

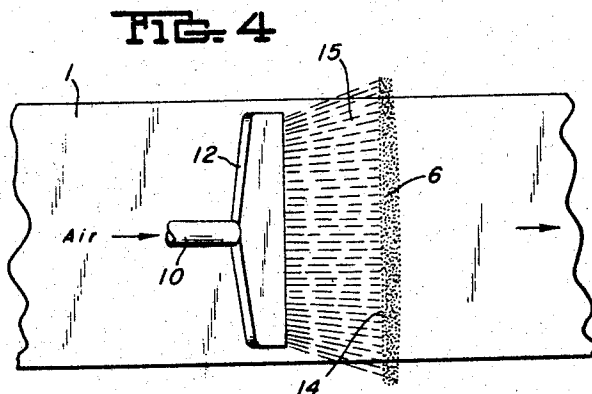
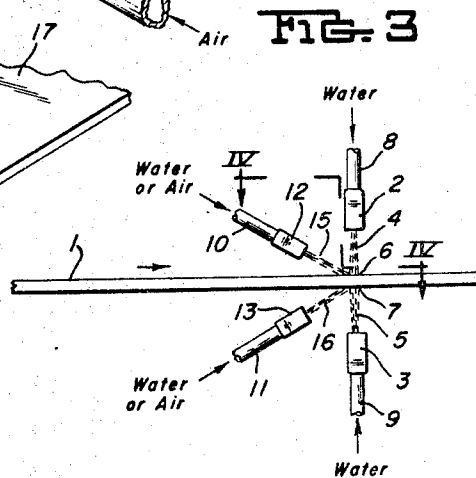
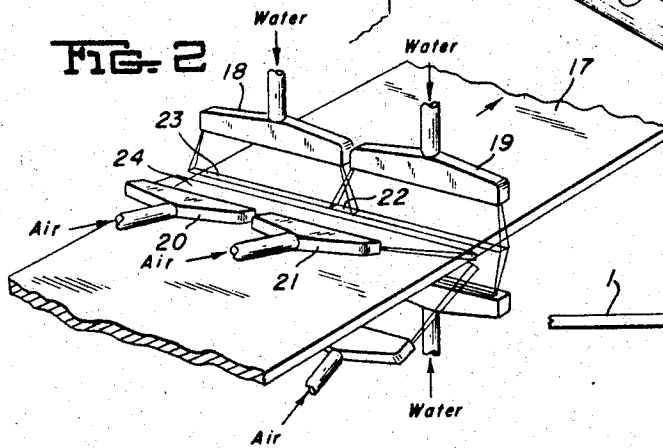
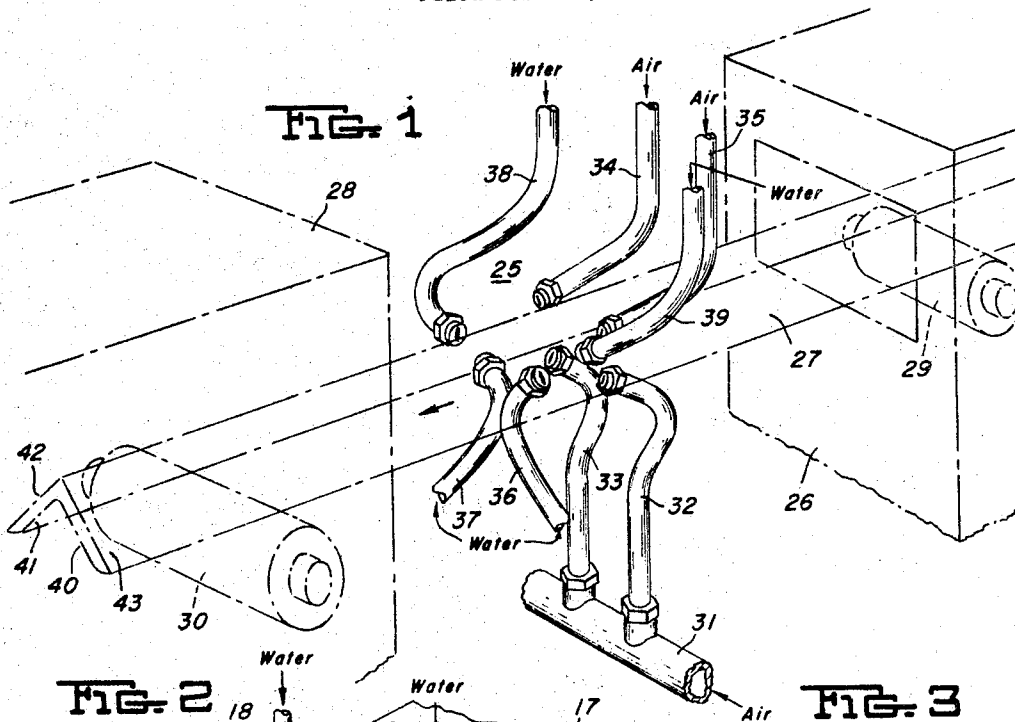
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APPARATUS FOR SPRAY QUENCHING

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APPARATUS FOR SPRAY QUENCHING

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This invention relates to the heat treatment of elongated steel shapes and more particularly to apparatus for quenching material progressively in a continuous processing line from a temperature above the transformation range, at a rate sufficient to produce the desired conversion of metallurgical structure.

Many workpieces that are produced on a continuous basis require heating before or during processing. Often these products then require quenching either to cool them for ease of handling or to improve the metallurgical properties of the material. In many progressive spray-quenching applications, it is necessary to provide a severe quench at a critical time after the workpiece leaves the heating source. To accomplish this, the quenching fluid must impinge on the workpiece at a definite quench line across any surface. This requires that the sprays be generally perpendicular to the workpiece surfaces, since in any other position movement of the workpiece from its pass line would change the positions of the quench lines and thus cause uneven cooling of the surfaces. Aside from affecting the time between heating and quenching, this may cause the workpiece to warp because of the temperature differential of its surfaces. However, when the sprays are directed perpendicular to the surfaces of the workpiece, particles of the quenching fluid tend to spray back toward the heating source after striking the workpiece at the quench lines. This also results in uneven cooling and the problems associated therewith.

It is customary, therefore, in spray-quenching applications to direct a spray at an angle to a workpiece surface so that the particles of fluid or coolant will spray toward the already-cooled portion of the workpiece after striking at the quench line. In addition to the problem of uneven cooling resulting from any movement of the workpiece from its pass line, this arrangement causes the effective pressure of the coolant striking the workpiece to be reduced, and thus more coolant is required to provide a quench of the desired severity.

I have invented a novel apparatus for quenching a workpiece progressively, as it travels along a predetermined path, whereby the aforementioned objections are overcome and the advantages of spray quenching normal to a workpiece surface are retained. I have discovered that a fluid spray directed along the path and at an acute angle toward a workpiece and impinging on a surface thereof in a line adjacent a quench line, will serve to shield the hot surface from deflected, quench-fluid particles. I have found that this arrangement is most effective for progressive quenching, that numerous factors in respect to the character, direction and distribution of the spray jets have a profound and previously unsuspected effect on the quenching operation and that by proper correlation of such factors, results may be achieved far superior to anything accomplished previously, particularly as regards the uniformity of hardening, freedom from warping and camber in strip, plates, angles, channels, I-beams, pipe and the like elongated workpieces, whether quenched as individual pieces or as a continuous workpiece.

In a preferred practice, I discharge sprays of any suitable quenching fluid such as water onto the workpiece after it emerges from any appropriate heating means. The water sprays may be provided by a plurality of

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nozzles spaced about the path traversed by the workpiece, in particular locations and positions as determined by the shape of the workpiece. The nozzles direct sprays generally perpendicular onto the surfaces of the workpiece to circumscribe it with a definite, substantially continuous quench line. On the side of the quench line toward the heating source, I provide further, spaced nozzles associated with the quenching nozzles, and discharge therefrom a jet of a suitable fluid such as air or water, at an acute angle to the surface of the workpiece to circumscribe it with a fluid line adjacent the quench line. The two nozzles may be of the same type, adapted to deliver a uniformly distributed elongated jet and spray impingement pattern in a definite fluid line that approaches a heavily drawn straight line or rectangle in appearance. Such location of the quench nozzles maintains the quench line substantially in a fixed position regardless of any movement of the workpiece from its pass line as it is quenched. The associated fluid-jet nozzles are arranged at a special acute angle to the workpiece surface so that the fluid jets strike the surface in a heavy fluid line. The proximate boundaries of the respective fluid lines are adjacent and may be contiguous or closely spaced apart. They are generally parallel to each other. This provides a fluid shield precluding passage of the particles of quenching fluid deflected from the metal surface. Hence, the hot workpiece from the quench line to the heating source and even the heating source itself are protected from cooling by sprayback or backflow of quenching fluid on the workpiece surfaces.

The apparatus preferred for carrying out the practice outlined above includes driven rolls or pinch rolls for moving the workpiece along a predetermined path or pass line, gas or electric workpiece-heating means, headers, spaced parallel manifolds generally normal to the pass line, each respectively communicating through tubing with nozzles spaced to circumscribe the workpiece. Quenching fluid and shielding fluid are supplied to the headers respectively, under pressure from suitable sources through supply lines. Valves in the supply lines permit the control of compressed air or even the quench water as shielding fluid and make possible rapid changeover from one to the other.

A complete understanding of the invention may be obtained from the following detailed description and explanation which refer to the accompanying drawings illustrating the present preferred embodiment. In the drawings:

FIGURE 1 is a perspective view of the apparatus of invention in conjunction with the heating and quenching of angles;

FIGURE 2 is a perspective view of strip being quenched;

FIGURE 3 is a side elevation of strip being quenched;

FIGURE 4 is a plan view taken on the line IV-IV of FIGURE 3.

Referring now in detail to the drawings and, for the present to FIGURES 3 and 4, my improved apparatus for quenching hot strip 1 moving in the direction of the arrow from a heating means (not shown) comprises two opposed spray nozzles 2, 3 which discharge sprays of an appropriate quenching fluid, such as water, substantially normal to the planes of the strip. The sprays of water 4, 5 issuing from the nozzles impinge in definite quench lines 6, 7 on the hot strip and quench it. The nozzles 2, 3, supplied with water under pressure from tubes 8, 9 respectively and a header (not shown), may be of a known type which delivers a uniformly distributed, elongated spray pattern that approaches a heavily-drawn straight line or rectangle in appearance. How-

ever, a type delivering an oval spray pattern has been found acceptable. For either pattern, the major axis is generally substantially greater than the minor axis. Both types of nozzles are available commercially.

Tubes 10, 11 from a header (not shown) conduct a shielding-fluid, under pressure, to nozzles 12, 13, which may be similar to nozzles 2, 3. Any appropriate fluid may be used, for example, air or water. The axes of the nozzles are arranged at an acute angle to the strip 1 and distribute jets of fluid impinging on the respective surfaces of the strip at an angle thereto, preferably about 30°, with their axes at acute angles to the traveling strip surfaces and the corresponding axes of nozzles 2, 3. The patterns of jet impingence are similar to those created by nozzles 2, 3, the major axes thereof being substantially the same and parallel. The projected minor axes are somewhat greater than for the quench lines. Where the strip or any workpiece surface to be quenched deviates but little from the pass line or predetermined travel path of the workpiece, it is preferred that the proximate boundaries of the fluid lines or patterns be substantially contiguous as shown in line 14 of FIGURE 4. Under these conditions and within a range of divergent fluid pressures, the fluid jets 15, 16 substantially form a shield against passage of any particles of quenching fluid tending to rebound or flow toward the heating source after impinging on the strip surfaces.

As shown in FIGURE 2, where a strip 17 is wider than a major axis of a single nozzle's quench pattern, two nozzles 18, 19, or a plurality of nozzles may be employed to approximate a single quench line, but with a slight overlapping thereof as shown at 22. While the preferred angle of the axes of companion shielding-fluid nozzles to strip 17 is about 30°, an angle between about 20° and 40° may be used. At an angle smaller than about 20°, there is danger of prequenching, especially when water is the shielding fluid. Beyond about 40°, the effective pressure of the fluid must be increased to achieve comparable results. FIGURE 2 also shows quench line 23 and shielding-fluid line 24 as being adjacent and substantially parallel. However, their proximate boundaries are not contiguous as in line 14 of FIGURE 4. These proximate boundaries may be separated where there is vertical movement of the strip from its path or pass line. It is apparent that if the strip is tilted upwardly of the pass line, the quench lines 6, 7 will remain relatively fixed. However, the proximate boundary line of jet 15 will move toward the left in FIGURES 3 and 4, whereas the respective line of jet 16 will move toward the right, with consequent interference of jets 5 and 16. The reverse will be true if the strip is tilted downwardly. While the described tilting with attendant uneven quenching and possibly warping, if carried to extremes, is not usual in a continuous strip-quenching operation, it can be an important factor where individual workpieces are quenched. For any number of reasons, the ends of such workpieces may exhibit warping. To avoid these difficulties, it has been found that the proximate boundaries of adjacent quench lines and shield-fluid lines may be separated by as much as 1/2". While the adapted shield-fluid velocity holds fixed the proximate boundary of the quench line, there is also no substantial impairment of the shielding action of the fluid jets. More importantly, the separation reduces the possibility of interference of the shield jet with the quench jet, with consequent impairment of quench efficiency. When operating under the described conditions, it is preferred to use compressed air, rather than water, as the shielding fluid, since water is much more drastic and may result in undesirable pre-quenching ahead of the quench line.

Referring now to FIGURE 1, my improved quenching apparatus indicated generally at 25, is disposed coaxially of and as close as convenient to the exit end of a continuous heating furnace 26. The furnace may be of any convenient, commercially available type such as a gas-

fired or electric furnace or an induction heating unit. The angle 27 being heated and quenched is conveyed through furnace 26, quenching apparatus 25 and hood 28 on driven rollers 29, 30. Mounted on any convenient support, the shielding and quenching apparatus is supplied respectively with air and water under appropriate pressure. Compressed air may be supplied sequentially to a header, manifold, tubes and nozzles.

Indicated partially at 31, is a manifold spaced along the pass line and normal thereto. Manifold 31 supplies tubing-nozzles 32, 33, 34, 35. Water may be similarly supplied to tubing-nozzles 36, 37, 38, 39 from a manifold (not shown) spaced from manifold 31 toward hood 28. The hood is adapted to confine the splash of the quenching and shielding fluids after they have impinged on the angle surfaces and to divert them onto the quenched portion of the workpiece to further cool it. If desired, any liquid that it used may be collected in a sump, for recirculation, after cooling and purification. In the progressive quenching of angle 27, four sets of air and water nozzles cooperate to quench simultaneously the four surfaces of the angle. Thus nozzles 32, 36 quench the right undersurface 40, nozzles 33, 37 the left undersurface 41, nozzles 34, 38 the left top surface 42 and the nozzles 35, 39 the right top surface 43.

In carrying out the method of my invention as shown in FIGURE 1, a 1/4" thick 90° angle, 3" x 3" x 12' long of constructional alloy steel is passed axially through furnace 26 at about 5 f.p.m. While passing therethrough, the temperature is raised to about 1700° F. While passing from the furnace to quenching apparatus 25, the temperature between the thinner metal flanges and heavier metal fillet or apex is equalized to about 1400° F. Immediately on entering the quenching zone the temperature is reduced almost instantaneously to about 200° F. This cooling is at a rate such as to convert the austenitized steel to martensite, with a small percentage of lower bainite. The produce meets minimum specifications of 40 Rockwell C hardness, 1/8" maximum camber in 5 feet and 1 1/2 degrees maximum out-of-squareness.

The quenching is effected with four pairs of similar nozzles, the quenching nozzles having their axes substantially perpendicular to the respective flat surfaces, each distributing about 0.6 g.p.m. water in an oval pattern having a major axis of about 3.5", a minor axis of about 1/8" at about 78 lbs. gage at the header, with the tip of each nozzle about 2" from the surface. The compressed air nozzles, have their axes at about 30° to the respective surfaces, with the tips of the nozzles about 1" from the surfaces. By supplying compressed air at about 40 lbs. gage at the header, the proximate boundaries of the quench- and air-shield lines are substantially contiguous. The impingement of the respective, proximate convex boundaries results in a substantially straight-line boundary. The quench line is beneficially concentrated as its minor axis is slightly reduced by about 1/32" to about 3/32". Substantially the same results are obtained when the header gage pressures are between a range of about 50 and 80 lbs. for the water and in a range of about 40 and 60 lbs. for the air. The compressed-air shield is effective in preventing any substantial back flow of quenching water or deflected quench water particles from pre-cooling the hot angle or splashing into the furnace.

The invention is characterized by numerous advantages. Foremost is the fact that it permits rapid quenching with good conversion to martensite, but without excessive distortion, for example, as warping or out-of-squareness. In addition, it produces uniform physical characteristics. The apparatus involved is simple in construction and its use does not involve any practical problems, in fact, it may be easily adapted to quenching the surfaces of other workpieces where conditions may differ from what has been described hereinabove.

In the example, temperature differences in an angle caused by variations in thickness were equalized by soak-

ing between furnace and quenching zone. If this delay for soaking is not permissible or where temperature differences exist in a surface for any reason, good quenching may be effected by rotating the quenching nozzle on its axis. A plane passed through the nozzle axis and major axis of the quench line will still be generally normal to the surface, but will not be normal to the workpiece path or pass line. The acute angle of rotation will be arranged in a direction to provide an earlier quench where the greater amount of heat must be removed. The fluid-shield nozzle would also be rotated to maintain the quench and fluid-shield lines generally adjacent and parallel.

An I-beam is an example of a workpiece with portions of varying metal thicknesses. For example, the inside fillets are of necessity heavier than the ends of the flanges. For quench nozzles arranged generally normal to flat surfaces, appropriately large and small nozzles may be used to quench heavier and lighter metal sections, respectively. For each fillet a separate nozzle may be used, its axis being appropriately on-center or off-center of the fillet arc. While the axes of these nozzles are not normal to the flat surfaces of the I-beam, all nozzles are generally in a plane normal to the pass line. The plane generally intersects and thus circumscribes the workpiece surfaces with substantially a continuous quench line. A companion fluid-shield nozzle would generally be used with each quench nozzle, although an effectively-large, fluid-shield nozzle may serve as a shield for two adjoining, smaller quench nozzles.

The hereinabove given description relates generally to producing a shielded, drastic quench. However, quenching requirements may vary. It may be preferred to employ a series of quenching nozzles or an elongated quench head spaced along the pass line of a workpiece. This may result in a spray pattern or patterns wherein the minor axis, as discussed above, becomes the major axis. Likewise, adequate quenching may be provided where the axis of a quench nozzle is not perpendicular, but at an acute angle to a surface being quenched. Under all these conditions a fluid-shield nozzle arranged, as above described, with respect to the proximate boundary line of a quench pattern, will protect the hot surface from quenching fluid. It is obvious, my invention may be used for progressive quenching whenever there is relative movement between a workpiece and my shield-quench apparatus.

Although I have disclosed herein the preferred embodiment of my invention, I intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

I claim:

1. Apparatus for progressively and uniformly quench-

ing an elongated workpiece having a plurality of major surfaces from a temperature above the transformation range, as it travels along a predetermined path, which comprises means for moving said workpiece longitudinally and supporting it at spaced points, at least one nozzle between said support means effective to discharge a wide, flat brush-like spray which is long and narrow in cross-section arranged substantially normal to each major surface of said workpiece, means connecting said nozzles to a source of quenching fluid under pressure whereby said nozzles deliver jets of quenching fluid against said surfaces thereby surrounding said workpiece with a substantially continuous spray to quench said workpiece, at least one nozzle effective to discharge a wide, flat brush-like spray which is long and narrow in cross section against each major surface of said workpiece, said second named nozzles being spaced from said first named nozzle in a direction toward the approaching workpiece, each of said last named nozzles being arranged at an angle between about 20° and 40° to the associated major surface, and means connecting said second named nozzles to a source of fluid under pressure whereby said second named nozzles deliver jets of fluid against said workpiece, the axis of each said second nozzle being arranged at an acute angle to the axis of the associated first nozzle whereby the fluid from said second nozzles surrounds said workpiece with a substantially continuous spray to shield the hot portion of said workpiece from quenching fluid, the first and second nozzles being so directed that the respective jets therefrom impinge on each said surface substantially parallel to each other and spaced apart by no more than about 1/2".

2. Apparatus as defined in claim 1 characterized by the fluid to said second nozzles being a gas.

3. Apparatus as defined in claim 1 characterized by a means for heating said workpiece arranged adjacent the approach side of said second nozzles, the fluid from said second nozzles shielding the heating means from quenching fluid deflected from the quenched surface.

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