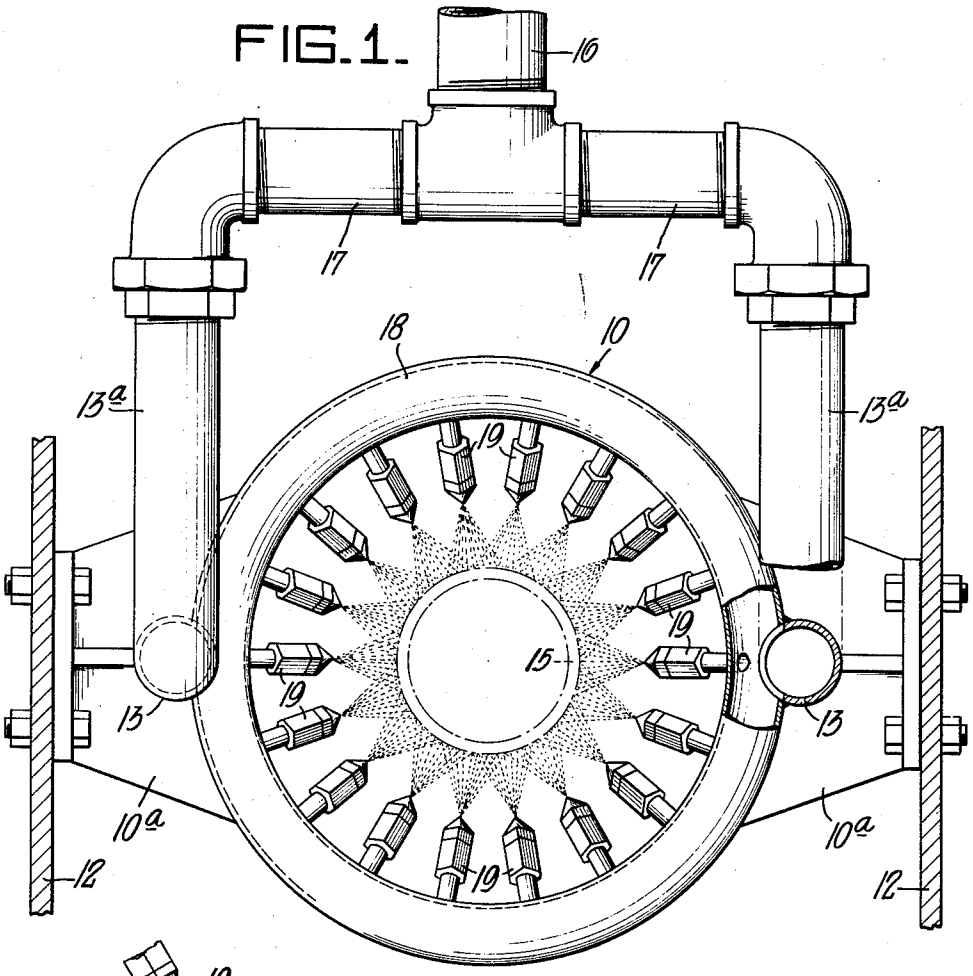
Jan. 1, 1957 J. A. SCOTT 2,776,230

METHOD AND APPARATUS FOR QUENCHING PIPE

Filed Oct. 22, 1951 2 Sheets-Sheet 1

FIG. 1.



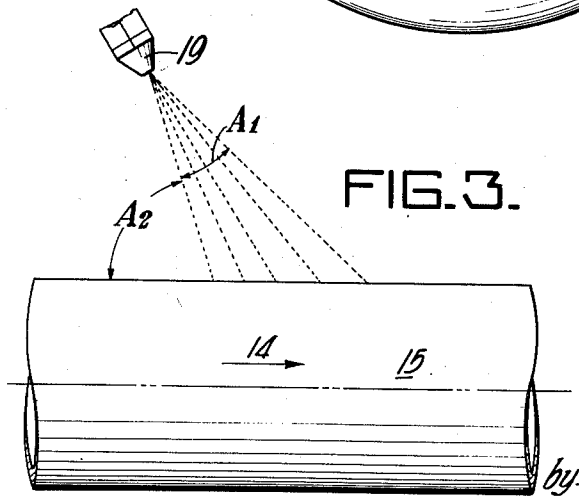


FIG. 3.

Inventor:
JAMES A. SCOTT,
by: Donald G. Dalton
his Attorney.

Jan. 1, 1957 J. A. SCOTT 2,776,230

METHOD AND APPARATUS FOR QUENCHING PIPE

Filed Oct. 22, 1951 2 Sheets-Sheet 2

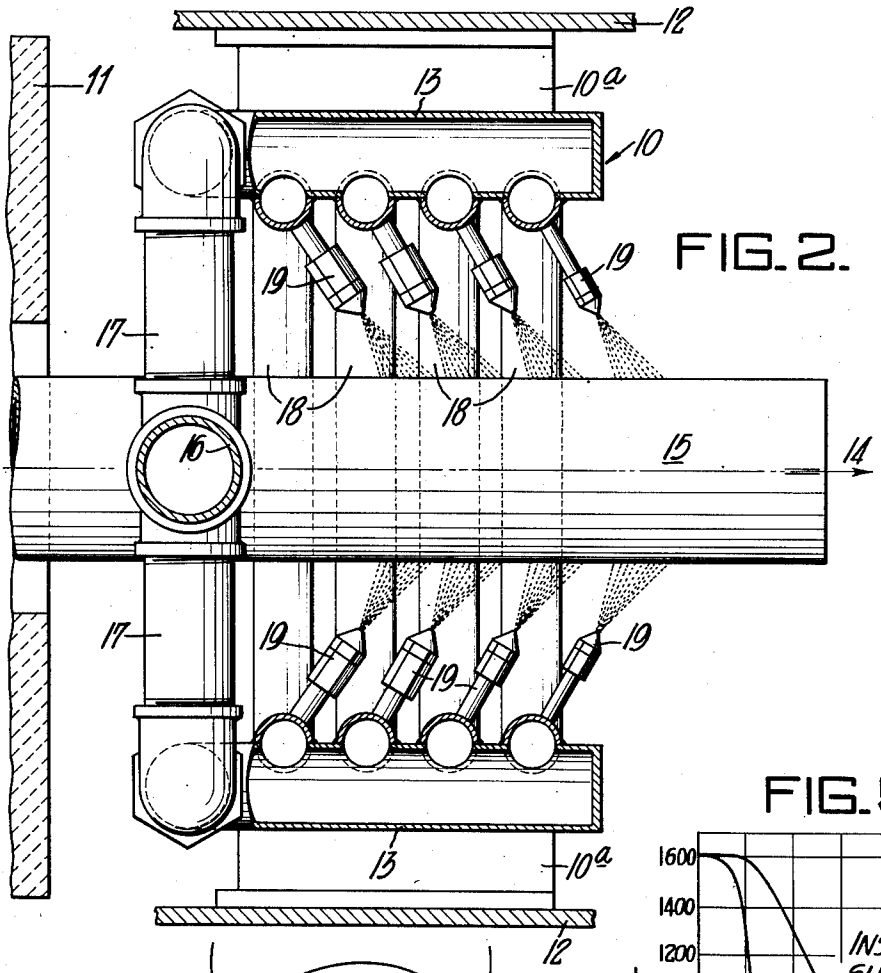


FIG. 2.

FIG. 4.

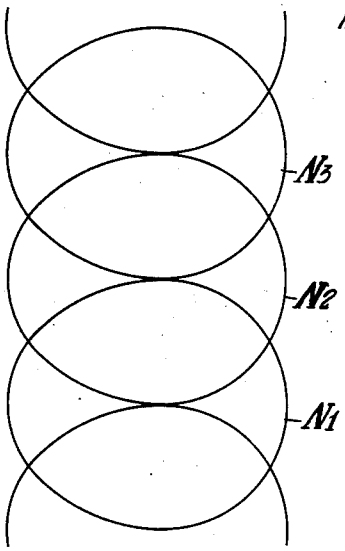
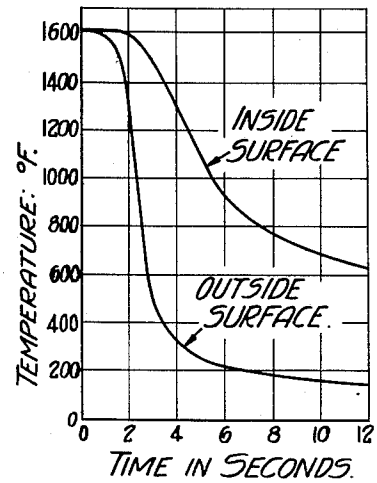


FIG. 5.



Inventor:
JAMES A. SCOTT,
by: Donald G. Dalton
his Attorney.

United States Patent Office 2,776,230 Patented Jan. 1, 1957

2,776,230

METHOD AND APPARATUS FOR QUENCHING PIPE

James A. Scott, Mount Lebanon Township, Allegheny County, Pa., assignor to United States Steel Corporation, a corporation of New Jersey

Application October 22, 1951, Serial No. 252,515

4 Claims. (Cl. 148—21.55)

This invention relates to the heat-treatment of steel pipe to increase its strength and, in particular, to a method and means for quenching pipe progressively along its length from a temperature above the transformation range, at a rate sufficient to produce the desired conversion of metallurgical structure.

The progressive quenching of steel pipe to provide the increased strength needed for casing in wells of 15,000 feet and more in depth is now being practiced commercially with good results but the practice followed hitherto has been characterized by special problems and has involved a difficult technique in order to obtain uniformity in the finished product. In the first place, the quenching zone must be immediately adjacent the heating furnace in order to prevent excessive atmospheric cooling and insure quenching at the rate necessary to produce a martensitic structure. With the apparatus used previously, this has caused damage to the furnace lining as a result of the entrance of quenching water into the furnace outlet, and also pre-cooling of the pipe. Secondly, the quenching effect of known apparatus is not uniform longitudinally or circumferentially of the pipe and severe distortion of the pipe is apt to occur. For example, a 40' length of pipe may have a camber of 6' when quenched requiring additional subsequent processing to straighten it. In an attempt to avoid this, rotation of the pipe about its own axis during quenching is usually resorted to.

I have invented a novel method and apparatus for quenching pipe progressively whereby the aforementioned objections are overcome and further advantages obtained. I have discovered that a spray of droplets of quenching liquid is most effective for progressive quenching, that numerous factors in respect to the character, direction and distribution of the spray 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 camber and the increase in final yield point after tempering.

In a preferred practice, I discharge sprays of any suitable quenching liquid such as water, onto the pipe as it emerges from a heating furnace, from a plurality of nozzles spaced circumferentially about the path traversed by the pipe, in particular locations and positions. The nozzles are of the type which deliver a mechanically broken, uniformly distributed spray in cones of a definite apex angle, and are located relative to the pipe path so that all the water is in the form of droplets by the time it strikes the pipe. The nozzles are further positioned at a special angle relative to the pipe path to avoid back flow along the pipe yet assure that the droplets strike the pipe with considerable impact. Finally the nozzles are located relative to each other so as to produce sprayed areas on the pipe surface which overlap to a predetermined extent. I thus correlate the several factors characteristic of the spray, which I designate, respectively, (1) angle of divergence, (2) means free path, (3) angle of incidence and (4) overlap of area of impingement.

The apparatus preferred for carrying out the practice outlined above includes spaced headers parallel to the pipe path, one on each side thereof, and a plurality of manifold rings or loops spaced therealong and communicating therewith. Nozzles are spaced circumferentially of the rings, the axes of the nozzles on each ring lying in a conical surface, the apex of which is on the line along which the axis of the pipe travels. Quenching liquid is supplied to the headers under pressure from any suitable source through branching pipe connections.

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 an elevation, with parts broken away and in section, looking on the apparatus in the direction in which pipe travels therethrough, the nozzles on the ring manifolds beyond the first being omitted;

Figure 2 is a horizontal central section showing the location of the apparatus relative to the exit end of the heating furnace;

Figure 3 is a diagram showing the angles of divergence and incidence;

Figure 4 is a diagram showing the development of the areas of impingement of a few of the nozzles on one ring; and

Figure 5 is a cooling curve showing the quenching stage of the heat-treating cycle graphically.

Referring now in detail to the drawings and, for the present, to Figures 1 and 2, my improved quenching apparatus indicated generally at **10**, is disposed coaxially of and as close as convenient to the exit end of a continuous pipe-heating furnace **11**. The furnace may be of any convenient type so long as it is capable of heating the pipe to a temperature above the transformation range, without the formation of a heavy scale which, being an insulator, interferes with rapid quenching. More specifically, a sectional, barrel-type furnace, which is available commercially, has proved satisfactory. The quenching apparatus may be mounted on any convenient support by means of welded web plates **10***a* and is preferably enclosed between spaced side plates, a portion of which is indicated at **12**, adapted to confine the splash of quenching liquid after it has been discharged onto the pipe. The liquid may be collected and conducted to a sump, if desired, for recirculation after cooling and purification. The quenching apparatus comprises a pair of spaced tubular headers **13**, one on each side of the line of travel **14** of the pipe **15**, and parallel thereto. Water or other quenching liquid under suitable pressure is supplied to the headers from any convenient source through a main **16** and branch pipes **17** connected to the laterally turned ends **13***a* of the headers. A plurality of manifold or nozzle rings or loops **18** spaced along line **14** and normal thereto, are notched at diametrically opposite points as shown, to mate with notches spaced along the headers, thus affording communication between each header and each ring. The meeting edges of the rings and headers are brazed together to provide water-tight joints.

Each ring **18** is fitted with a plurality of nozzles **19** spaced therearound, inclined at an angle of about 30° to the plane of the axis of the ring and thus lying in a conical surface having its apex on said axis. The nozzles are of a known distributive type having internal inclined vanes to produce a swirling motion of the jet

discharged, thereby mechanically causing the water to break into droplets uniformly dispersed in a cone, instead of remaining as a solid stream. Such nozzles are available commercially. The nozzles of each ring are staggered relative to the nozzles of adjacent rings. Conveyor rollers (not shown) beyond the quenching apparatus receive and support the pipe after its passage therethrough, in precisely coaxial relation with rings **18**.

The size of the rings **18** and the length of the nozzles **19** are correlated with the size of the pipe **15** so that the nozzle tips are located far enough from the pipe to insure that all the water breaks into droplets before striking the pipe. At a water pressure of 100 p. s. i., the tips of nozzles should be about 4" from the pipe. This gives the droplets a velocity of at least 50 F. P. S. on striking the pipe. The apex angle of the cone of spray produced by each nozzle, or the angle of divergence, furthermore, should be not more than 36° for 2½" pipe, 50° for 6" pipe and 60° for 11" pipe. This angle is shown at A_1 in Figure 3.

The angle of incidence, or the maximum angle between the pipe surface and the path of any droplet of spray in the plane of the pipe axis, shown at A_2 in Figure 3, should be between 60° and 80°. This is conducive to the most effective quenching since it causes the droplets to penetrate the steam film which forms immediately adjacent the pipe. It also minimizes back flow of water along the pipe toward the furnace. The several nozzles of each ring are positioned relative to each other so that the areas in which the jets of spray from alternate nozzles impinge on the pipe surface, are approximately tangent. The preferred overlap is shown in Figure 4. That is to say, the area of impingement of one nozzle N_1 is approximately tangent to that of the nozzle N_3 second from N_1, and so on.

In carrying out the method of my invention, pipe of steel containing say .30% C and 1.6% Mn is passed axially through furnace **11** at any convenient speed. While passing therethrough, the temperatures of its exterior and interior rise progressively. The length of the furnace is correlated with the speed of travel of the pipe to cause heating at the desired rate. Preferably, the temperature of the pipe is quickly raised above the transformation range as it passes through the furnace. Immediately on entering the quenching zone, however, the temperature is reduced almost instantaneously, as shown graphically in Figure 5, the curves of which represent the cooling of a pipe of 7" outside diameter and a wall thickness of .453". This cooling is at a rate such as to cause conversion of the greater portion of the steel to a martensitic structure. Naturally, the cooling of the exterior is more rapid than the cooling of the interior as shown, but the latter proceeds at a rate almost as great. From these curves, it will be noted that the temperature of the exterior decreases from 1475° F. (the transformation range) to below 900° F. in less than ¾ second. There is but little cooling of the pipe in air before entering the quenching zone since the latter is only a foot or so from the end of the furnace.

The pipe may be rotated on its axis while passing through the quenching apparatus, by having the conveyor rolls skewed appropriately but this is not necessary if the pipe is kept accurately centered with the quenching apparatus. Usually, however, it is easier to provide for rotation of the pipe than for precise centering thereof.

The temperature of the quenching water does not seem to be important but I prefer to keep it below 110° F. to prevent execessive vaporization in the early stages of the quenching.

For quenching thin-walled pipe, a single ring of nozzles may suffice to produce the desired rate of cooling.

After quenching, the pipe is tempered in the usual manner.

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 or ovality. In addition, it produces uniform physical characteristics including a high yield strength after tempering. The apparatus involved is simple in construction and its use does not involve any practical problem.

The spray of uniformly dispersed droplets discharged at an oblique angle with the pipe surface effectively penetrates the steam film thereon and maintains a high cooling rate with a minimum of back flow along the pipe which would cause pre-cooling or injury to the furnace lining. In fact, the back flow is so slight that it is unnecessary to provide a mechanical barrier to prevent water from entering the furnace. Such a spray of droplets, furthermore, is more efficient in cooling the pipe than a solid sheet of water. A spray of finely atomized particles, i. e., of such size that they tend to float in air, is not effective because of the small volume and the lack of momentum of individual particles. Coarser particles or droplets of such size as to fall freely in air, on the other hand, when sprayed, have an impact which penetrates the steam film. The variation in the angle of divergence with the pipe size preserves the penetrating effect of the spray and insures that substantially all the droplets discharged strike the pipe, thus obtaining a high efficiency in the use of cooling water.

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. A method of quenching steel pipe heated above the transformation temperature, consisting in moving the pipe axially along a straight line, discharging onto the pipe from points spaced substantially equally apart in a plane normal to said line and substantially equally spaced radially from said line, diverging sprays of liquid the axes of which sprays constitute elements of an imaginary cone having its apex in said line, maintaining the spacing of said points from said apex such that substantially all the liquid breaks into substantially uniformly dispersed droplets before impinging on the pipe, maintaining the spacing between said points such as to cause partial overlapping of the areas of impingement on the pipe of droplets from adjacent points, and maintaining the apex angle of said cone such that the maximum angle between said line and any element of said sprays is from 60° to 80°, thereby minimizing backflow of liquid along the pipe and affording the droplets sufficient velocity toward the pipe to penetrate the steam film forming immediately adjacent the pipe.

2. Apparatus for progressively quenching steel pipe as it emerges from a heating means at a temperature above the transformation range, comprising a manifold structure disposed around the path of axially moving pipe and connected to a source of quenching liquid, a plurality of nozzles mounted on said manifold structure and extending inwardly therefrom, substantially equally spaced circumferentially about said path and substantially equally spaced therefrom, with their axes at an acute angle to said path and constituting elements of an imaginary cone coaxial with said path and having its apex therein, each of said nozzles being adapted to discharge a diverging spray onto the pipe, the tips of said nozzles being spaced from said path by a distance such that substantially all the liquid from each nozzle breaks into substantially uniformly dispersed droplets before impinging on the pipe, the spacing between adjacent nozzles being such that the areas of impingement on the pipe of droplets from adjacent nozzles partially overlap, and the apex angle of said cone being such that the maximum angle between said path and any element of said sprays is between 60° and 80° to minimize backflow of quenching liquid along the pipe and afford the droplets sufficient velocity toward the pipe to penetrate the steam film forming immediately adjacent the pipe.

3. Apparatus as defined in claim 2, characterized by said manifold structure including spaced headers parallel to said path and on opposite sides thereof, and a pipe ring

coaxial with said path, disposed in a plane normal thereto, communicating with said headers, said nozzles being mounted on the ring.

4. Apparatus as defined in claim 2, characterized by the circumferential spacing of said nozzles being such that the areas of impingement on the pipe of the droplets from alternate nozzles are substantially tangent.

References Cited in the file of this patent

UNITED STATES PATENTS

563,978	Meinhausen	July 14, 1896
1,516,407	Sandberg	Nov. 18, 1924
1,521,390	Reynolds	Dec. 30, 1924
1,563,170	Davis	Nov. 24, 1925
1,697,068	Kenney	Jan. 1, 1929
1,910,497	Peik	May 23, 1933
2,228,836	Macquaid	Jan. 14, 1941
2,321,431	Somes	June 8, 1943
2,394,514	Evans	Feb. 5, 1946
2,427,422	Sebald	Sept. 16, 1947
2,578,804	Holveck	Dec. 18, 1951
2,616,437	Secor	Nov. 4, 1952
2,623,531	Waddington et al.	Dec. 30, 1952