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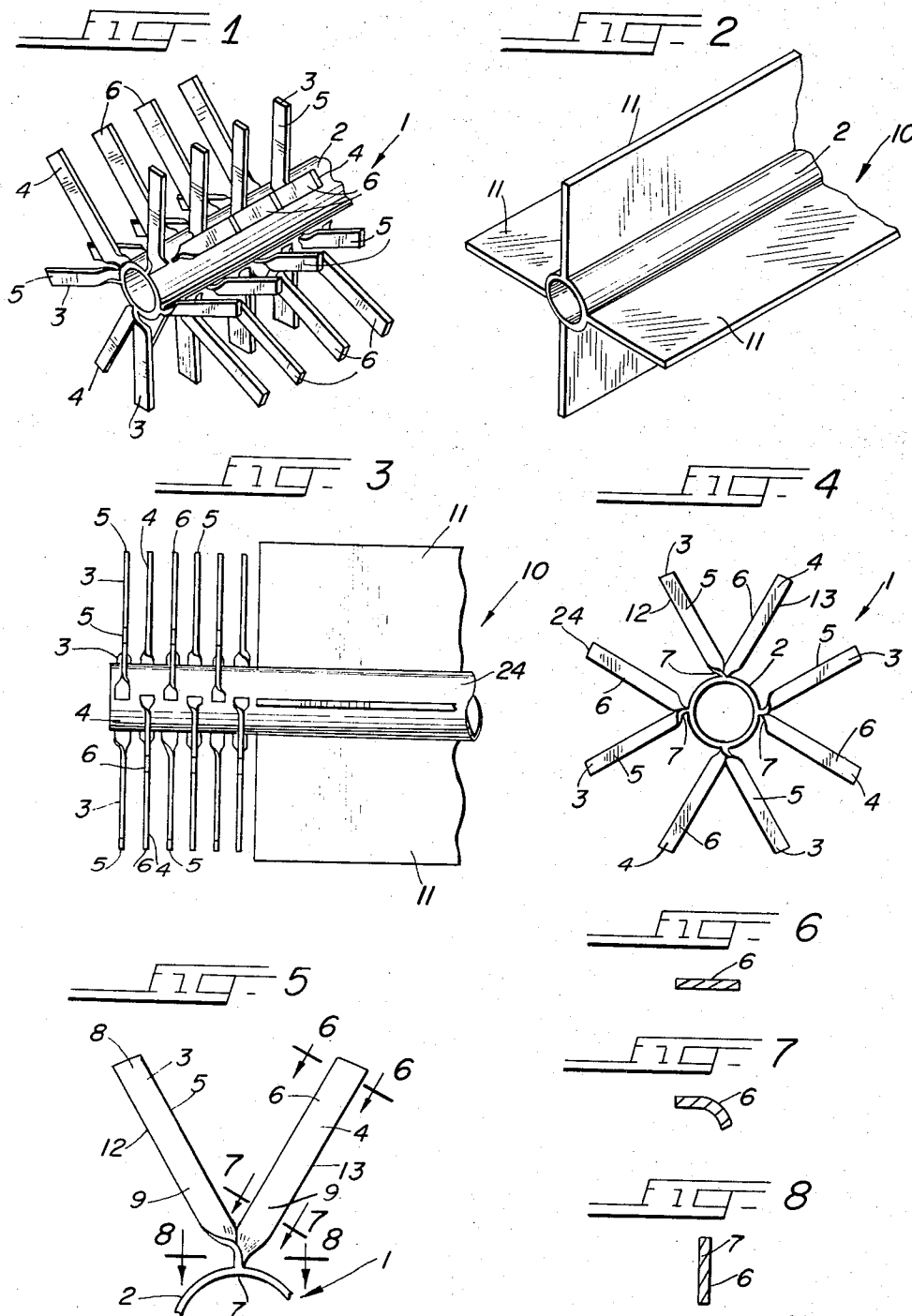
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3,360,040

HEAT EXCHANGER ELEMENTS

Filed July 30, 1965

2 Sheets-Sheet 1



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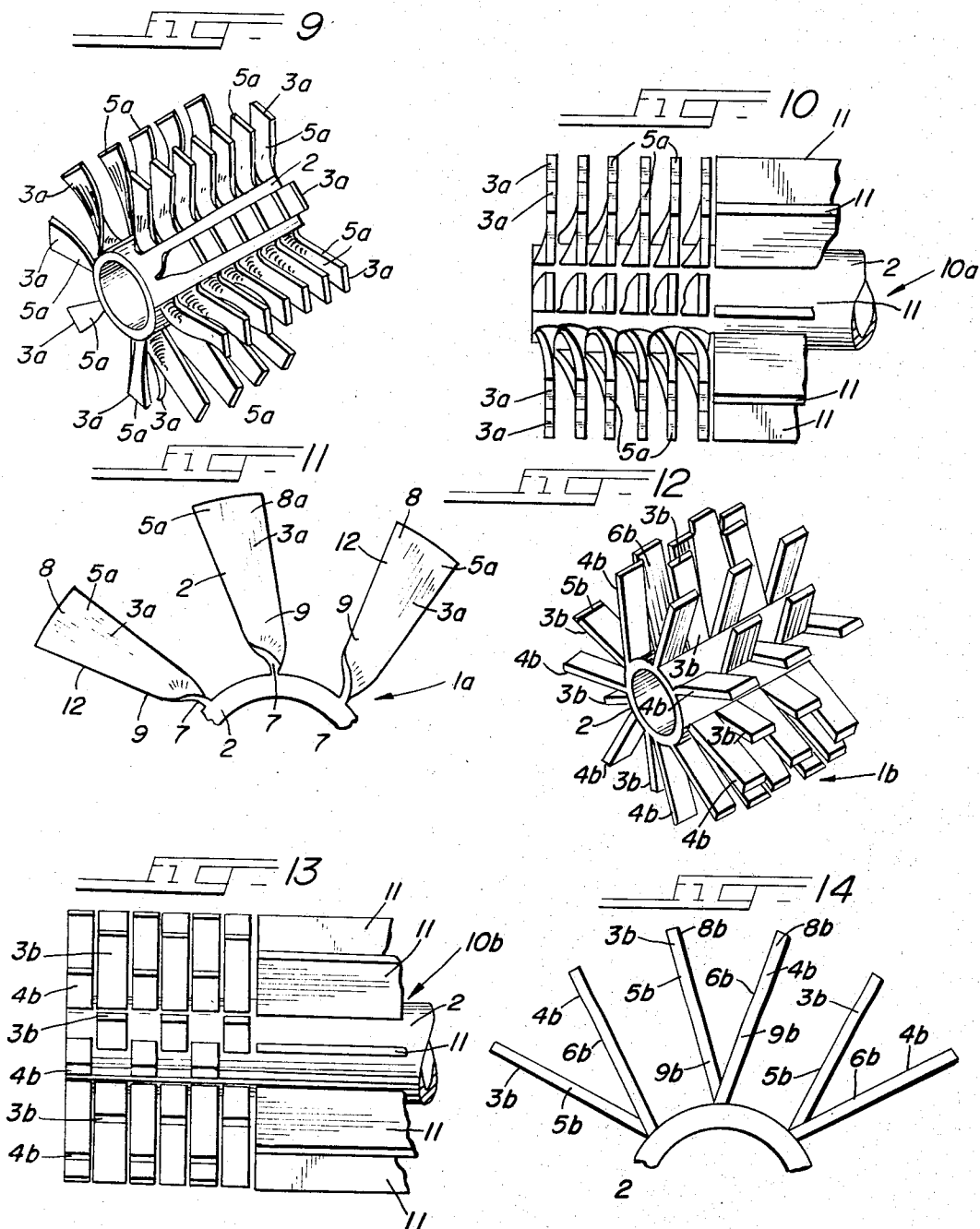
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2 Sheets-Sheet 2



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HEAT EXCHANGER ELEMENTS

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ABSTRACT OF THE DISCLOSURE

A heat exchanger having integral spine-type fins having base portions aligned to afford elongated ribs, and having outer end portions disposed transversely to said ribs.

This application relates to heat exchanger elements and the method of making same.

It is a primary object of the present invention to afford a novel heat exchanger element.

Yet another object of the present invention is to enable novel heat exchanger elements in the form of conduits having heat transfer fins thereon to be afforded in a novel and expeditious manner.

A further object is to enable novel heat exchanger elements in the form of conduits having outwardly projecting heat transfer spines thereon to be afforded in a novel and expeditious manner.

Heat exchanger elements in the form of tubular conduits having heat transfer fins and spines projecting therefrom have been heretofore known in the art. However, heat exchanger elements of this general type which have been heretofore known in the art have commonly had several inherent disadvantages, such as, for example, being difficult to manufacture commercially; requiring such fins or spines to be soldered or otherwise adhered to the tubular portion; affording poor heat flow or heat transfer between the fins or spines and the side wall of the tubular conduit; or not affording a good air flow pattern thereover, and the like. It is an important object of the present invention to overcome such disadvantages.

Another object of the present invention is to afford a novel heat exchanger element of the aforementioned type embodying spines projecting outwardly from the side wall of the conduit portion thereof, wherein the spines are connected to the side wall along a substantial base affording a highly effective path for the flow of heat between the spines and the side wall.

Another object is to afford a novel heat exchanger element of the aforementioned type wherein the spines and side wall portion thereof may be constructed of a single, unitary tubular member in a novel expeditious manner.

Yet another object of the present invention is to enable spines of novel heat exchanger elements of the aforementioned type to be constituted and arranged relative to each other in a novel and expeditious manner.

An object ancillary to the foregoing is to enable such spines to be constituted and arranged in such a manner as to be effective to afford novel heat transfer fin construction on the side walls of such tubular members.

A further object is to enable a novel heat exchanger element of the aforementioned type, embodying spines projecting from the side walls of a conduit, to be constructed in a novel manner wherein the spines thereof may be arranged to afford effective air flow longitudinally or transversely of the conduit.

Another object of the present invention is to increase the turbulence of the air flowing across heat exchanger elements.

Another object is to afford a novel heat exchanger element of the aforementioned type which is practical and

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efficient in operation, and which may be readily and economically produced commercially.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show the preferred embodiments of the present invention and the principles thereof and what I now consider to be the best mode in which I have contemplated applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

FIG. 1 is a fragmentary, perspective view of a heat transfer element embodying the principles of the present invention;

FIG. 2 is a fragmentary perspective view of a tubular member from which the heat transfer element shown in FIG. 1 may be manufactured in accordance with my novel method of manufacture, and illustrates an early step in the making of the heat transfer element shown in FIG. 1;

FIG. 3 is a fragmentary, top plan view of the tubular member shown in FIG. 2, illustrating an intermediate step in the manufacture of the heat transfer element shown in FIG. 1;

FIG. 4 is an end view of the heat transfer element shown in FIG. 1;

FIG. 5 is an enlarged, fragmentary end view of a portion of the heat transfer element shown in FIG. 4;

FIG. 6 is a detail sectional view taken substantially along the line 6-6 in FIG. 5;

FIG. 7 is a detail sectional view taken substantially along the line 7-7 in FIG. 5;

FIG. 8 is a detail sectional view taken substantially along the line 8-8 in FIG. 5;

FIG. 9 is a fragmentary, perspective view, similar to FIG. 1 but showing a modified form of the present invention;

FIG. 10 is a fragmentary, top plan view, similar to FIG. 3, but showing the form of the invention illustrated in FIG. 9;

FIG. 11 is a fragmentary, front elevational view of a portion of the member shown in FIG. 9;

FIG. 12 is a fragmentary perspective view of another modified form of the present invention;

FIG. 13 is a fragmentary, top plan view, similar to FIG. 3, but showing the modified form of the invention shown in FIG. 12; and

FIG. 14 is a fragmentary, front elevational view of a portion of the member shown in FIG. 12.

A heat transfer element in the form of a tubular heat exchanger unit 1, embodying the principles of the present invention, as shown in FIGS. 1-8 of the drawings to illustrate the presently preferred embodiment of the present invention.

The heat transfer element 1 embodies, in general, an elongated tubular body member 2, from the outer periphery of which project a plurality of identical pairs of fins 3 and 4, FIGS. 1 and 4. Each of the fins 3 and 4 embodies a plurality of spines 5 and 6, respectively, spaced from each other longitudinally of the tubular body member 2. The heat transfer element 1 shown in the drawings embodies four of the aforementioned pairs of fins 3 and 4 equally spaced from each other around the periphery of the tubular body member 2, FIG. 4. However, as will be appreciated by those skilled in the art, this is merely by way of illustration and not by way of limitation, and a greater or lesser number of such pairs of fins may

be afforded without departing from the purview of the present invention.

Each of the spines 5 and 6 embodies a substantially flat base portion 7, which extends longitudinally of the tubular body member 2, FIGS. 5 and 8; a substantially flat free, outer end portion 8 disposed transversely to the base portion 7 thereof and to the length of the tubular body member 2; and a curved or twisted intermediate portion 9 interconnecting the base portion 7 and the outer end portion 8 of the respective spines 5 or 6. In the preferred form of heat transfer element 1 shown in FIGS. 1-8, the base portions 7 of all of the spines 5 and 6 in each respective pair of fins 3 and 4 are disposed in longitudinal alignment with each other, FIGS. 3 and 5, with the free end portions 8 and the intermediate portions 9 of the spines 5 and 6, respectively, projecting outwardly at acute angles, and in opposite directions, from the longitudinally aligned base portions 7, FIG. 4.

Preferably, in the manufacture of the novel heat transfer element 1 shown in FIGS. 1-8, inclusive, an elongated extrusion, such as the extrusion 10 shown in FIG. 2, is first made. The extrusion 10 embodies the elongated tubular body member 2 of the heat transfer element 1 and four equally spaced ribs 11 projecting outwardly therefrom, FIG. 2. The ribs 11 extend longitudinally of the body portion 2 throughout the full length thereof, and are of a width which is equal to the length of the spines 5 and 6 of the heat transfer element 1. In the manufacture of the heat transfer element 1 from the extrusion 10 in the preferred manner of carrying out the novel method of manufacture, which constitutes a part of the present invention, each rib 11 is progressively sliced or cut from the outer edge thereof to the outer periphery of the tubular member 2 to alternately form a spine 5 and a spine 6 throughout the length thereof. Each of the spines 5 and 6 embodies what will be referred to herein as its leading edge 12 and 13, FIGS. 4 and 5, which is the edge portion thereof which is remote from the edge thereof along which it is severed from the remainder of the respective rib 11 during the aforementioned manufacture of the heat transfer element 1.

In the preferred practice of the novel method of manufacture constituting a part of the present invention, as each spine 5 is severed from a rib 11, in the aforementioned manner, the leading edge 12 thereof is simultaneously and progressively twisted from right to left, as viewed in FIG. 5, and the outer end portion 8 and the intermediate portion 9 is simultaneously and progressively offset to the left, as viewed in FIG. 5, so that upon completion of the severing of the spine 5 from the rib 11 the outer end portion 8 and the intermediate portion 9 thereof is disposed in the previously described position relative to the base portion 7 thereof, as illustrated in FIGS. 4 and 5, wherein the portions 8 and 9 of the rib 5 project outwardly to the left, as viewed in FIG. 5, at an acute angle to the base portion 7 thereof with the free edge portion 12 at the free end portion 8 facing outwardly to the left.

In the preferred manner of practicing the aforementioned novel method of manufacture, the spines 6 are formed from the ribs 11 in the same manner as that previously described with respect to the spines 5, except that the spines 6 are twisted, and bodily offset relative to the base portion 7 thereof to the right, as viewed in FIG. 5, so that in the completed heat transfer element 1, the free end portion 8 and the intermediate portions 9 of the spines 6 project outwardly at an acute angle to the right, relative to the base portions 7 thereof, with the free edge portions 13 of the free end portions 8 thereof facing outwardly to the right, as in FIG. 5.

In the preferred form of the heat transfer element 1 as shown in FIGS. 1-8, the spines 5 are disposed in parallel rows around the periphery of the tubular body member 2, with the spines 5 in each row equally spaced from each other, and with the spines 5 in each respective fin

3 disposed in equally spaced alignment with each other longitudinally of the body member 2. Similarly, the spines 6 are disposed in parallel rows around the tubular body portion 2, between respective pairs of the rows of spines 5, with the spines 6 in each row equally spaced from each other, and with the spines 6 in each respective fin 3 disposed in equally spaced alignment with each other longitudinally of the body member 2.

With the heat transfer element 1 constructed in the aforementioned preferred manner, paths for the passage of air longitudinally of the heat transfer element 1 are afforded between the adjacent fins 3 and 4, and paths for the passage of air transversely to the heat transfer element 1 are afforded between the adjacent rows of spines 5 and 6. The curved or twisted formation of the spines 5 and 6 imparts a turbulence to the air passing thereacross, which is effective to promote the transfer of heat between the air and the heat transfer element 1.

Also, it is to be noted that with the fins 3 and 4 made up of a plurality of individual spines 5 and 6, rather than solid ribs or fins of the type exemplified by the ribs 11 alone, in FIG. 2, an increased heat-transfer surface is afforded on the heat transfer element 1. For example, in the heat transfer element 1 wherein the width of each of the spines 5 and 6 is .125 inch and the spines are .027 inch thick, the exposed surface area is increased more than 20%. However, it has been observed that a greater efficiency in the heat transfer, than would be indicated by the mere increase in heat transfer surface, is afforded by so constructing the heat transfer element 1 that it embodies the spines 5 and 6 shown in FIGS. 1 and 4, rather than embodying fins of the type exemplified by the ribs 11 in FIG. 2.

Also, it will be seen that with the heat transfer element 1 constructed in the manner illustrated in FIGS. 1-8, the spines 5 and 6 are integrally connected to the outer peripheral surface of the tubular body member 2 by substantial base portions, which are of the same width and thickness as the spines 5 and 6, so that good heat transfer paths between the tubular body member 2 and the spines 5 and 6 are afforded.

Although the heat transfer element 1, shown in FIGS. 1-8, is shown as being straight, it will be appreciated by those skilled in the art that this is merely by way of illustration, and not by way of limitation, and that after the spines 5 and 6 have been formed on the body member 2, the heat transfer element 1 may be bent into any practical, desired shape, such as, for example, a serpentine path, a rectangular shape, or a circular shape, or the like. Also, it will be observed that, if desired, a plurality of passes of heat transfer elements constructed in the manner of the heat transfer element 1 shown in FIGS. 1-8 of the drawings may be nested together, laterally, with adjacent spines 5 and 6 of adjacent ones of the passes disposed in interfitting, spaced relation to each other.

In FIGS. 9 to 11, inclusive, of the drawings, a modified form of the present invention is shown. In the modified form of the invention shown in FIGS. 9-11, parts which are the same as parts shown in FIGS. 1-8 are indicated by the same reference numerals, and parts which are similar to, but which have been substituted for parts shown in FIGS. 1-8 are indicated by the same reference numerals with the suffix *a* added thereto.

The heat transfer element 1a, FIGS. 9 and 11, embodies an elongated tubular body member 2 having a plurality of fins 3a equally spaced from each other around the periphery of the body member 2 and extending the length thereof. Each of the fins 3a is made up of a plurality of spines 5a equally spaced from each other longitudinally of the tubular body member 2, FIG. 9. Like the spines 5, FIGS. 1-8, the spines 5a embody base portions projecting from the outer periphery of the body member 2 of the heat transfer element 1a, and extending longitudinally relative thereto; a substantially flat outer end portion 8 disposed transversely to base portions 7

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and to the length of the tubular body member 2; and a curved or twisted intermediate portion 9 connecting the outer end portions and the base portions 7. However, unlike the spines 5, the end portion 8 and the intermediate portion 9 of each of the spines 5a project substantially straight out from the base portion 7 thereof, rather than at an acute angle thereto, FIG. 11.

In the heat transfer element 1a shown in the drawings, eight fins 3a are shown, rather than the four fins 3, shown in FIGS. 1-8. However, this is merely by way of illustration, and not by way of limitation, and a greater or lesser number of fins 3a may be afforded without departing from the purview of the present invention.

The extrusion 10a, from which the heat transfer element 1a is constructed in accordance with the preferred practice of the present invention, embodies eight longitudinally extending fins 11, FIG. 10, projecting radially outwardly from the tubular body member 2 in equally spaced relation therearound, and the spines 5a for each of the fins 3a are formed from a respective one of the fins 11, FIG. 10. In forming each of the spines 5a, it is cut from a respective one of the ribs 11, and the leading edge 12 thereof is progressively turned or twisted to the left, as viewed in FIG. 11, in the same manner as heretofore discussed with respect to the spines 5 shown in FIGS. 1-8. However, in forming the heat transfer element 1a, the spines 5a are preferably not bodily displaced from their radially outwardly projected relation to the body member 2, in alignment with the base portion 7 thereof. The spines 5a are preferably disposed in equally spaced, parallel rows around the tubular body member 2, FIG. 10.

With this construction of the heat transfer element 1a passageways for the passage of air longitudinally thereof are afforded between adjacent pairs of fins 3a, and passageways for the passage of air transversely to the length of the body member 2a are afforded between the adjacent rows of spines 5a, FIGS. 9 and 11. In the modified form of the invention shown in FIGS. 9-11, the passageways, transverse to the length of the heat transfer element 1a, are not interrupted by spines in alternate fins, as they are in the heat transfer element 1 shown in FIG. 1, so that the paths for the air are somewhat more unobstructed. However, the twisted form of the spines 5a are effective to impart a turbulence to the air passing between the adjacent spines 5a to thereby insure effective heat transfer between the air and the heat transfer element 1a.

The heat transfer element 1a, like the heat transfer element 1, may be bent into any practical, desired shape after the ribs 3a have been formed thereon.

In FIGS. 12 to 14, inclusive, another modified form of the present invention is shown. In FIGS. 12-14, parts which are the same as parts shown in FIGS. 1-8 are indicated by the same reference numerals, and parts which are similar to, but which have been substituted for parts shown in FIGS. 1-8 are indicated by the same reference numerals with the suffix *b* added thereto.

Like the heat transfer element 1 shown in FIGS. 1-8, the heat transfer element 1b embodies a plurality of pairs of fins 3b and 4b projecting outwardly from an elongated, tubular body member 2, in equally spaced relation to each other therearound, with each of the fins 3b and 4b composed of a plurality of spines 5b and 6b, respectively, spaced from each other longitudinally of the body member 2.

The heat transfer element 1b shown in the drawings, embodies eight pairs of such fins, but this is merely by way of illustration, and not by way of limitation, and a greater or lesser number of such pairs of fins may be embodied therein without departing from the purview of the present invention.

In the preferred method of forming the heat transfer element 1b, it is formed from an extrusion 10b, FIG. 13, embodying the elongated tubular body member 2, from which radially project eight of the elongated ribs

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11. Each pair of fins 3b and 4b is formed from a respective one of the ribs 11. In forming each of the pairs of fins 3b and 4b, the spines 5b and 6b thereof are alternately sliced or cut from the respective rib 11 as hereinbefore described with respect to the spines 5 and 6 shown in FIGS. 1-8. However, the spines 5b and 6b are not twisted or turned, as they are in the form of the invention shown in FIGS. 1 to 11, inclusive, but are merely bodily offset to the left and right, respectively, as shown in FIG. 14.

With this construction, the base portions 7 of the spines 5b and 6b in each pair of fins 3b and 4b are disposed in longitudinal alignment with each other, longitudinally of the outer periphery of the body member 2 with the end portion 8b and the intermediate portion 9b of each of the spines 5b thereof disposed in uniplanar relation to each other, at an outwardly opening acute angle to the left relative to the base portion 7 thereof, and with the end portions 8b and the intermediate portions 9b of the spines 6b disposed in uniplanar relation to each other at an outwardly opening acute angle to the base portion 7 thereof in a right-hand direction, as used in FIG. 14.

With the heat exchanger element 1b constructed in the manner shown in FIGS. 12-14, substantially unrestricted passageways, longitudinally of the body member 2 are accorded between adjacent ones of the fins 3b and 4b, FIG. 14, and relatively tortuous passageways, which wind around adjacent ones of the fins 5b and 6b, are afforded transverse to the length of the tubular body member 2, FIG. 13.

The heat transfer element 1b, like the heat transfer elements 1 and 1a, after it has been formed from the extrusion 10b, may be bent into any practical, desired shape. Also, if desired, like the heat transfer elements 1 and 1a, the heat transfer element 1b may be divided into a plurality of passes which are disposed in transversely nested relation to each other.

From the foregoing, it will be seen that the present invention affords a novel heat transfer element which affords good heat transfer between the main body portion and the fins thereof.

Also, it will be seen that the present invention affords a novel heat transfer element wherein outwardly projecting fins on the body portion thereof are constituted and arranged in a novel and expeditious manner.

In addition, it will be seen that the present invention affords a novel heat transfer element which may be manufactured in a novel and expeditious manner.

Also, it will be seen that the present invention affords a novel method of manufacturing heat transfer elements having spines projecting from a tubular body portion.

Further, it will be seen that the present invention affords a novel heat transfer element which is practical and efficient in construction and operation, and which may be readily and economically produced commercially.

Thus, while I have illustrated and described the preferred embodiments of my invention, it is to be understood that these are capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. A heat transfer element comprising
 - (a) an elongated tubular member, and
 - (b) a plurality of fins projecting outwardly from said tubular member and extending longitudinally thereof,
 - (c) each of said fins comprising
 - (1) a base portion projecting radially outwardly from said tubular member, and
 - (2) a plurality of pairs of elongated spines projecting longitudinally outwardly from said base portion, with the fins in each pair projecting

at an oppositely opening acute angle to the radius along which said base portion projects, (d) adjacent ones of said spines in each of said fins being disposed alternately at said oppositely opening angles, and

(e) adjacent spines in adjacent ones of said fins projecting from the respective base portions thereof in the same general direction around said tubular member.

2. A heat transfer element as defined in claim 1, and in which each of said spines in each of said fins has a substantially flat free end face disposed transversely to the length of said tubular member.

3. A heat transfer element as defined in claim 1, and in which each of said spines in each of said fins has a laterally twisted intermediate portion connecting said free end face of said spine to said base portion of said fin.

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