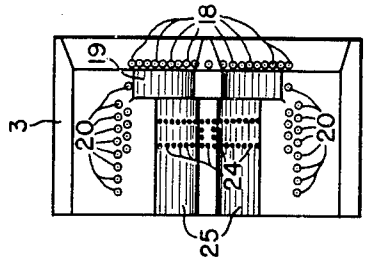


FIG. VI

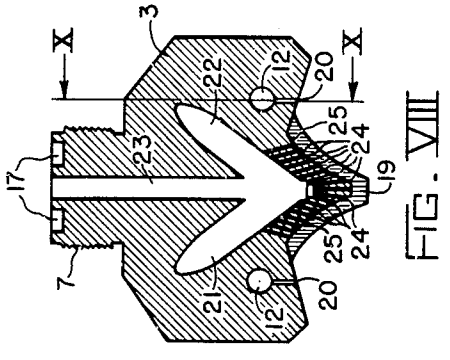


FIG. VIII

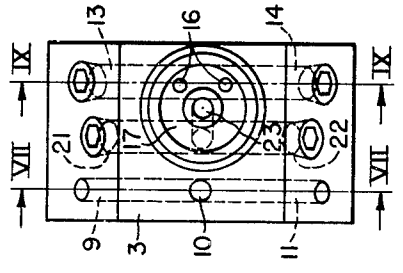


FIG. V

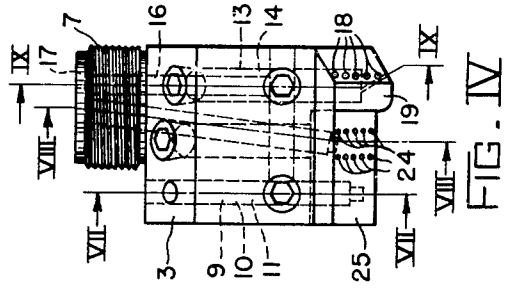


FIG. IV

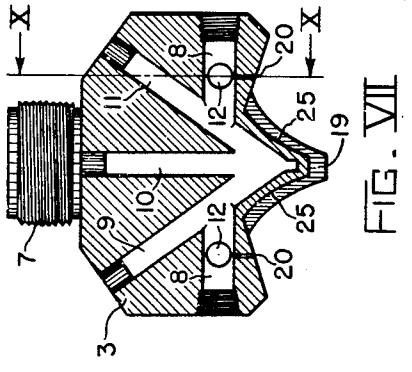


FIG. VII

INVENTORS.
ALBERT L. HARTLEY
AND ADOLPH H. DAVIS
BY
Taulmin & Taulmin
ATTORNEYS.

SEARCH ROOM

Patented Feb. 15, 1949

2,461,734

UNITED STATES PATENT OFFICE

2,461,734

FLAME HARDENING APPARATUS

Albert L. Hartley and Adolph H. Davis, Cincinnati, Ohio, assignors to The R. K. LeBlond Machine Tool Co., Cincinnati, Ohio, a corporation of Delaware

Original application June 19, 1945, Serial No. 600,354. Divided and this application December 8, 1945, Serial No. 633,731

1 Claim. (Cl. 266—4)

1

This invention pertains to an improved apparatus for surface hardening metallic objects. More particularly, this invention pertains to metallurgical apparatus for surface hardening gear teeth in which a blow torch or other equivalent device for applying intense heat is traversed longitudinally along the intertooth space or crotch between the gear teeth of a gear, the heated tooth surfaces being quenched immediately after the intense heating by spraying the surface locally with some cooling medium such as water or oil. It is also within the contemplation of this invention to treat gears made of air hardening steel in this manner, in which case a quenching medium would not be required.

This application is a divisional application of the original case Serial No. 600,354, filed June 19, 1945.

Heretofore, in the surface hardening of gears, it has been the practice to progressively traverse a flame and quenching medium along the tooth surface to be treated and to limit this heat treatment by the flame to the working surface of the tooth. Special precautions were taken to prevent the application of heat to any part of the gear other than the working surfaces of the teeth and it was the frequent practice to entirely submerge the gear being heat treated in coolant except for the small tooth portion which it was desired to surface harden.

It has been found that when the surface hardening effect is confined to the working surface of the teeth the gear has enhanced possibility of fatigue failure with consequent relatively short life and small load carrying capacity. This is due to the fact that the hardened area does not extend across the root of the tooth but terminates on the tooth surface at or near the base of the tooth. The areas along the teeth base are not heat treated, in fact, in the past, great precaution has been taken to prevent these root areas from receiving any heat treatment.

As a result, the line of demarcation between the flame hardened portion of the gear tooth working face and the underlying core material, which occurs at the base of the tooth and extends longitudinally of the tooth parallel to the gear axis, gives rise to a stressed area which is readily subject to fatigue failure when strain is applied to the gear tooth face under operating conditions. Thus, there is a tendency for the gear tooth to fracture and break off along the line of demarcation between the flame hardened portion and the soft root and fillet portion between the gear teeth when only its working faces are surface hardened.

2

It is therefore an object of this invention to provide apparatus to effect a flame hardening or surface hardening operation for gear teeth which is not confined to the working surfaces of the gear teeth but which also treats the fillets and root areas adjacent the teeth in the same manner so as to provide a uniform, uninterrupted flame hardened surface for the intertooth space. In this way there will be no points of stress or possible fatigue failure existent adjacent the base of the teeth as in former practices.

Still another object of this invention is to provide an improved apparatus for surface hardening gear teeth which effects an uninterrupted flame hardened surface in the intertooth space or crotch between the teeth, including the working face, the fillets, and the root areas between the teeth.

Still another object of this invention is to provide an improved means for applying the flames of a flame hardening apparatus to the teeth of a gear to be flame hardened so as to effect more efficient heat application to the gear tooth surfaces to be hardened with a minimum of thermal distortion and a greater degree of nicety of control of the flame hardening process.

Another object is to provide apparatus for flame hardening gear teeth by the application of surface heat treatment to adjacent working faces of the intertooth space between a pair of gear teeth and the root area therebetween in a simultaneous progressive manner.

And it is still another object to provide a method of flame hardening gear teeth by which a greater degree of quenching and heat control for portions previously flame hardened may be had.

Still another object is to provide apparatus for surface hardening gear teeth, utilizing the gas blow pipe form of heating device in which the entire intertooth space, including the root and fillets, is subjected to the same surface hardening temperatures as the working surfaces of the gear teeth so as to reduce fatigue failure at the base of the teeth and to thereby increase the life and dependability of the gear.

Another object is to provide an improved method for surface hardening gears, particularly the portions which are subjected to the greatest amount of wear and stress during operation, and to perform these improved surface hardening effects in a simple and inexpensive manner.

A further object is to provide an improved

method for progressively simultaneously flame hardening adjacent facing working surfaces of a pair of teeth, together with their associated fillets and root area, to a uniform depth of heat treatment to thus cause the physical properties of the material along this entire surface to be such as to provide an uninterrupted strengthened surface for the gear structure.

The above objects are attained in brief by providing an improved burner and also an improved method of operating the burner. The burner is so designed as to conform to the contour of the space between the teeth of the gear, rack, or any similar work configuration. This burner is provided with means for separating the flame area from the quenching area and also contains additional rows of coolant holes for protecting the outer contours of the teeth from becoming drawn or softened while the inner surfaces are being subjected to temperatures above the upper critical point for the material being treated.

The invention will be better understood when reference is made to the following description and the accompanying drawings, in which:

Figure I is a front elevational view showing the burner being applied to the teeth of a gear.

Figure II is a side view showing the improved surface hardening method being applied to a number of gears for simultaneous treatment.

Figure III is an enlarged view of one of the gears shown in Figures I and II, and indicating the optimum distribution of hardness penetration obtainable by this improved method and apparatus.

Figure III*a* is an enlarged fragmentary view of a gear showing the former method of flame hardening confined to the working faces of a gear tooth.

Figure III*b* is an enlarged fragmentary view of a gear showing the present method of flame hardening the entire intertooth space between a pair of gear teeth.

Figure IV is a view looking from the right of the flame hardening burner.

Figure V is a plan view of the burner shown in Figure IV.

Figure VI is a view of the bottom of the burner shown in Figure IV, illustrating particularly the arrangement of the flame and quenching holes.

Figure VII is a vertical transverse section taken along line VII—VII of Figures IV and V to illustrate particularly the coolant chamber incorporated in the front portion of the burner.

Figure VIII is a vertical transverse section taken along line VIII—VIII of Figure IV to show, in particular, the gas chamber and its associated openings.

Figure IX is a transverse sectional view taken along line IX—IX in Figures IV and V and showing particularly the coolant chamber with its associated openings as incorporated in the rear portion of the burner.

Figure X is a vertical section taken along line X—X in Figures VII, VIII, IX, illustrating the position of the openings for applying coolant to the outer surfaces of the teeth.

In carrying out our method of flame hardening, the gear or gears **1** are mounted on a suitable mandrel **2** which in turn is supported on centers (not shown) with associated well-known apparatus for effecting relative traversing of the gear or gears past the burner and cooling head in order to surface harden the desired portions of the gears. Preferably a machine such as disclosed in the Groene Patent No. 2,264,752, granted

December 2, 1941, and assigned to the same assignee as the present application may be utilized.

It was the former practice in surface hardening gear teeth to confine the hardened portion to the working face of each tooth. This was considered sufficient as it was primarily the object in former practice to merely increase the wear resistance of the gear and not the resistance of the gear teeth to fatigue. The former practice is shown in Figure III*a* in which the flames F from the burner B were caused to impinge only on the working faces of gear tooth contact G of the gear so as to provide flame hardened portions C along these faces. Furthermore, this practice was followed because of the difficulty of disposing of the burned gases which could best be done, it was thought, by this arrangement wherein the burned gases might readily escape through the spaces S between the side of the burner B and adjacent gear teeth.

While this method thus provides some measure of improvement in the wear characteristics of the working face of the gear tooth, an inherent weakness is developed in the gear tooth structure at the point P where the line of demarcation between flame hardened material C and the untreated core or gear body merges with the tooth surface near its base and juncture with the root area between the gear teeth. This is caused by the fact that the flame hardened material C tends to expand relative to the untreated core material in the gear so that the mass of core material holds the material C under compression after the completion of the flame hardening process. Thus there is a tendency for fracture and cleavage to develop at the points P which is particularly aggravated by the application of load to the working faces of the gear teeth when in operation. Thus, in time, a fracture may develop at the point P and travel through the gear tooth base along the line D which ultimately results in the fracture of the gear tooth.

In this new method a flame hardening burner **3** is mounted by the usual connecting conduit **4** to the mixing chamber of a flame hardening torch (not shown), using in this case mixed acetylene and oxygen as its heating medium. The burner is adjusted to fit in the interspace or crotch formed by two adjacent teeth T1 and T2, Figure III*b*, of the gear **1**. The burner is progressively traversed longitudinally along the gear teeth in the direction of travel shown in Figure II. When the burner **3** has finished its traverse across the gear teeth, the flame is then extinguished and the burner **3** is returned to its initial starting position, at which time the gears are indexed in any suitable manner to the next space and the procedure again repeated.

In Figures III and III*b*, the shaded areas H indicate the ideal or optimum distribution of hardness to be provided on the working faces **5** and in the fillet and root areas **6** between a pair of gear teeth. This flame hardened portion H, it will be noted, comprises an uninterrupted hardened surface extending from the tip of one gear tooth down through its working face, through the fillets and root portions between it and the next adjacent tooth, and up through the working face of said adjacent tooth to its tip. There is thus provided a homogeneous continuous flame hardened portion H. This portion is maintained under compresssion due to the rigid unaltered core material and has no break or interrupted juncture such as the points P, Figure III*a*, as occurs in former practice. Since fatigue failures result

SEARCH ROOM

only from tension stresses, maintenance of the area H in uninterrupted compression results in a gear structure highly resistant to fatigue.

This entire area H is flame hardened simultaneously by a new arrangement of the burner which is applied in the intertooth space or crotch formed between the gear teeth T1 and T2, Figure III*b*. The burner is so arranged as to efficiently and accurately develop the flame hardened surface area H by providing baffle means and an arrangement of flame jets and coolant jets so as to effect this result. Furthermore, an additional cooling arrangement is provided for the outer faces T3 opposite the faces being hardened, the coolant being distributed over a wide area extending longitudinally of these faces T3 so as to maintain the interior structure of the gear teeth unaltered during the flame hardening process.

In Figures IV, V, VI, VII, VIII, IX, and X, elevational and sectional views of the improved burner are shown, this burner having a unique construction in which the threaded portion **7** is provided for coupling with a standard flame hardening torch **4**. In general, the surface hardening unit is formed of three integral sections, all contained within a single casting or metal forging and internal passageways are provided between some of the sections in order to effect the best results. The first section of the unit, as illustrated in Figure VII, comprises a series of cylindrical compartments **8**, **9**, **10**, and **11**, of which compartment **10** extends vertically, compartment **8** extends horizontally, and compartments **9** and **11** extend diagonally. These compartments merge together at the lower end of the section to form in effect a reservoir for a coolant as will be explained hereinafter. The compartments are formed in the easiest manner by coring or drilling large holes at the proper positions and then plugging up the outer ends of the holes by pipe plugs. The combined chamber or reservoir formed by the various compartments is in communication through a pair of oppositely disposed longitudinally extending openings **12** with another chamber formed by the holes or compartments **13**, **14**, and **15** located in the rear portions of the unit **3**, as shown in Figure IX. These holes **13**, **14**, and **15** are also appropriately plugged and two of them extend diagonally down through the unit while the compartment or opening **15** extends horizontally. It will be noted that the opening **12** which passes into the front portion of the unit **3** has an ingress at the compartment **15**. As in the case of the front section, the small compartments **13**, **14**, and **15** all merge together to form a reservoir and vertical openings **16** extend upwardly from this reservoir to terminate in a circular chamber **17** formed in the stem of the unit. The chambers in the front and rear sections of the unit provide ideal cooling conditions for the middle or burner section, as shown in Figure VIII, which when being operated is under the influence of very high temperatures.

The lower surface of the front section of the unit **3**, as shown in Figure VII, is provided with projections **25** of a substantially a V-shape with a lower surface conforming roughly to the shape of an intertooth space. The lowermost or flat surface of the projection **25** does not extend as far down as the depth of a tooth but instead there is an appreciable space left between the wearing surfaces including the root of the teeth and all of the lower surface portions of the projection **25**.

The rear section of the unit **3**, as shown in Figure IX, also has a downwardly depending projection of substantially a V-shape, similar to the front section but the lowermost or flat surface, as indicated at **19**, extends to a greater depth than the projection **25** of the front section. Actually, the surface **19** is so positioned that it will just nicely clear the working faces and root area between the pair of teeth being operated upon. In this way, coolant applied to quench the flame heated portions between the gears is confined to the rear portion of the burner to prevent its interference with the flames in the front portion.

Directly below the position of the horizontal openings **12** which interconnect the coolant compartments of the front and rear sections of the burner, there are a number of aligned coolant discharge openings **20** extending longitudinally of the gear teeth to be treated, as seen in Figure VI, and in general, conforming to two straight lines at opposite sides of the lower face of the unit. These openings communicate with the longitudinal interconnecting openings **12**.

In addition to the openings **20**, the rear section (Figure IX) is also provided with a series of substantially vertical openings **18** extending entirely through the projection and communicating with the interior compartment formed by the plugged up holes **13**, **14**, and **15**. It will be noted that these openings are fairly close together and extend for a considerable distance over the projection as viewed in the vertical plane as far as the openings **20**.

It is apparent that when a coolant is admitted to the passageways **16** through a separate pipe contained within the blow pipe **4**, the cooling medium which is under considerable pressure will be forced out through the openings **18** against the gear teeth and a part of the medium will flow through the horizontal openings **12** to reach the compartment in the front section causing fine streams of the coolant to issue from the openings **20** en route.

As shown in Figures I and III*b*, these streams of coolant issuing from the outer lines of openings **20** (Figure VI) strike the far sides of two adjacent teeth tending to keep these surfaces and the body of the teeth being treated at a temperature below the critical heating temperature. The coolant streams issuing from the inner lines of openings **20** (Figure VI) are so positioned that they strike the two inner tips of adjacent teeth so that the entire outer edge and working faces of the teeth are thus maintained at a reduced temperature. This effect is shown in Figures III and III*b* which indicates that the depth of surface hardening is practically negligible at the outer edges of the respective teeth. The reason for limiting the depth of the surface hardening at this point is to prevent these edges from being heated above the critical temperature during the time that the wear surfaces and the root areas of the teeth are being treated. It is desirable that the tips of the teeth under these circumstances be maintained at a temperature less than the critical surface hardening temperature.

The central or middle section of the unit **3** constitutes strictly the burner or heater portion and is shown in section in Figure VIII. As illustrated, the gas or burner chamber is positioned intermediate the two end chambers carrying the coolant. This gas chamber is formed by a pair of compartments **21**, **22**, which extend diagonally outwardly through the unit **3** and may be formed, if desired, by drilling holes from the exterior of the unit and then plugging them up as in the case of the coolant chambers. There is a cen-

trally positioned opening **23** extending from the upper surface of the screw plug **7** in a direction slightly diagonal, as indicated in Figure V, to communicate with the chambers **21**, **22**. A mixture of acetylene and oxygen is applied to the opening **23** through the blowpipe so that the chambers **21**, **22** constitute a reservoir filled with this mixture. For emitting a pattern of flames to the surfaces being flame hardened, a series of openings **24** which form the flame jets are provided, these openings extending from the V-shaped surfaces **25** to the gas chamber. It will be noted that there are a large number of these openings and they extend uniformly over the entire curved surfaces of the V-shaped projection and also along the lowermost flat horizontal surface of the projection. This is important because it permits the jet flames to not only strike against the curved wearing surfaces of the teeth but also the fillets and the root areas. As shown in Figure VI, there are preferably two rows of jet openings **24**, these rows being spaced apart a distance depending on the width of the tooth in order to uniformly heat all of the surfaces of the teeth including the root areas but excluding the tips.

The V-shaped projection **19** of the coolant section, Figure IX, extends for a greater depth than the corresponding projections of the heater section, which communicate with the chambers **13**, **14**, and **15** are considerably removed from the openings **24** in the burner section since the openings **18** are positioned in a single row and emerge at a tapered surface, indicated at **27**, formed at the coolant section end of the burner on the opposite side of the shoulder portion **26** from the burner openings **24**. Thus, there can be little or no interference between the two sets of openings **24** and **18**, and each set will perform its individual function of first heating the wearing surfaces of the teeth (except the tips), also the fillets and root areas, and then suddenly quenching the heated areas to obtain a surface hardening effect without permitting the cooling fluid from substantially detracting from the heating effects offered by the jets **24**.

The coolant discharge outlets **20** are so positioned relative to the flame jets **24** that the gear teeth being operated upon serve to shield the coolant from interference with the flames by confining the coolant to the outside working surfaces T3 of the pair of teeth being hardened, as best seen in Figure III*b*.

It has been found that when a head or burner unit **3** having the three sections described above is caused to move longitudinally of the interspace between a pair of gear teeth, as shown in Figures II and III*b*, the adjacent wearing surfaces of the teeth together with the fillets and root area will be first heated above the critical temperature and then immediately thereafter will be quickly cooled to obtain a hardened surface which is prestressed by the unaltered core of the gear and maintained in compression for providing added strength and resistance to fatigue failure of the gear. The original material at these heated surfaces is changed from a pearlitic or sorbitic structure to a hardened martensitic structure of expanded volume and the entire surface including the root areas are thus placed under compression due to this change

which takes place in the internal structure of the material.

Thus, with this improved technique in which the fillets and root areas as well as the working surfaces of the gear teeth are flame hardened, gears or racks treated in this manner have been found capable of sustaining unusually heavy loads and of operating without fatigue failure or appreciable wear over long periods of time.

While the apparatus herein disclosed and described constitutes a preferred form of the invention, it is to be understood that the apparatus is capable of mechanical alteration without departing from the spirit of the invention and that such mechanical arrangements and commercial adaptations as fall within the scope of the appendant claims are intended to be included herein.

Having thus fully set forth and described this invention, what is claimed as new and desired to be secured by United States Letters Patent is:

In a flame hardening burner, for progressively flame hardening the gear tooth surfaces of the intertooth space between a pair of teeth of a gear, a burner body having a portion conforming to the shape of said intertooth space of the gear to be hardened, and heating, quenching, and cooling means in said portion including a series of flame jet openings in said portion, a series of quenching jet openings in said portion, a baffle formed integral with said portion at an interspaced position between said flame and quenching jets, a series of tooth cooling jets located in the body portion of said burner in rows parallel to the direction of progressive movement of gear tooth and burner including jet openings for projecting coolant normal to said direction of progressive movement so as to direct a cooling liquid to the outside faces of the pair of gear teeth being hardened at a point opposite point of engagement of the flames on the faces of the teeth in the intertooth space, passageways in said body for conducting a source of fuel to said flame jets, and further passageways for conducting a source of quenching and cooling liquid to said quenching and cooling jet openings.

ALBERT L. HARTLEY.
ADOLPH H. DAVIS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,711,835	Davis	May 7, 1929
2,188,637	Walker	Jan. 30, 1940
2,220,002	Rollman et al.	Oct. 29, 1940
2,254,306	Mott et al.	Sept. 2, 1941
2,273,809	Kinzel	Feb. 17, 1942
2,274,861	Gridley	Mar. 3, 1942
2,294,187	Kullman et al.	Aug. 25, 1942
2,312,839	Kullman et al.	Mar. 2, 1943
2,433,055	Linden et al.	Dec. 23, 1947

FOREIGN PATENTS

Number	Country	Date
225,333	Great Britain	Dec. 4, 1924
294,709	Great Britain	Aug. 2, 1928
484,365	Germany	Dec. 14, 1929