Sept. 9, 1969 J. J. CUNNINGHAM ET AL 3,466,023

SIDE QUENCH MECHANISM FOR INDUCTION INTENSIFIERS

Filed Jan. 16, 1967 2 Sheets-Sheet 1

Fig. 1

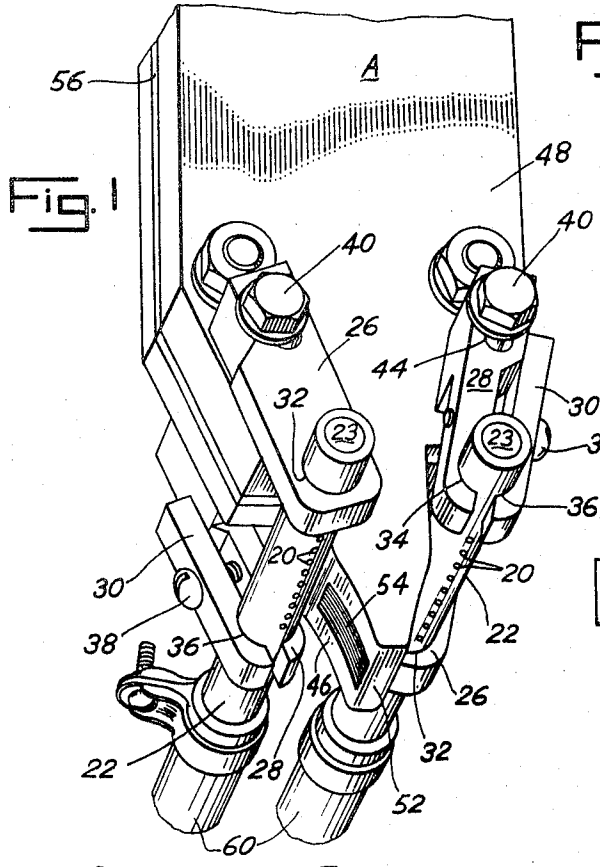


Fig. 2

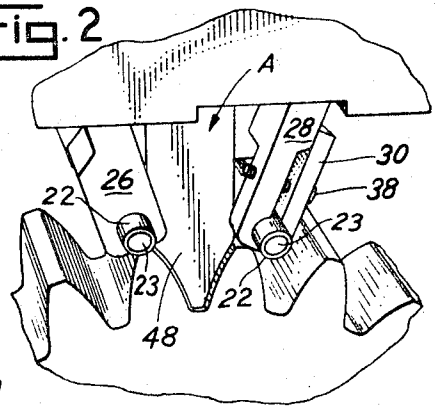


Fig. 3

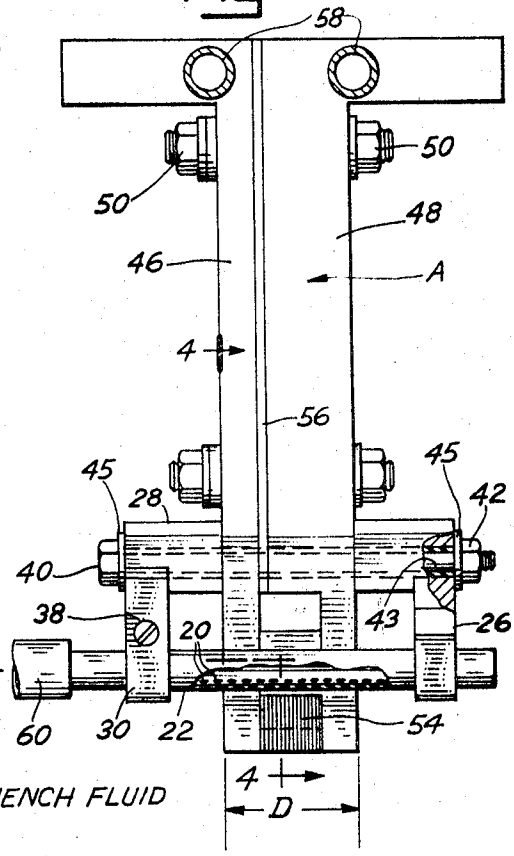
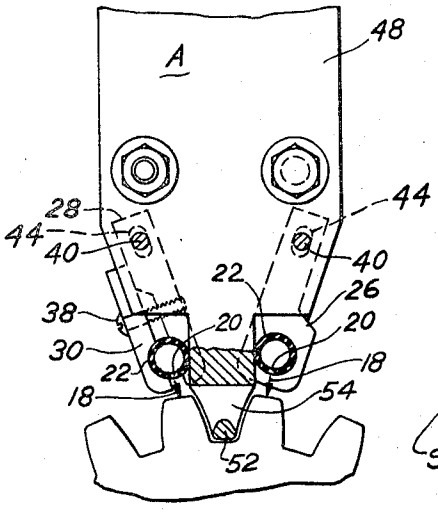


Fig. 4



INVENTORS
JAMES J. CUNNINGHAM,
WEBSTER F. HALL
BY & ALLEN J. MYERS
Bair, Freeman & Molinare
ATTORNEYS

Sept. 9, 1969 J. J. CUNNINGHAM ET AL 3,466,023

SIDE QUENCH MECHANISM FOR INDUCTION INTENSIFIERS

Filed Jan. 16, 1967 2 Sheets-Sheet 2

Fig. 5

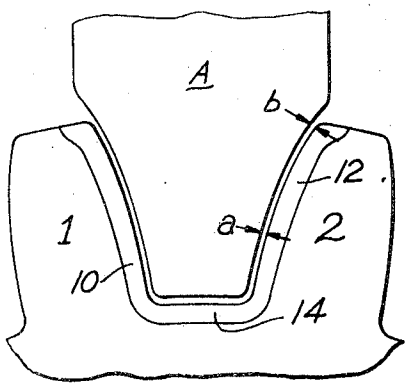


Fig. 8

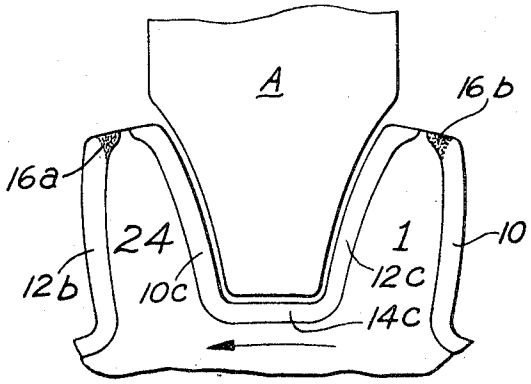


Fig. 6

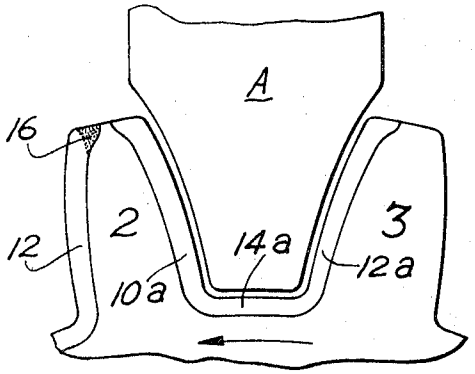


Fig. 9

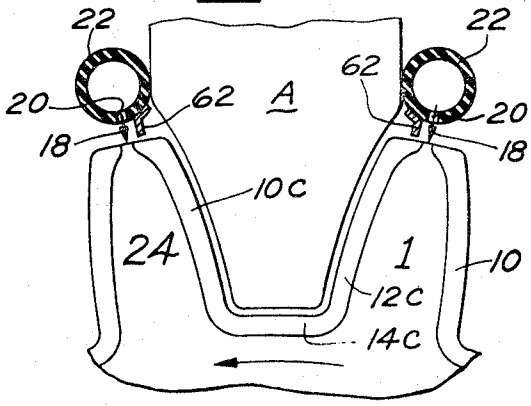


Fig. 7

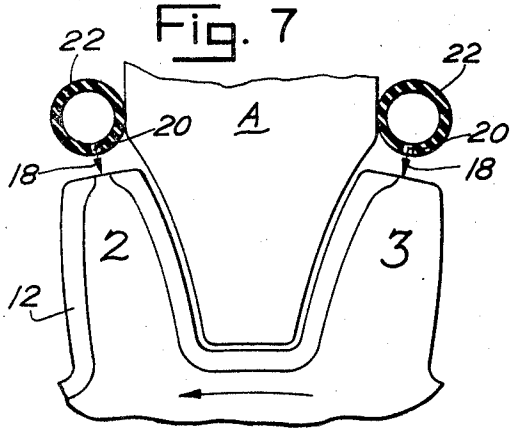
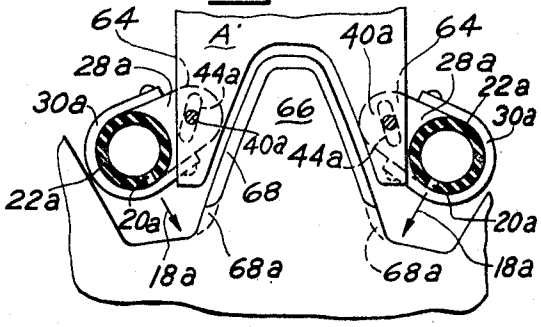


Fig 10



INVENTORS
JAMES J. CUNNINGHAM,
WEBSTER F. HALL
BY & ALLEN J. MYERS
Bair, Freeman & Molinare
ATTORNEYS

United States Patent Office 3,466,023
Patented Sept. 9, 1969

3,466,023

SIDE QUENCH MECHANISM FOR INDUCTION INTENSIFIERS

James J. Cunningham and Webster F. Hall, Richmond, and Allen J. Myers, Fountain City, Ind., assignors to National Automatic Tool Co., Inc., a corporation of Indiana

Filed Jan. 16, 1967, Ser. No. 609,388
Int. Cl. C21d 1/66, 9/32
U.S. Cl. 266—4 11 Claims

ABSTRACT OF THE DISCLOSURE

Quenching means for an induction intensifier which hardens gear teeth or the like in tooth-by-tooth fashion, such means being operable to concentrate quench liquid on specific areas of the gear teeth in order to improve the hardness pattern thereof.

One object of the invention is to provide quench mechanism carried by an induction intensifier so that each intensifier includes its own side quench mechanism so that when intensifiers are changed the side quench nozzles do not have to be adjusted for each new tooth hardening job.

Another object is to provide quench nozzles in the form of tubes located at the sides of an induction intensifier and extending longitudinally of the gear teeth, each tube having a row of perforations from which jets of quench liquid issue and are directed against the adjacent areas of gear teeth to prevent previously hardened portions thereof from being partially annealed by a subsequent hardening operation.

Still another object is to provide a means for mounting the quench nozzles directly on the intensifier itself so as to become an integral unit therewith, the character of the mounting being such as to permit adjustment of the nozzles in all three planes to thus provide all possible and any desirable character of quench action on the gear teeth being hardened.

Still a further object is to provide quench mechanism in the form of a pair of tubes, one for each side of the induction intensifier and each provided with a row of jet discharge openings distributed lengthwise of the gear teeth, mounting means for the tubes being provided so that they may be adjusted toward or away from the gear teeth or from side-to-side with respect to the gear teeth, and the tubes may be rotated for directing the jets issuing through the jet orifices thereof in the desired direction.

With these and other objects in view, our invention consists in the construction, arrangement and combination of the various parts of our side quench mechanism for induction intensifiers, whereby the objects above contemplated are attained, as hereinafter more fully set forth, pointed out in our claims and illustrated in detail on the accompanying drawings, wherein:

FIG. 1 is a perspective view of an induction intensifier with one of our side quench units mounted on each side thereof;

FIG. 2 is a perspective view of the lower end of the intensifier illustrating it passing through the trough between two adjacent gear teeth;

FIG. 3 is a side elevation of FIG. 1;

FIG. 4 is a sectional view on the line 4—4 of FIG. 3 and shows most of the intensifier in elevation;

FIGS. 5 to 9 inclusive are diagrammatic views of adjacent gear teeth, an induction intensifier and our side quench jets, illustrating in FIGS. 5, 6 and 8 teeth hardening without quench jets and in FIGS. 7 and 9 tooth hardening with quench jets; and

FIG. 10 is a view similar to FIG. 4 showing a modification.

In COLD-HEAT hardening of gear teeth by the tooth-by-tooth method, the hardening process is actually carried out beneath the surface of a quench liquid which serves to keep the gear at a uniformly cold temperature at all times except for that portion which is being hardened by the passage of an energized induction intensifier through the trough between two gear teeth. Such passage heats the adjacent tooth flanks progressively and thus only a minimum portion of a tooth is at the hardening temperature at any given instant. The intensifier scans from one gear face to the other and thus progressively hardens both tooth flanks and the root between two adjacent flanks to provide a continuity of hardness pattern at the root which is the portion of a tooth that usually fails from repeated or excessive loading.

At the outer ends of the teeth the hardness patterns may overlap, especially if these outer ends are very narrow, and even when they do not overlap, a hardness pattern secured by a previous passage of an intensifier may become partially annealed during a subsequent passage on the other side of the tooth. This is illustrated in FIGS. 5 and 6. An intensifier is shown generally at A and there are two gear teeth numbered **1** and **2**, the intensifier being located between them and producing a hardness pattern **10** along the right side flank of the tooth No. **1** and **12** along the left side flank of the tooth No. **2** as well as a hardness pattern at **14** in the bottom of the trough or at the root of the teeth.

In tooth-by-tooth hardening the intensifier A is passed longitudinally along the tooth trough and is shaped to clear the adjacent gear tooth side flanks with a spacing in the neighborhood of .015" as illustrated at *a* in FIGS. 5 and 6. At the tips of the teeth the spacing may be increased (*b*) depending on the hardness pattern desired.

After the intensifier has passed between the teeth **1** and **2**, the gear is rotated counter-clockwise to the position shown in FIG. 6 so that the next passage of the intensifier is between the teeth **2** and **3**. We now have a hardness pattern **10***a*, **12***a*, **14***a* for the teeth **2** and **3**, but in spite of the entire operation being performed under quench liquid the trailing outer end of the hardness pattern **12** becomes annealed as indicated by stippling at **16** thus destroying part of the harness pattern previously accomplished.

Referring to FIG. 7 this annealing result shown at **16** in FIG. 6 may be eliminated by providing jets of quench liquid indicated by the arrows **18** forced from jet orifices **20** of quench tubes **22** so that the hardness pattern **12** it will be noted remains as accomplished in FIG. 5. The hardness pattern is thus controlled by the jets **18** issuing from the side quench tubes **22** which obviously may be located in reference to the intensifier A so as to always deliver the jets **18** at desirable points on the outer ends of the gear teeth, usually and preferably halfway between the side flanks thereof. Hereinafter we will describe how the side quench tubes **22** are mounted on the intensifier A in such manner as to be fully adjustable to the desired positions in reference to the gear teeth to be hardened by the intensifier.

Assuming the gear illustrated in FIGS. 5 to 9 as having 24 teeth, it will be noted in FIG. 8 that the 24th–1st gear tooth trough is now in position for hardening the adjacent side flanks of the gear teeth **1** and **24**. Without our side quench mechanism it will be noted the trailing end of the hardness pattern **12***b* on the tooth **24** has been annealed as at **16***a* while the leading edge of the hardness pattern **10** on the tooth **1** has been annealed as at **16***b*. Thus the trailing ends of the hardness patterns on the left-hand flanks of all the teeth **2** through **24** are annealed while the leading edge of the hardness pattern on the right-hand flank of the tooth **1** is also annealed, but the right-hand flank of No. **24** and the left-hand flank

of No. 1 are neither one annealed. This results in an unevenness of annealing in addition to the objection of annealing.

When our side quench tubes 22 are used as in FIG. 9 the outer ends of both teeth 1 and 24 are not annealed, and the same is true of all teeth of the gear.

The volume of quench liquid supplied to the side quench tubes 22 determines the degree of cooling and consequently the degree of elimination of annealing. In other words, if the volume is insufficient some annealing may occur whereas a certain rate of quench liquid flow is sufficient to eliminate all annealing. Accordingly, for a given gear tooth size and/or shape a flow meter record can be kept and duplicated when gear teeth of the same size and/or shape are to be hardened by the particular intensifier designed for the type of gear teeth encountered. By mounting the quench tubes 22 directly on the intensifier A, once they are adjusted in relation thereto, and relative to the gear teeth for which that intensifier was designed, no further adjustments need to be made except in the regulating valve for the flow meter. The quench liquid may be supplied to one end of each tube by a hose 60, the opposite end of the tube being plugged as at 23. The tubes are made of insulating material so as to avoid any possible short circuits or grounding.

Turning now to FIGS. 1 to 4 inclusive, we disclose a form of mounting for the quench tubes 22 on the intensifier A comprising a pair of brackets 26, a pair of brackets 28, and clamp bars 30. Each bracket 26 is provided with an opening 32 of a size to rotatably and slidably receive the side quench tube 22. Each bracket 28 is provided with a seat 34 and each clamp bar 30 is provided with a seat 36 which engage opposite sides of the quench tubes and clamp them in position when clamp screws 38 are tightened down.

The brackets 26 and 28 are provided with slotted openings 44 through which clamp bolts 40 extend and the clamp bolts also extend through the body of the intensifier A and are provided with clamp nuts 42 as shown in FIG. 3 whereby the brackets are secured to the intensifier A to become part of an integral unit therewith.

The intensifier A may be of the general type shown in Jones Patents Nos. 2,810,054 and 2,857,154 having a pair of L-shaped sides as shown in FIG. 3, one at the left and identified 46 and the one at the right identified 48. Each has a terminal 50 connected to the high frequency generator. The sides 46 and 48 serve as conductors and are insulated from each other by a conductor 52 so that the lower end of the intensifier provides a closed loop for the HF or RF current used to energize the intensifier. A stack of laminations 54 is shaped for the particular size and pitch of the gear teeth for which the intensifier is specifically designed. Quench liquid supply tubes 58 are provided, one of which may serve as an inlet and the other as an outlet, the liquid passing down one leg 46 and up the other leg 48 and being so directed with respect to the laminations 54 as to cool them in the manner disclosed in the Jones patent.

Heat is generated in the induction-heating process by current passing through the conductor loop 46, 52, 48 which produces by a rapidly changing magnetic field an induced HF or RF current within the gear teeth adjacent the lamination. The resistance to flow of this induced current creates heat in the gear teeth proximate to the intensifier. The eddy-current effect of the magnetic field causes this heat by magnetic hysteresis. By using the COLD-HEAT process and tooth-by-tooth heating, distortion in the work is much less than in overall heating, and tooth strength is much greater. However, in certain gear teeth and particularly those having narrow outer ends, the annealing effects illustrated in FIGS. 6 and 8 are sometimes encountered and we have found that this trouble can be entirely eliminated by the use of side quench mechanism of the type herein disclosed.

The slots 44 permit adjustment of the side quench tubes 22 toward and away from the ends of the gear teeth and also permit the brackets to be swung inwardly or outwardly to accommodate the spacing between adjacent gear teeth. A third adjustment is provided in that the clamp bars 30 may be loosened and the side quench tubes 22 rotated for directing the jet orifices 20 in the proper direction. After the adjustments are made and the clamp screws 38 as well as the clamp bolts 40 and their clamp nuts 42 tightened, the intensifier and the side quench mechanism mounted thereon become an integral unit. Thus when the intensifier is removed from the hardening machine and laid aside its side quench mechanism remains with it until such time as another gear for which the intensifier is designed is to be hardened, and when the intensifier is again mounted on the machine, the side quench mechanism is already in adjusted position so that the only further adjustment required is the flow rate of the quench liquid to the side quench tubes 22. The hoses 60 can be readily disconnected from the intensifier and its side quench mechanism when it is removed from the induction hardening machine and associated with the side quench tubes of the next intensifier and side quench mechanism to be used in the machine.

The clamp bolts 40 and the clamp nuts 42 are insulated in respect to the brackets 26 and 28 and the intensifier A so as to avoid short circuits by means of insulation tubes 43 and insulation washers 45. The jet orifices 20 are arranged along each quench tube 22 preferably in a straight row, the length of which is greater than face-to-face dimension D of the intensifier A as shown in FIG. 3. Thus quench fluid is discharged against the gear tooth in the area at any time being heated and somewhat ahead of and behind that area. The jet orifice pattern may be varied however, and tailored for work which presents specific hardening pattern problems.

While we have illustrated the perforations 20 as drilled holes, they may be slotted longitudinally of the tube 22, or may be in the form of a single slot.

In addition to COLD-HEAT induction hardening herein before described, some hardening can be done without submerging the work and the induction internsifier in quenching liquid. The use of our side quench mechanism is even more important for this type of hardening to avoid annealing such as shown at 16 in FIG. 6, and 16*a* and 16*b* in FIG. 8, as the degree of annealing is not reduced by submersion in quench liquid. In FIG. 9 we show flanges 62 secured to the quench tubes 22 in position to reduce the effect of the flow from the perforations 20 on the hardness pattern 10*c* being produced by the intensifier A.

While we have described our side quench mechanism in detail with respect to an intensifier which passes through the trough between two adjacent gear teeth, it may also be applied to a design of intensifier such as shown at A' in FIG. 10 having a pair of fingers 64 straddling the tooth 66 so as to produce a hardness pattern that does not extend to the root of the gear tooth. One example is the hardening of the teeth of a worm which meshes with a worm gear for driving machinery and the like.

FIG. 10 is comparable to FIG. 4 except the parts are somewhat different in design but comparable parts bear the same reference numeral with the addition of *a*. A hardness pattern 68 is being produced, and is prevented by the jets 18*a* from extending down to the root as it might otherwise do as indicated at 68*a*.

Some changes may be made in the construction and arrangement of the parts of our side quench mechanism without departing from the real spirit and purpose of our invention, and it is our intention to cover by our claims any modified forms of structure or use of mechanical equivalents which may reasonably be included within their scope.

We claim as our invention:

1. A side quench mechanism for induction intensifiers of the type defined for tooth-by-tooth hardening of gears and the like wherein the intensifier scans a flank of a gear

tooth; bracket means mounted on and carried by said intensifier, said bracket means comprising a bracket and means for clamping said bracket to a face of the intensifier comprising a clamp bolt, a side quench tube supported by said bracket means and extending along a side of said intensifier, said bracket having a slotted opening for said clamp bolt to permit adjustment of said side quench tube toward and away from the gear tooth, and being swingable on said clamp bolt for adjustment toward and away from the side of said intensifier and said side quench tube having jet orifice means directed toward the portion of the gear tooth adjacent the end of the hardening pattern when said intensifier is in operative position relative thereto.

2. In side quench mechanism for induction intensifiers of the type designed for tooth-by-tooth hardening of gears and the like wherein the intensifier is designed to pass through a trough between two gear teeth; bracket means mounted on and carried by said intensifier, side quench tubes supported by said bracket means and extending along opposite sides of said intensifier, said bracket means comprising a pair of brackets for each side quench tube, means for clamping each bracket of said pair of brackets to opposite faces of said intensifier comprising clamp bolts, said brackets having slotted openings for said clamp bolts to permit adjustment of said side quench tubes toward and away from the ends of the gear teeth, and being swingable on the clamp bolts for adjustment toward and away from the sides of the intensifier, said side quench tubes each having jet orifice means spaced therealong and directed toward the ends of a pair of adjacent gear teeth when said intensifier is in operative position in the trough between said pair of gear teeth.

3. A side quench mechanism for induction intensifiers according to claim 1 wherein said bracket means includes clamp means for said side quench tube to hold it in any position of rotational adjustment relative to said bracket means.

4. A side quench mechanism for induction intensifiers according to claim 1 wherein said bracket means includes a first bracket in which said quench tube is rotatably and slidably mounted, a second bracket having a seat for one side of said quench tube, a clamp bar having a seat for the other side of said quench tube, and a clamp screw for clamping said clamp bar to said second bracket.

5. A side quench mechanism for induction intensifiers according to claim 1 wherein a pair of said side quench tubes is provided and said bracket means comprises a pair of brackets for each side quench tube, means for clamping each bracket of said pair of brackets to opposite faces of said intensifier comprising clamp bolts, said brackets having slotted openings for said clamp bolts

to permit adjustment of said side quench tubes toward and away from adjacent gear teeth, and being swingable on the clamp bolts for adjustment toward and away from the sides of said intensifier.

6. A side quench mechanism for induction intensifiers according to claim 5 wherein said bracket means includes clamp means for said side quench tubes to hold them in any position of rotational adjustment relative to said bracket means.

7. A side quench mechanism for induction intensifiers according to claim 5 wherein at least one bracket of said pair of brackets has clamp means for its side quench tube to hold it in any position of rotational adjustment relative to said bracket means.

8. A side quench mechanism for induction intensifiers according to claim 5 wherein said bracket means includes for each of said quench tubes a first bracket in which the quench tube is rotatably and slidably mounted, a second bracket having a seat for the other side of the quench tube, a clamp bar having a seat for the other side of the quench tube, and a clamp screw for clamping said clamp bar to said second bracket.

9. A side quench mechanism for induction intensifiers according to claim 2 wherein said bracket means includes clamp means for said side quench tubes to hold them in any position of rotational adjustment relative to said bracket means.

10. A side quench mechanism for induction intensifiers according to claim 1 wherein at least one bracket of said pair of brackets has clamp means for its side quench tube to hold it in any position of rotational adjustment relative to said bracket means.

11. A side quench mechanism for induction intensifiers according to claim 1 wherein a flange is carried by said side quench tube and positioned between said jet orifice means and intensifier.

References Cited

UNITED STATES PATENTS

2,157,948	5/1939	Beeny	148—149
2,338,496	1/1944	Denneen et al.	
2,958,524	11/1960	Delapena et al.	

J. SPENCER OVERHOLSER, Primary Examiner

J. S. BROWN, Assistant Examiner

U.S. Cl. X.R.

148—147, 149; 219—10.43, 10.59