Aug. 12, 1941. P. R. SEEMILLER 2,252,211

HEAT EXCHANGE CORE

Original Filed Oct. 18, 1939 2 Sheets-Sheet 1

Fig. 1

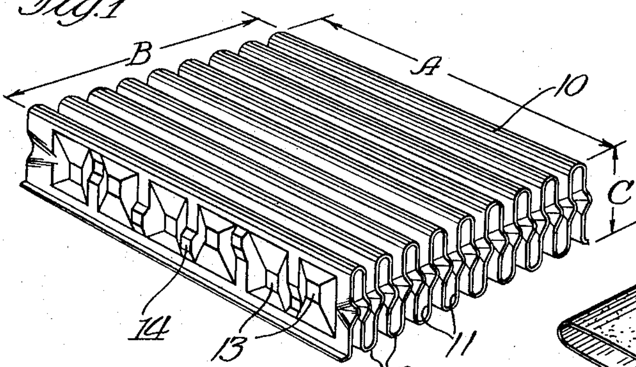


Fig. 2

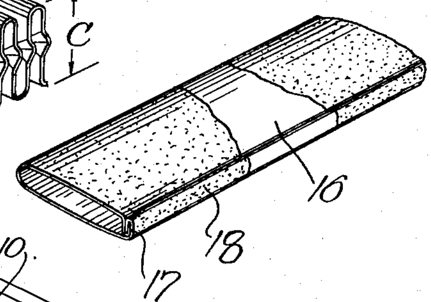


Fig. 4

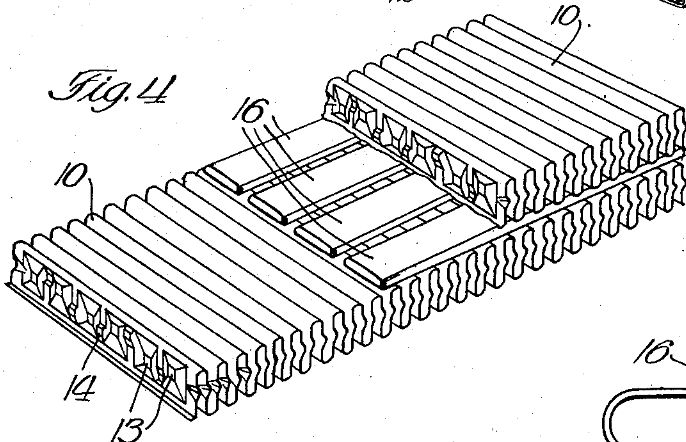


Fig. 3

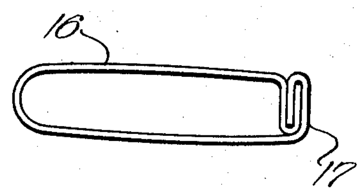


Fig. 6

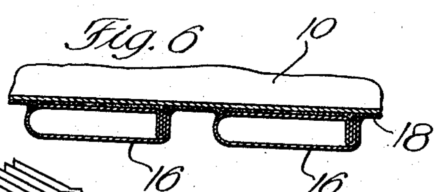
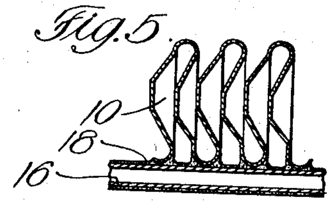


Fig. 5



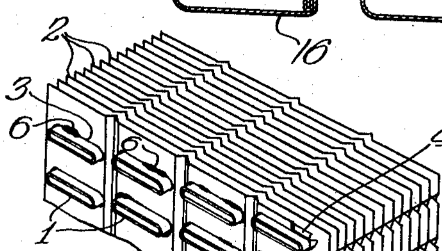
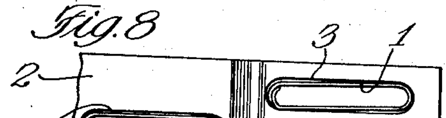


Fig. 7

Fig. 8



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HEAT EXCHANGE CORE

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Fig. 9

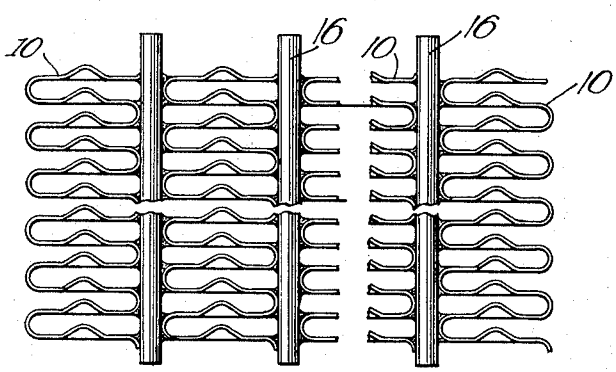


Fig. 10

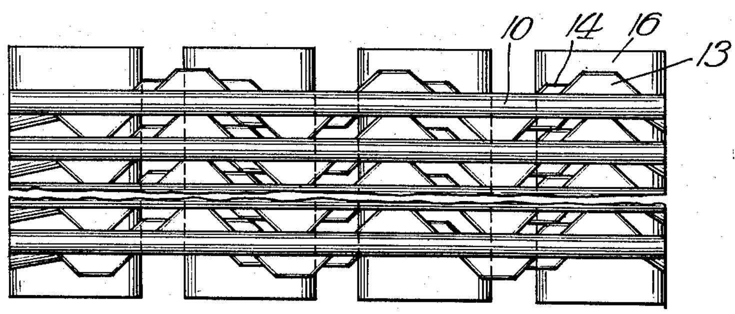


Fig. 11

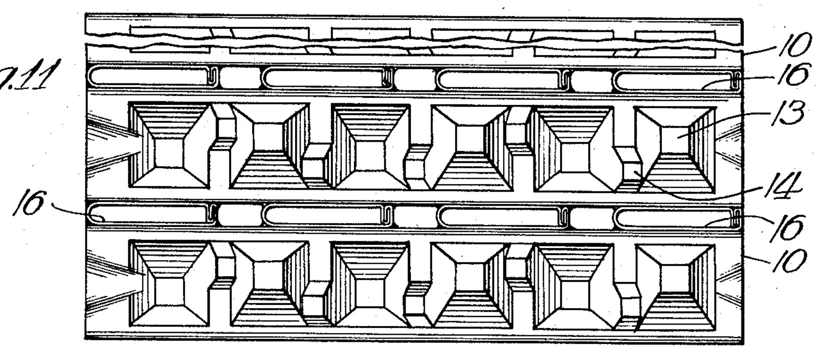


Fig. 13

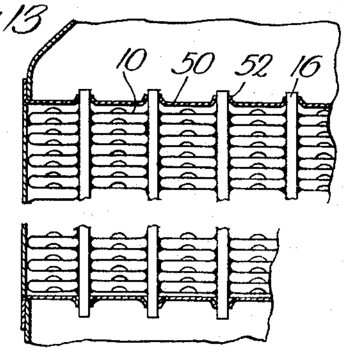
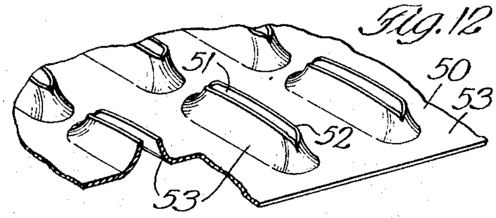


Fig. 12



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Patented Aug. 12, 1941 2,252,211

UNITED STATES PATENT OFFICE

2,252,211

HEAT EXCHANGE CORE

Paul R. Seemiller, Detroit, Mich., assignor to McCord Radiator & Mfg. Co., Detroit, Mich., a corporation of Maine

Original application October 18, 1939, Serial No. 299,954. Divided and this application January 26, 1940, Serial No. 315,677

5 Claims. (Cl. 257—130)

This invention relates to a heat-exchange core and the present application is a division of my copending application Serial No. 299,954, filed October 18, 1939. It primarily concerns a tubular type radiator core for use with internal combustion engines such as those used in motor vehicles and airplanes, but it also may be used in other heat-exchange devices.

The general object of the invention is to provide an improved tubular heat-exchange core. Other objects and advantages of the invention will appear from the following specification and drawings.

An embodiment of the invention is shown in the accompanying drawings in which:

Figure 1 is a perspective view of one of the heat-exchange elements or fin sections used in the core.

Fig. 2 is a perspective view of one of the tubes employed in the core.

Fig. 3 is an enlarged end view of the tube shown in Fig. 2.

Fig. 4 is a perspective view showing how the fin sections and tubes are assembled to make the core.

Fig. 5 is a partial, longitudinal cross section of a portion of a completed core showing how the fin sections and tubes are united.

Fig. 6 is a partial cross section at right angles to that of Fig. 5 showing how the fin sections and tubes are united.

Fig. 7 is a partial perspective of a portion of the standard type of tubular radiator core.

Fig. 8 is an enlarged partial end view of the core of Fig. 7.

Fig. 9 is a front elevation of a completed core, the view being broken along both vertical and horizontal lines so that it will not occupy so much space.

Fig. 10 is an end view of the completed core of Fig. 9, said view being broken along a horizontal line.

Fig. 11 is a top view of the completed core, said view also being broken along a horizontal line.

Fig. 12 is a partial perspective of one of the head pieces of a radiator.

Fig. 13 is a front sectional elevation of a completed core showing it mounted in head plates and as it appears in a finished radiator, the view being broken along a horizontal line.

The present invention is a continuation-in-part of prior application Serial No. 280,133, filed June 20, 1939.

The invention can be more clearly explained by first outlining the problems involved in radiator core construction and manufacture so that their solution by the present invention will be understood.

The two types of automotive radiator cores in general use are the cellular and the tubular types. The cellular type has been predominant because of the ease and cheapness of assembly as well as better cooling capacity in a restricted space and more cooling capacity per pound of metal used. On the other hand, the cellular type has certain disadvantages in that the water passages are not as free, or straight, or of as large a size as desirable; the structural strength is not great; and it has a multiplicity of overlapping seams that are sealed only by solder, the latter condition being increasingly detrimental owing to the present-day tendency of allowing a small pressure to develop in the cooling systems of automobiles.

The tubular type has certain well-recognized advantages such as straight and unobstructed water passages of adequate size formed by the tubes; greater structural strength; and no lapped seams that are sealed only by solder. However, owing to the nature of its construction and the manner in which it has had to be assembled, the cost of the tubular type has been such as to offset, to a great extent, its advantages.

The characteristics desired in a tubular heat-exchange core are a maximum cooling capacity per cubic inch of core so as to get the required cooling action in a minimum space; the maximum cooling action per pound of metal used to thereby keep the cost low because the materials employed, such as copper, brass, and solder, are relatively expensive; a construction that can be easily, rapidly and inexpensively manufactured in large quantities and which is susceptible of full or semiautomatic assembly; a construction that will operate efficiently under all sorts of conditions of temperature, hard usage, and different kinds of cooling fluids, including anti-freeze solutions, such as obtain in automobiles; and a construction that can be easily and effectively serviced; together with which there must be the requisite structural strength, flexibility, and pleasing appearance.

The present invention achieves these results and, in fact, retains the advantages of the tubular type of core while, at the same time, obtaining the advantages of the cellular type.

Present-day tubular radiators are made by pushing tubes 1 (Fig. 7) through openings in individual fins 2 of which there are usually a large number as shown in Fig. 7. The fins 2 are stamped out of copper or brass that must be relatively hard and stiff in order that the tubes may be pushed through the openings in the fins. This requires the use of what is known as a silver-bearing copper of which there is only a limited supply and which is relatively expensive. A multitude of slot-like openings 3 are punched in the fins which requires expensive dies that wear quite quickly and that require constant attention. In punching these holes, the metal is drawn out to form a short flange 4 (Fig. 7) at right angles to the surface of the fin, but these flanges are invariably ruptured at both ends of the slot as illustrated in Fig. 7 because of the hard nature of the copper that must be employed to make the fins stiff. Thus, the flanges are very imperfect. After the fins have been stamped and punched, they must be assembled and held in proper spaced relation which requires a special jig or fixture in which the fins must be carefully assembled. The tubes 1 are then pushed one at a time through the openings in the assembled group of fins. The tubes must be quite stiff to prevent bending but, even when made stiff, they must first be inserted through an arbor which is put against the opening in the first fin and the tube pushed through the arbor and then carefully pushed on through the openings in all the fins, the arbor being necessary to prevent bending of the tubes. It has been found from experience that, in order to reduce the fin and tube deformation to the lowest practical value, the fins must be made of hard copper of at least four thousandths of an inch (.004″) thickness and the tube walls must be at least six thousandths of an inch (.006″). Even with these thicknesses, it is necessary, after the core has been completed, to carefully go over it to see that the fins are properly spaced apart and that they have not been deformed in the assembly process. The above process is a slow, tedious and costly one that must be performed by skilled operators. Even with the best materials available and with skilled operators, there is a marked wastage of tubes, fins, and partly assembled cores. The efficiency of a core of this type depends largely upon the metal-to-metal contact between the tubes and the fins because the heat from the water in the tubes must pass through the tube walls to the fins so that it may be dissipated by the air going past said fins. In the construction just described, the metal-to-metal contact is very poor and haphazard. In the first place, the dies for punching the holes wear rapidly and to different extents so that some of the holes are soon slightly larger than others. The tubes 1 do not always come of uniform size nor of the same size throughout, and the thickness of the metal employed in them may vary slightly. Also, the tubes may be bent or twisted slightly either before or during the assembly. Then, too, the holes in the fins must be appreciably larger than the tubes in order that the tubes can be pushed through the fin assembly. Because of these conditions there is often a space between the edges of the openings in the fins and the tubes, which space may vary and is difficult, if not impossible, to control. This condition is illustrated in Fig. 8 by the space 5, the actual dimensions being somewhat exaggerated in order that the lines of the drawing may not run together. After the core is assembled, the tubes are soldered to the fins but, at the time this occurs, the core is in assembled condition and there is no way of getting at the openings except on the two outside fins. The result is that the soldering is very uncertain and, because of the varying space between the tubes and the edges of the openings, the soldering may be only in spots 6 as illustrated in Fig. 7. There is no way of correcting this difficulty in the assembled core, as the interior of the core is inaccessible. The metal-to-metal contact in a core of this type is so uncertain that cores of the same size vary in cooling capacity by as much as four per cent. From all of this it will be clear that the standard type of tubular core is not only expensive but it is also of uncertain efficiency. These factors have worked against the use of the tubular type of core as compared with the cellular type.

The present invention departs radically from the usual practice in making tubular cores. Instead of using a multiplicity of independent fins, the heat dissipating elements are made in integral sections, such as the section 10 shown in Fig. 1. These sections will be called the "fin sections" for convenience in description. Each fin section is made of an integral strip of soft metal, preferably soft, pliable copper, which has a width in the direction A of Fig. 1 equal to the thickness of the radiator core and a length B, preferably substantially equal to the height of said core (Fig. 13).

The metal strip 10 is reversely folded, or accordion-pleated, as shown in Fig. 1, to form a multiplicity of folds 11 that are substantially parallel to one another and relatively close together. The frequency of the folds is usually about ten per inch, that is, there are ten thin metal strips 11 per lineal inch of completed fin section. This frequency may be varied to suit the requirements but is preferably kept between nine and twelve folds per inch. The bends in the metal are approximately 180 degree bends so that the folds are approximately parallel to each other but it is to be noted that there is a substantial curve at the bends or edges of the folds as illustrated at 12 in Fig. 1 so as to provide a substantial surface along the tops of the bends for purposes that will presently appear. The copper employed need not be a silver-bearing copper but may be a soft copper that is less expensive. Also, the metal employed is thinner than that which can be safely used in the old style tubular construction. For example, copper three thousandths of an inch (.003″) thick can be easily and safely used, whereas the fins in the old construction must be at least four thousandths (.004″) inch thick. While this is not a great difference in actual fractions of an inch, relatively it is a big difference and results in a marked economy in the use of an expensive metal, as will be explained later. The thickness of the completed fin section in the direction C in Fig. 1 is preferably approximately seven sixteenths of an inch ($\frac{7}{16}$″). This thickness or depth of fold in a metal as thin as .003″ soft copper is greater than has heretofore been considered obtainable, and this fin section and the process of making it are the subject matter of a separate application.

The fin section is very rigid in the direction of its thickness, which is important in connection with accurate spacing of the tubes that are placed between the fin sections as presently will be explained. This rigidity with a fin section made of soft copper is obtained by having the folds parallel, the edges rounded and by having a multiplicity of folds per inch.

The fin section is preferably formed with humps or projections 13 in the individual folds, which humps may also be considered indentations depending upon which side of the fold is being considered. It is to be noted that these humps are obtained without cutting or breaking the metal, the fin folds being imperforate. Because of the soft metal used, these humps may be made higher, or of more substantial depth, than is possible in the old hard copper fins, and the resulting air surface of the fins can thus be increased for a given dimension of fin section. The humps are about three thirty-seconds of an inch ($\frac{3}{32}''$) deep and they are in the form of truncated pyramids which not only alternate in direction relative to the surface of the fold from one end of the fold to the other but which also alternate as to height from the top or bottom of the fold. In other words, starting from the right-hand end of the first fold in Fig. 1, the first hump projects toward the reader and is toward the top of the fin fold, the next hump projects away from the reader and is toward the bottom of the fold, the next hump projects toward the reader and is toward the top, and so on across the length of the fold. In the completed section, these indentations or humps in one fold register with those in the next adjacent fold as shown in Fig. 10. The result is that an air passage is provided between the individual folds of the fin section which is undulating or sinuous in planes that are at right angles to one another or, when the core is in vertical position, the air passage is undulating in both a horizontal and a vertical plane. This provides an improved air turbulence over prior constructions and this improved turbulence, together with the increased size of the humps made possible by the soft metal employed, increases the cooling capacity and efficiency of the fin section without interfering with proper air flow through the passage.

The fin section also may have a series of spacer humps 14 (Figs. 1, 10 and 11) formed on it which are used in making the fin section, which tend to keep the folds properly spaced after the fin section is completed, and which increase the air surface slightly.

The tubes 16, shown in Figs. 2 and 3, are made of copper or brass and, because these tubes do not have to be pushed through openings in fins as will presently appear, it has been found that the tube wall thickness can be reduced by sixteen per cent as compared with the old construction and that a tube wall thickness of five thousandths of an inch (.005″) gives as good a performance as was previously obtained with a tube wall thickness of six thousandths of an inch (.006″). Furthermore, variations in size or in the straightness of the tubes do not interfere with the assembly or with the efficiency of the core.

The tubes are substantially flat though slightly bulged along the longitudinal center as shown in Figs. 2 and 3. They are formed with lock seams such as shown at 17, and these lock seams are preferably located along the side edges of the tubes. The lock seams extend for the full thickness of the tubes to provide four thicknesses of metal on edge and an important feature is that these lock seams are accurately made to act as spacers for determining the final thickness of the tubes in the completed core. The dimensions of the lock seams in the direction of the thickness of the tubes are kept to within four thousandths of an inch. The lock seams also stiffen the tubes and prevent their collapse during assembly of the core by acting as stops or spacers preventing the fin sections from compressing the tubes beyond a certain limit.

The tubes are formed in a tube mill, which has not been shown because it is of a well known type, by a continuous process that bends a strip of sheet metal to shape and forms a lock seam in it. In the present invention, the tube mill is adjusted to give a lock seam of accurate dimensions and of the type shown and described. During the making of the tube, the lock seam is soldered and, while this is being done, the entire outside of the tube is covered with a thin coat of solder as illustrated at 18 in Fig. 2. This coating is regulated as to its thickness and is preferably quite thin. As the tube issues from the tube mill, a coating of suitable soldering flux is applied which hardens as the tube cools and which remains on the outside of the tube. The tube is then cut into desired lengths, which vary with the height of the core with which they are to be used.

The purpose of these tubes in the completed core is to provide water passages and it will be observed that they provide straight, smooth, unobstructed passages that cannot be easily clogged by rust or other foreign material. Furthermore, the passages are devoid of lapped or soldered joints such as would easily leak under severe service conditions. Instead a lock seam has been provided which will not leak under severe service conditions including considerable pressure.

After the tubes and fin sections have been formed, the process of making the core starts with one of the fin sections 10 shown in Fig. 1. Referring to Fig. 4, one of these fin sections is placed in position and then a set of tubes 16 having solder and flux on their outside surfaces is placed on top of the fin section in proper spaced relation. Four tubes comprise a set in the core illustrated in Fig. 4. It is to be noted that the substantially flat, lower sides of the tubes rest on the edges 12 of the folds of the fin section so as to contact all of the top edges of the fin folds for the width of the core.

Next, another fin section is placed on top of the set of tubes and, as will be clear from Fig. 4, the top of the set of tubes contacts all the lower edges of the folds of the second fin section.

Then a second set of tubes is placed on top of the second fin section, a third fin section is placed in position, a third set of tubes is placed on top of the third fin section, and these steps are continued until the radiator core is of the desired size.

The assembled fin sections and tubes are then forced tightly together and clamped to hold the parts firmly in position and to obtain complete and definite contact between each tube and all the edges of the fin sections adjacent it. The pressure applied straightens out the bulges along the center lines of the tubes and flattens them, which allows all the tubes and fin sections to move into contact even though there may be some inequalities in the size of the tubes or some bending or deformation of the parts. The tendency of the tubes to assume their original condition also tends to keep them in good contact with the fin sections. This flattening of the tubes does not deform their inner surfaces. They still have ample capacity and provide smooth unobstructed passages. The lock seams on the sides of the tubes provide four spacers between each two fin sections which accurately space the fin sections and which prevent collapse of the tubes. The soft copper out of which the fin sections are made may allow some of the edges of the folds to yield slightly should some of the edges be slightly higher than others, although, as a whole, these fin sections are very resistant to pressure owing to the construction of the fin elements with the folds substantially parallel and close together and the bends rounded. The fin sections thus space the sets of tubes and the tubes space the fin sections, with the result that the sets of tubes are accurately spaced to enable them to enter the holes in the headers later described. This spacing must be within several thousandths of an inch but by using accurate lock seams and by means of the type of fin section employed, it has been found that this accurate spacing of the tubes can be obtained.

While the core elements are thus held tightly together in proper relation to each other, the assembly is subjected to heat sufficient to cause the solder on the tubes to soften and flow enough to solder the tubes to the fin sections.

Immediately afterward, the unit is either cooled or quenched or allowed to cool in the atmosphere to thereby solidify the solder, the parts being held firmly in position by the clamps until the solder has solidified.

The process also results in integrally bonding or uniting all the folds of each fin section to the respective tubes engaged by it, that is, to the sets of tubes on each side of it; and this uniting or bonding is not only a definite and uniform one for each and every fold, but it is a uniting that occurs for the full width of each tube along a band of substantial width owing to the substantial width of the bends of the folds in the fin sections.

The resulting construction is shown in one cross section in Fig. 5 and in another cross section in Fig. 6, where, however, the relative amount of solder between the fin edges and the tubes has been exaggerated to avoid having the lines of the drawings run together. In actual practice the amount of solder is kept at a minimum in order to obtain as nearly as possible a metal-to-metal contact between the copper fin edges and the brass tubes, copper and brass being better heat conductors than solder. Figs. 5 and 6 show how the fins are made an integral part of the tubes and how they are united along a line of substantial width and for the full width of each tube. It is to be observed that the soldering takes place along the edges of the fin folds only, as distinguished from constructions that are dipped, where the entire fin section is covered with solder. Such constructions are not only wasteful of solder but are not as efficient because the solder on the fin sections detracts from the efficiency of said sections as heat conductors.

This method of making a radiator core is much simpler and a great deal less expensive than the constructions heretofore used in which the tubes are pushed through individual fins. The assembly operations that have been wasteful of time and material have been eliminated. The new assembly operations are few and very easy. The number of parts in a radiator of a given size and capacity is reduced approximately one third. Moreover, the contact between the tubes and the fins is much greater and much better, and there is no uncertainty about it. Even though the tubes may vary slightly in size and even though the folds of the fin section may vary slightly at places or be slightly bent or twisted, nevertheless, this type of construction and method of assembly are such that, when the parts are clamped together, the tubes will yield slightly and flatten out to give complete and definite contact between each fold of each fin section and each of the tubes that it is supposed to contact and, after the soldering action, every fold is intimately united to its tube throughout the entire surface of contact; and this is not a contact along a sharp edge but a substantial contact over a folded edge of substantial width and for the full width of the tube.

The lock seams on the side edges of the tubes provide four accurate spacers between each two fin sections and prevent collapse of the tubes. The nature of the fin sections is such that, even though they are made of soft copper, they accurately space the tubes and they act as a firm bracing means between the tubes to give the core excellent structural strength.

One of the most important advantages is that the thickness of the metal in the fin sections and the tubes may be reduced without in any way reducing the heat dissipating capacity of the core or interfering with its assembly. It has been found that, for cores of a given heat dissipating capacity, the amount of metal per finished core is reduced by five pounds, or about twenty-five percent, as compared with the standard tubular construction. Thus, a much greater efficiency per pound of metal used is obtained. Since the metal is expensive, this results in a very substantial saving when it is considered that thousands of these cores are made per day. There is, of course, also a commensurate saving in the simplicity and ease of assembly. It has also been found that only about one-third (⅓) as much solder is used as compared with the standard cellular type. This is a great economy in tin which is one of the main ingredients of solder and which has to be imported into this country.

Another advantage is that there is no damaging, and consequent scrapping, of valuable metal during the assembly. As stated, in the old construction, even when the utmost care was used by trained operators, there was a considerable percentage of damaged fins, tubes and partly assembled cores.

After the core has been completed, the ends of the tubes which project from the bottom and top of the core are inserted in head sheets **50**, as shown in Fig. 13. These head sheets, a portion of one of which is illustrated in detail in Fig. 12, have openings **51** punched in them to receive the tubes. During the punching operation the metal is drawn out into flanges **52**. These openings are provided with considerable lead at their ends and side edges, as shown at **53** in Fig. 12, so that, if any of the tubes in the finished core should be slightly out of line, the head sheet can, nevertheless, be easily pushed on the ends of the core. After the head sheets are placed in position, the parts are held together and the assembly is heated at its ends only. This results in soldering the ends of the tubes to the head pieces by means of the solder on the outsides of the tubes and it also softens the solder a few inches back from the top and bottom of the core to allow any tubes that may be slightly out of line to adjust themselves so that there will be no strain on the core.

It is to be understood that the radiator core construction and method of making the same disclosed herein are for purposes of illustration only and that variations may be made within the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A heat-exchange core of the tubular type comprising a plurality of sets of substantially flat tubes with the tubes of each set arranged in line from front to rear of said core, and a single integral fin section between and united to each two adjacent sets of tubes, said tubes spacing said fin sections apart and each of said tubes being provided along one edge with a multi-layered portion forming a stiffening element extending transversely to the adjacent fin sections, said fin section being made of metal less than four thousandths of an inch (.004") thick and comprising a pleated metal strip having all of its folds substantially parallel with one another and of a frequency of at least nine per inch, the turned-over edges of said folds being rounded and of substantial width and each and every fold being integrally united over all its substantial width with the flat sides of the tubes on the respective sides of the fin section and for substantially the full width of the tubes.

2. A heat-exchange core of the tubular type comprising a plurality of sets of substantially flat tubes, the tubes of each set being arranged substantially in line from front to rear of said core, and a single integral fin section between and united to each two adjacent sets of tubes, said fin section comprising a pleated metal strip having all of its folds substantially parallel with one another, said folds being imperforate but having a multiplicity of humps of substantial depth therein with the humps alternating across the length of the folds both as to distance from the edges of the folds and the direction in which they project from the faces of the folds, the humps in one fold registering with those in adjacent folds to provide an air passage between them that undulates in planes at right angles to one another, the turned-over edges of said folds being of substantial width and each and every edge being integrally united over all of its width with the flat sides of the tubes on the respective sides of the fin section and for substantially the full width of said tubes.

3. A heat-exchange core of the tubular type comprising a plurality of sets of separate substantially flat tubes, the tubes of each set being arranged in line from front to rear of said core, and a single integral fin section between and united to each two adjacent sets of tubes, said tubes having a special means formed in their walls which is positioned to act and which is accurately dimensioned in the direction of the thickness of said tubes to act as a rigid spacing means between the fin sections, each fin section comprising a pleated metal strip having all of its folds substantially parallel with one another with humps formed in the parallel folds to stiffen them and provide undulating air passages between adjacent folds, the turned-over edges of said folds being of substantial width and each and every fold being integrally united over its substantial width with the flat sides of the tubes on the respective sides of the fin section for substantially the full width of said tubes.

4. A heat-exchange core of the tubular type comprising a plurality of sets of substantially flat tubes, the tubes of each set being arranged in line from front to rear of said core, and a single integral fin section between and united to each two adjacent sets of tubes, said tubes having lock seams along their side edges dimensioned in the direction of the thickness of said tubes to act as spacers between the fin sections, each fin section comprising a pleated metal strip having all of its folds substantially parallel with one another, the turned-over edges of said folds being of substantial width and each and every fold being integrally united over its substantial width with the flat sides of the tubes on the respective sides of the fin section for substantially the full width of said tubes.

5. A heat-exchange core of the tubular type comprising a plurality of sets of thin, substantially flat tubes having lock seams along their side edges positioned to act as spacers for the thickness of said tubes, the tubes of each set being arranged in line from front to rear of said core, and a single integral fin section between and united to each two adjacent sets of tubes, said fin section being made of metal less than four thousandths of an inch (.004") thick and comprising a pleated metal strip having all of its folds substantially parallel with one another and of a frequency of at least nine per inch, said folds being imperforate but having a multiplicity of humps of substantial depth therein with the humps in one fold registering with those in adjacent folds to provide undulating air passages from the front to the rear of said core, the turned-over edges of said folds being rounded and of substantial width and each and every fold being united over all its substantial width with the flat sides of the tubes on the respective sides of the fin section and for substantially the full width of the tubes.

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