May 14, 1929. R. W. BOWNE 1,713,020

RADIATOR TUBE

Original Filed Jan. 20, 1923

Fig. 1

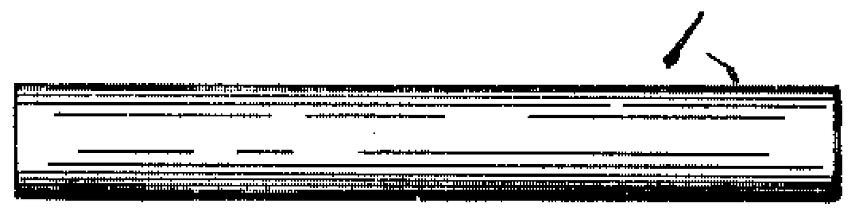


Fig. 2

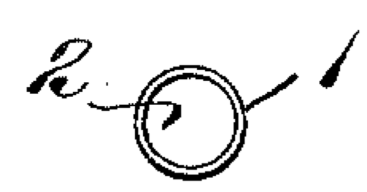


Fig. 3

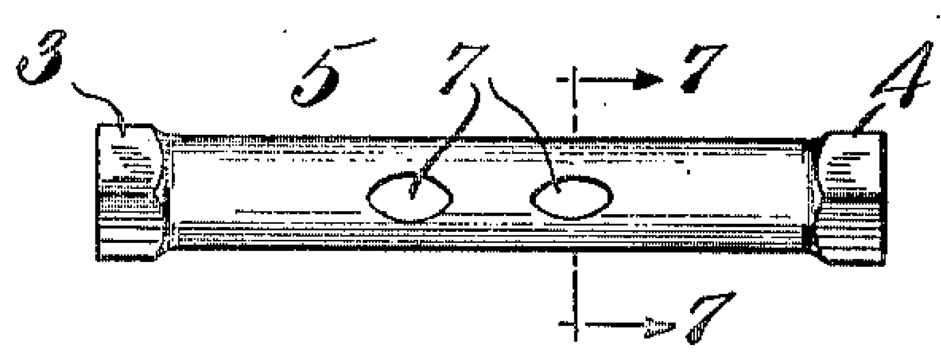


Fig. 6

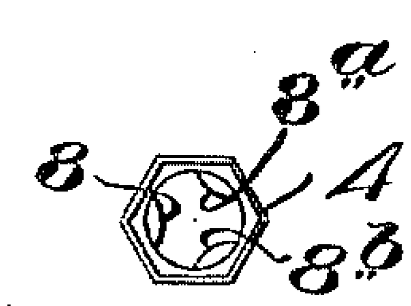


Fig. 4

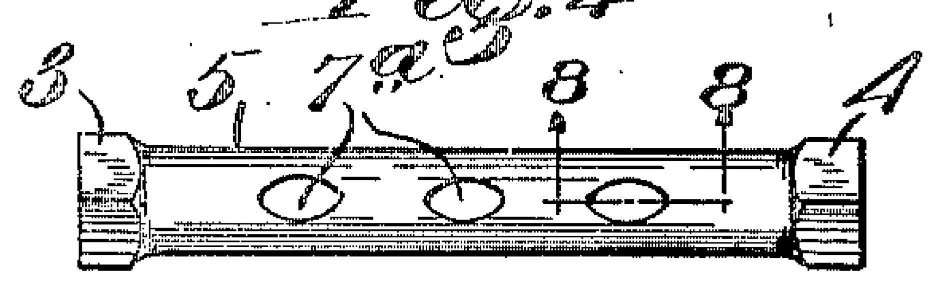


Fig. 7

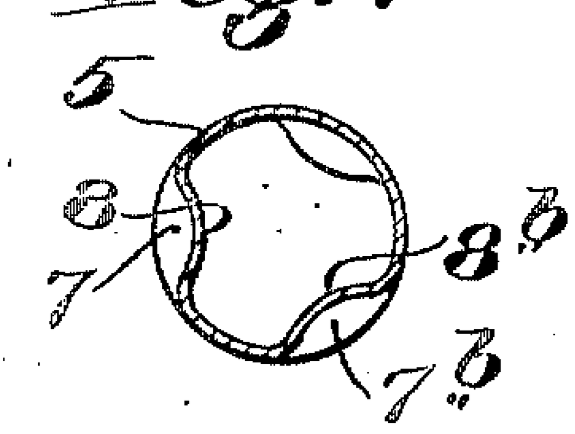


Fig. 5

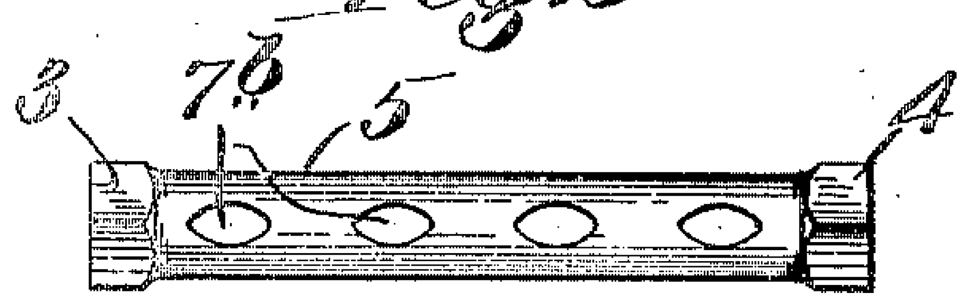


Fig. 9

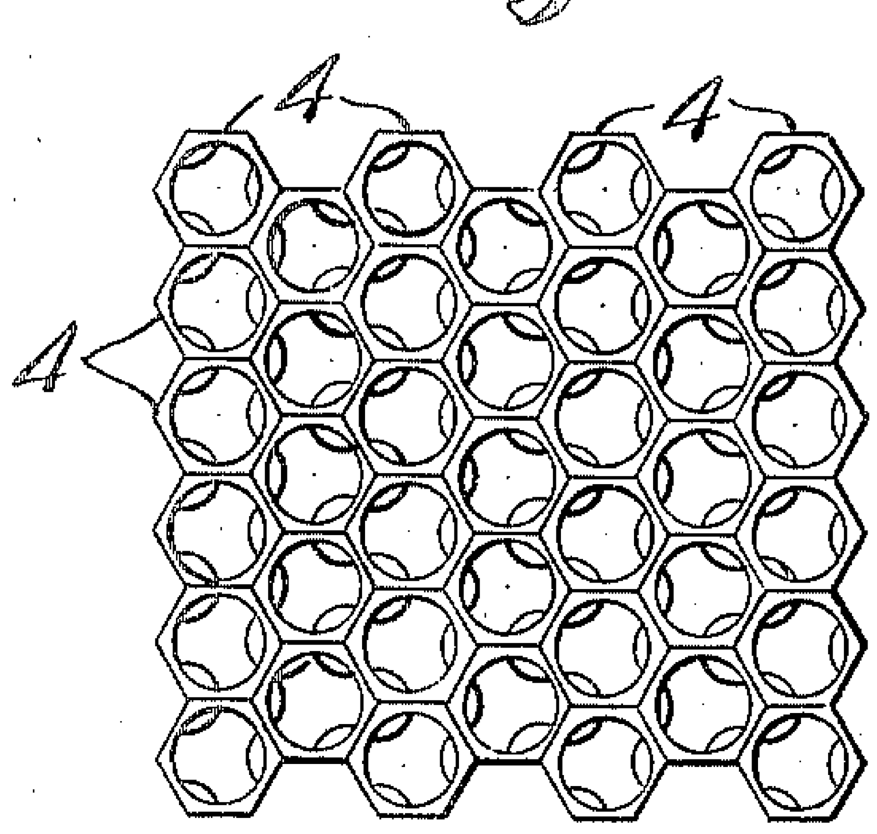


Fig. 10

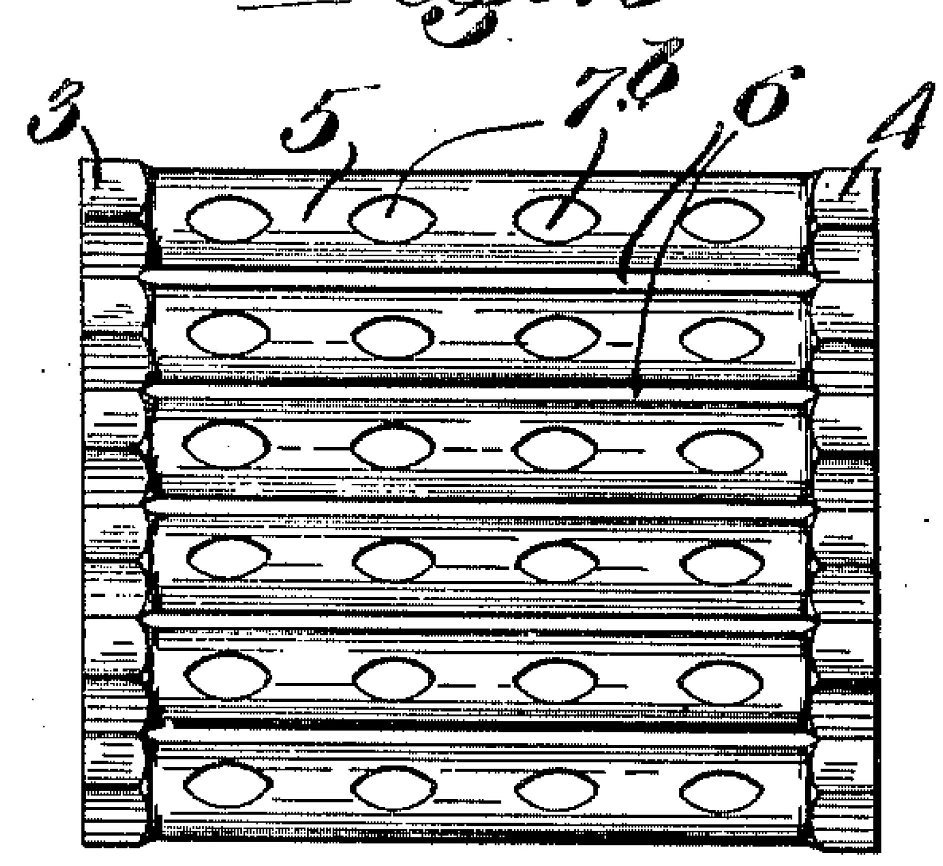
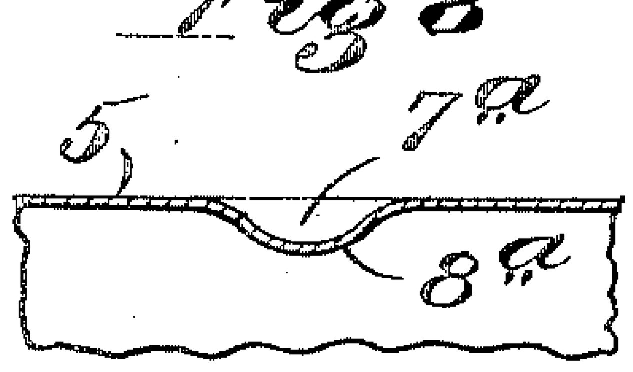


Fig 8



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UNITED STATES PATENT OFFICE.

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RADIATOR TUBE.

Application filed January 20, 1923, Serial No. 613,885. Renewed December 3, 1927.

This invention pertains to heat exchange apparatus, such for example as radiators for water-cooled internal combustion engines, wherein fluids at different temperatures are caused to circulate in heat exchanging relationship through passages defined by thin walls of heat conducting material, and relates more particularly to the construction of fluid conducting tubes for use in such heat exchange apparatus, and especially useful in the making of engine radiators of the so-called "honey-comb" type.

Radiators of the latter type commonly consist of a large number of open-ended tubes arranged horizontally in a stack and in parallel relation and suitably spaced apart to provide passages for the circulation of the water or other cooling liquid over the outer surfaces of the tubes. Air is caused to flow longitudinally through the tubes and serves to absorb the heat of the cooling liquid through the thin walls of the tubes. Due to limitations of space it is desirable and in many cases necessary to limit the thickness of the radiator structure, or in other words, to limit the lengths of the tubes of which the radiator is composed. Such limitation in length necessarily shortens the duration of time in which the air and liquid are maintained in heat exchanging relationship, and for structural considerations, it is not practicable to decrease the diameter of the tubes beyond a certain limit so that it is thus impossible to increase the cooling surface by increasing the number of tubes in a given space. For the above reasons the efficiency of ordinary radiators for the cooling of the circulating water is not all that could be desired.

The principal object of the present invention is to provide a tube useful in the construction of radiators and similar devices of such character as greatly to increase the cooling effect obtainable as compared with the ordinary straight tube but without increasing the external dimensions of the radiator. Other objects are to provide a tube having the above characteristics without sacrificing any substantial part of the original strength of the tube or subjecting it to internal strains such as might result in the formation of cracks; to provide tubes of a type such that when assembled to form a radiator, ample space is provided for the circulation of water between the tubes; and to embody the above desirable characteristics in a tube which may be produced at relatively low cost.

With the above objects in view the tubes, which are preferably produced by an extrusion process from short lengths of annealed rod or heavy tube and which are furnished with hexagonal ends for honey-comb assemblage, are subjected to the action of dies which produce series of indentations of generally spheroidal curvature in the outer surface of the tube, the metal being forced inwardly so that a smoothly rounded protuberance projects into the interior of the tube at each of the indentations. Such protuberances serve in a highly effective manner as baffles to break the continuity of the stream of air passing through the tube and to form eddies therein which cause molecules of air to be brought into intimate contact with the walls of the tube, thus greatly increasing the rapidity of heat interchange. Likewise the indentations at the outer surface of the tube act to produce swirls or turbulence in the water flowing over the outer surface of the tube so that substantially every particle of water is at one time or another brought into direct contact with the tube wall, and in efficient heat interchange relationship to the air passing through the tube.

The making of indentations in the cylindrical wall of the tube necessarily decreases its initial strength to some extent due to the deformation of its normal arch form. The larger the area of the wall surface involved in such deformation and the larger such indentation is, particularly in a circumferential direction, the greater will be the decrease in strength so that it is manifestly desirable to make such indentations of small superficial area. On the other hand the effectiveness of such indentations and corresponding protuberances, when acting as baffles, depends largely upon their depth or the extent to which they depart from the cylindrical surface of the tube. It is evident that an indentation whose surface is of substantially spherical curvature will most nearly meet the above requirements in providing a maximum volume displacement with a minimum surface deformation. An indentation of this shape has the further advantage that in its formation no marked lines of strain are set up in the tube such as might constitute incipient cracks, as the metal involved in the formation of the indentation is stressed in a substantially uniform manner and the edges of the indentation merge smoothly into the main surface of the tube. The action of indentations and projections of this shape is efficient in breaking up the continuity of the stream flowing thereover, as the surface with which the fluid engages constitutes a curved wedge which deflects the particles fanwise in all directions, thus producing movements of the fluid most conducive to the interchange of heat between the fluid and the walls of the tube.

These curved indentations are preferably formed by the action of punches carried by the forming die, the operative surface of the punches being of spherical curvature. Such curvature may, for example, have substantially the same radius as the tube, and in such case the trace of its lower (or inner) portion will be more or less parallel to the opposite, undepressed portion of the tube. As the metal of the tube is somewhat more resistant in a circumferential than in an axial direction due to the arch effect of its cylindrical wall, the action of such punches is to form indentations which, while of generally spherical curvature, are somewhat elongate, but symmetrical, in an axial direction. In other words, the indentations produced have substantially the shape of a segment of a prolate spheroid cut by a plane parallel to its axis of revolution. These indentations, being elongate in a direction axial of the tube, detract to a minimum extent from the normal strength of the tube and while not of truly spherical curvature, approximate such curvature so closely as to secure in large measure the above noted desirable results. In some cases, particularly if the punches do not approach the tube in an exact radial direction, the bottom of the indentations may be of substantially diamond shape, elongate axially of the tube, but in any case the edges of the indentations merge gradually and with smoothly rounded contours into the surface of the tube.

The punches are preferably so positioned as to form at least three series of longitudinally spaced indentations, the series being disposed symmetrically about the tube and comprising the same or a different number of indentations as may be found most convenient in practice.

A preferred embodiment of the invention is illustrated by way of example in the accompanying drawings in which:

Fig. 1 is a side elevation of a tubular blank such as is employed in making the tube of the present invention;

Fig. 2 is an end view of the blank shown in Fig. 1;

Figs. 3, 4 and 5 are side elevations spaced 120° apart about the circumference of the tube and showing the tube as completed and embodying the present invention;

Fig. 6 is an end elevation of the tube as positioned in Fig. 3;

Fig. 7 is a transverse cross section to larger scale on the line 7—7 of Fig. 3;

Fig. 8 is a fragmentary longitudinal cross section on a line such as 8—8 of Fig. 4;

Fig. 9 is an end elevation of a radiator structure formed from tubes made in accordance with the present invention; and

Fig. 10 is a side elevation of the structure shown in Fig. 9.

Referring to the several figures of the drawings, the numeral 1 indicates a cylindrical tubular blank from which the improved tube may be formed. This blank is preferably produced by an extrusion process from a short section of a solid rod or heavy tube and preferably such rod or tube are also produced by an extrusion process. By producing the blank in this manner, it is possible to make it of minimum thickness, as the walls of the tube are substantially homogeneous and without incipient cracks or lines of strain. While it is preferred to employ a blank made by the above process, it is to be understood that the present invention is not in any manner restricted thereto, but that the blank might also be made by any other of the known or usual processes employed in the making of metallic tubes. This blank, as shown in Fig. 2, provides a substantially smooth and uninterrupted cylindrical passage 2. The blank having been cut to proper dimensions, it is then subjected to the action of suitable dies which produce heads 3, 4 at opposite ends and preferably of polygonal contour. As here shown, such heads are of hexagonal shape to facilitate the building up of the tubes into a honeycomb structure as indicated in Figs. 9 and 10. The body portion of the tube indicated at 5 is provided with indentations such as 7, 7^a, 7^b in its outer surface.

The indentations may be formed at the same time that the heads 3 and 4 are produced or may be made at an independent operation as is found most convenient. Preferably these indentations are produced by the action of a die and are arranged to form circumferentially spaced series as indicated in Figs. 3, 4 and 5, respectively. These series of indentations are preferably spaced symmetrically about the tube and the several series may comprise the same number of indentations or a different number as may be desired. As herein shown the series comprise two, three and four indentations respectively, and it will be noted that the indentations of the series 7 are in staggered relation to the indentations of the series 7^a, the latter being staggered as respects the indentations of the series 7^b. The die employed for forming these indentations is preferably provided with punches whose active faces are of spherical curvature. Such faces may consist of balls set into the body of the die or of the spherical ends of adjustable members having screw threaded engagement with openings in the dies. When such spherical surfaces are brought into contact with the outer surface of the wall of the tube, such wall is pressed inwardly, thus forming the indentations above described and corresponding protuberances 8, 8^a and 8^b upon the interior surface of the tube. By reason of the fact that the tubular wall is somewhat more resistant in a circumferential direction than longitudinally, the effect of the spherical punches is to produce indentations and corresponding protuberances which are not exactly spherical in curvature, but which are symmetrically elongate in an axial direction. The indentations and protuberances may thus be considered as of spheroidal curvature having the shape in fact of a segment of a prolate spheroid formed by a plane cutting the spheroid parallel to its axis of revolution.

As clearly seen in Fig. 6, the protuberances act to restrict the cross sectional area of the tube and constitute baffles against which the stream of air flowing through the tube impinges and which serve to break up the continuity of the air stream, thereby causing substantially every molecule of air to come into contact with the wall of the tube at one time or another during its passage through the tube. The spherically curved protuberances act in a highly efficient manner to break up the stream as it is evident that the approaching particles of air are caused to spread out in a fanwise direction in striking such protuberances so that an especially efficient stirring up of the air is secured.

As indicated in Fig. 10, the assemblage of the several tubes in honey-comb relation produces spaces as at 6 between the tubes through which the water is circulated. The indentations in the outer surfaces of the tubes have an effect upon the stream of water quite similar to that of the protuberances in acting upon the air stream. Such indentations cause areas of decreased pressure which produce swirls in the water stream so that all particles of the latter are brought into close and immediate contact with the walls of the tube.

While it is preferred to arrange the indentations of adjacent series in staggered relation, thus to some extent assisting in the breaking up of the continuity of the fluid streams, this arrangement is not essential, and it is contemplated that under some circumstances each series of indentations might be identical in all respects with each of the others. The tube produced as above is not only very effective for its intended purpose as a heat interchange element, but may also be constructed at relatively low cost as it is possible to produce the heads 3, 4 and the several indentations in one operation, if desired. Moreover, the punches necessary for forming the desired type of indentation may be constructed very cheaply and are extremely durable, while by reason of the use of punches of this form, there is substantially no waste of tubes due to fracture in the punching operation which is frequently occasioned when punches of other and more abrupt contour are employed.

What I claim and desire to secure by Letters Patent of the United States is:

1. A radiator tube comprising a body portion continuously integral circumferentially and having a plurality of axially spaced indentations in its wall, said indentations being elongate in an axial direction and merging gradually and smoothly into the surface of the undepressed wall of the tube, the trace on a transverse plane of the bounding wall of said indentations being of similar curvature to the diametrically opposite portion of the wall of the tube.

2. A radiator tube having a plurality of axially spaced indentations in its wall, said indentations being elongate in an axial direction and merging gradually and smoothly into the surface of the undepressed wall of the tube, the transverse curvature of the bounding wall of said indentations, at the deepest points of the latter, being substantially the reverse of the undepressed wall of the tube.

3. A radiator tube generally cylindrical in shape having a plurality of inwardly directed indentations in its outer surface, said indentations being of elongate substantially spheroidal curvature.

4. A radiator tube having a plurality of spaced protuberances upon its interior surface, said protuberances each having substantially the form of a segment of a prolate spheroid cut by a plane parallel to the axis of the spheroid.

5. A radiator tube comprising a body portion constructed and arranged for honeycomb assemblage with similar tubes, and a plurality of series of indentations in the outer surface of said body portion, each of said indentations being of substantially spheroidal curvature and elongate in the direction of the axis of the tube.

6. A radiator tube comprising a cylindrical body portion and a plurality of series of indentations in the outer surface thereof with corresponding protuberances on the inner wall of the tube, said series being spaced symmetrically about the circumference of the tube and the indentations and protuberances being of substantially spheroidal curvature.

Signed by me at Lowell, Mass., this 6th day of Jan., 1923.

RAYMOND W. BOWNE.