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HIGH-FREQUENCY INDUCTION HEATING APPARATUS

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Fig. 1.

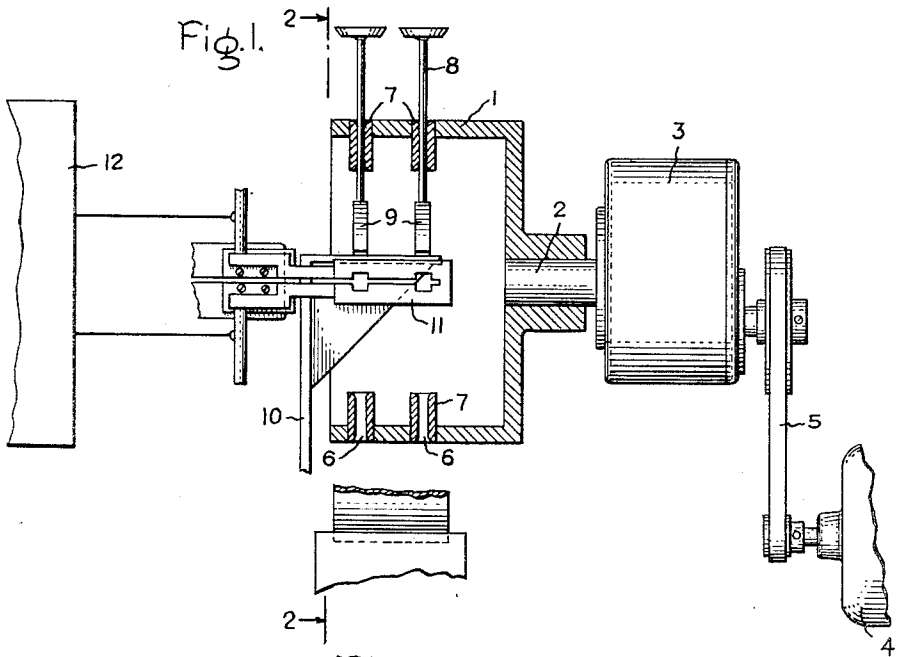
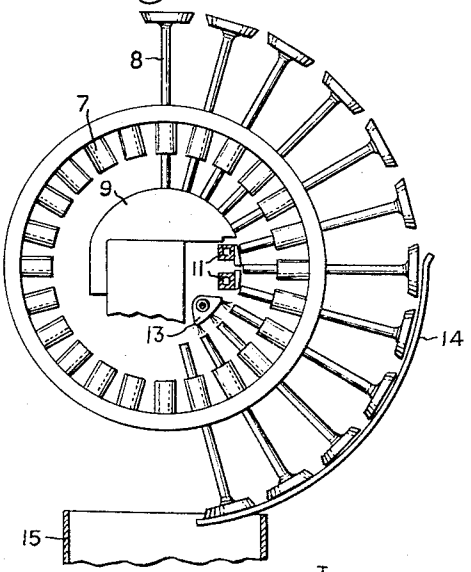


Fig. 2.



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HIGH-FREQUENCY INDUCTION HEATING APPARATUS

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3 Claims. (Cl. 219—47)

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Our invention relates to high frequency heating apparatus and more particularly to high frequency inductive heating apparatus for heating the ends of rod-like members for hardening purposes, such as the tips of valves, and has for its object simple and reliable apparatus for moving a plurality of members to be heated consecutively past high frequency heating means so that a selected portion of each member is heated.

It is known that, for many applications, it is desirable to harden the tip ends only of rod-like members, which ends in normal usage are subjected to high temperatures and hard work conditions. For example, the tips of valves used in internal combustion engines are subjected to conditions which cause wearing of these ends unless they are treated to resist wear at these points. Usually rod-like members of this type are formed of steel or alloy and it is desired that only the tip end, which is subjected to hard working conditions, be hardened. Thus, in the case of the valves for an internal combustion engine, the heat treatment should extend over only approximately one-eighth of an inch of the valve stem. In the past it has been customary to heat treat the tip ends of rod-like members of this type by passing the ends through a controlled gas flame for a predetermined period of time and, thereafter, quenching or cooling the member. It is an object of our invention to provide new and improved apparatus for heat treating the ends of rod-like members of this type which effects improvements in both the rapidity and the uniformity of the heat treatment.

One of the features of our invention consists of a rotary feed mechanism which holds the rod-like members in a radially disposed position with the tips being accurately positioned relative to an induction heating apparatus used for heat treating the tip ends of the members. In the feed mechanism, the rod-like members to be treated are successively loaded, accurately positioned, heated by induced electric currents, cooled if desired, and discharged from the mechanism.

For a more complete understanding of our invention, reference should be had to the accompanying drawing in which Fig. 1 is a side view, partly in section, of the heat treating apparatus of our invention and Fig. 2 is an end view showing the relation of the rotating wheel and the work pieces in the apparatus of Fig. 1.

Referring to the drawing, we have shown our invention in one form as applied to the surface heating and hardening of the tips of valves used in automobile engines. The requirement is to

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harden the tip of the valve uniformly over the face and to a depth which is usually specified not to exceed ⅛".

The heat treating apparatus illustrated comprises a fixture 1 mounted on the horizontally positioned output shaft 2 of speed reducer 3 which is in turn driven by any suitable means such as an electric motor 4 and a connecting belt and pulley drive 5. The fixture or support 1 comprises an open ended cylindrical member or drum around the circumference of which are located parallel rows of equally spaced openings 6. Each of these openings is provided with a radially extending tubular insert or guide 7 which is fitted into the fixture in any suitable manner as, for example, by means of a press fit. These inserts are of a length and have a central bore such that they hold the valves 8 or other work pieces to be processed, as fixture 1 is rotated, without permitting an undesirable amount of lateral movement of the valve. On the other hand, the bore of inserts 7 is sufficiently large that a work piece to be treated may easily be inserted therein and falls freely therefrom at a later step in the heat treatment cycle.

During operation of the apparatus illustrated, the valves 8 are placed either manually or by any suitable automatic feeding means (not shown) in the inserts 7 on or before these inserts reach the top vertical position. In order that the tip end of each valve or work piece be accurately positioned for subsequent heat treatment thereof, we provide a plurality of positioning members or stops 9 formed as shoe-like members rigidly supported by an adjustable rigid arm 10 extending into the open end of fixture 1. The stops or positioning members 9 are so positioned that the tip ends of the valves 8 rest thereon when placed in inserts 7. The stops 9 preferably are faced with a suitable wear resisting material such as Stellite or may be formed of surface hardened steel, and are formed as a circular sector having an axis coincident with that of the fixture so that the valves maintain a fixed position radially with respect to the fixture during the rotation. The fixture as shown in Fig. 2 rotates in a clockwise direction.

As the valves approach the horizontal position their tip ends leave the end of stop or positioning member 9 and pass in front of the heating coil or inductor 11, which is shown in the form of a hairpin loop. The inductor 11 is supplied with current from a source 12 at a suitable high frequency, such as 500,000 cycles a second. As is well known, such high frequency currents induce

high frequency currents in an object located in the vicinity thereof. Accordingly, when the end of the stem of a valve 8 passes adjacent inductor 11, this end is rapidly heated to a high temperature. Since the valves are approximately horizontal at this point, they remain at a fixed position in the fixture and the spacing of the ends of the valves with respect to the inductor is uniform resulting in uniform heating and uniform hardening of the ends of all valves. The clearance between the valve tip and the inductor is independent of the lengths of the valves and can be accurately adjusted by adjusting the relation of the inductor to the stop or positioning member, in order accurately to control heating and hardening.

In the operation of our apparatus, heating current is supplied by the source 12 to inductor 11. Passing the tip of the valve across the face of the inductor provides more uniform heating across the tip than other methods such as inserting the valve tip into a round electric heater or in passing it through a gas flame. In a rod member heat treated by our improved apparatus, variation in depth of hardness is from front to back of the valve tip, rather than from side to center. Thus, the hardness pattern can be checked on the sides and if all the sides are within acceptable limits, the valve is satisfactory. Our improved apparatus obviates the necessity of cutting the valve to determine the depth of hardness in the center.

As the valves pass the inductor and approach the vertical position at the bottom they slide out of the fixture and are discharged from the machine. After passing the inductor the valves can be allowed to self-quench, or can be passed through a stream of water or air supplied from a suitable source 13 as illustrated in Fig. 2 for quenching if desired. To maintain the valves in position for the quenching operation, the machine is equipped with a guard 14 which retains the valves until the quenching operation is completed and the valves are discharged into a chute or hopper 15.

While this machine is shown equipped with a guard 14 to retain the valves after they have passed the inductor at the horizontal position, such a guard will very often not be required. Quenching the tip ends of the valves takes such a short time that it usually can be done before the valves fall out of the machine even without a guard to retain them.

In the foregoing, while we have illustrated our heat treating apparatus as accommodating two rows of valves, it is apparent that any desired number of rows of work pieces may be accommodated.

The mechanism described above is particularly suited to the hardening of the tips of valves for internal combustion engines of the type shown on our drawing, because of the enlarged heads of such valves. If it were necessary for the valves to travel horizontally past the inductor with the valve stems parallel to each other, the spacing between valves would be determined by the diameter of the head of the valve and not by the diameter of the stem. Since the diameter of the stem is usually less than 3/8" and the diameter of the head is usually more than 1½", it can be readily seen that there would be considerable idle time when no heating was being done and as a result production would be low. With our radial mechanism, idle time between pieces is reduced to a minimum.

In the actual operation of our machine, it has been found that approximately 3000 valve tips per hour can be heat treated where each tip is raised to a temperature of 1925° F. When a temperature of 1550° F. is required, our machine will handle approximately 4500 pieces per hour. For both of these particular operations it has been found that a clearance of .025 inch between the inductor and the work pieces gives the best results.

While we have shown a particular embodiment of our invention, it will be understood, of course, that we do not wish to be limited thereto, since many modifications may be made and we therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for heat treating rod-like members comprising, a horizontally disposed rotatable drum having a plurality of spaced openings around the circumference thereof for receiving a rod-like member, positioning means adjustably supported within said drum in fixed position relative thereto and located to be slidably engaged by the end of a rod-like member inserted in one of said openings while in an upper position, said means comprising a substantially circular sector having an axis approximately coincident with the axis of said drum and having a trailing end lying substantially along a horizontal radius of said drum, high frequency heating means positioned adjacent the trailing end of said positioning means, and means for rotating said drum whereby as said drum is rotated a rod-like member supported by said drum is adjusted by said positioning means in a desired radial position relative to said heating means and moved substantially vertically adjacent said heating means during the portion of said rotation in which said rod-like member is substantially horizontally disposed.

2. Apparatus for heat treating rod-like members comprising, a horizontally disposed rotatable drum having a plurality of equally spaced openings around the circumference thereof, a tubular guide supported within each of said openings for receiving a rod-like member to be treated, positioning means supported within said drum in fixed relation thereto and located to be engaged by the end of a rod-like member inserted in one of said guides while said guide is in an upper position, said positioning means comprising a circular sector having an axis coincident with the axis of said drum and having a trailing end lying substantially along a horizontal radius of said drum, high frequency heating means positioned adjacent said trailing end of said positioning means, and means for rotating said drum, whereby as said drum is rotated a rod-like member carried thereby is located by said positioning means in a desired position relative to said heating means and arranged substantially in a horizontal position when the end thereof leaves said positioning means and passes adjacent said heating means.

3. Apparatus for heat treating rod-like members comprising a hollow circular member rotatable about a horizontal axis, said member having a plurality of equally spaced openings arranged around the circumference thereof, a radially extending tubular guide supported in each of said openings and arranged to receive a rod-like member to be treated while said guide is in an upper

position, a positioning member supported within said rotatable member in fixed relation thereto and arranged to be slidably engaged by the inner end of a rod-like member when inserted in one of said guides, said positioning member comprising a circular sector having an axis coincident with the axis of said rotatable member, said sector terminating in a trailing end lying along a substantially horizontally positioned radius of said positioning member, high frequency heating means positioned adjacent said trailing end of said positioning member at a distance from said axis slightly less than the radius of said sector, and means for rotating said drum, whereby as said drum is rotated a rod-like member inserted in one of said guides is located by said positioning member in a desired position relative to said heating means and said end thereof is passed adjacent said heating means.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,288,644	Purtell	July 7, 1942
2,414,362	Denneen et al.	Jan. 14, 1947
2,456,962	Lee	Dec. 21, 1948

FOREIGN PATENTS

Number	Country	Date
69,817	Norway	Dec. 17, 1945

OTHER REFERENCES

Hotchkiss, "Progressive Heating, Quenching," Steel, July 9, 1945, pages 104 and 162, particularly page 104.