Sept. 21, 1943. H. E. SCHANK ET AL 2,329,789

APPARATUS FOR MAKING HEAT-EXCHANGE ELEMENTS

Original Filed Nov. 16, 1939 3 Sheets-Sheet 1

Fig. 1

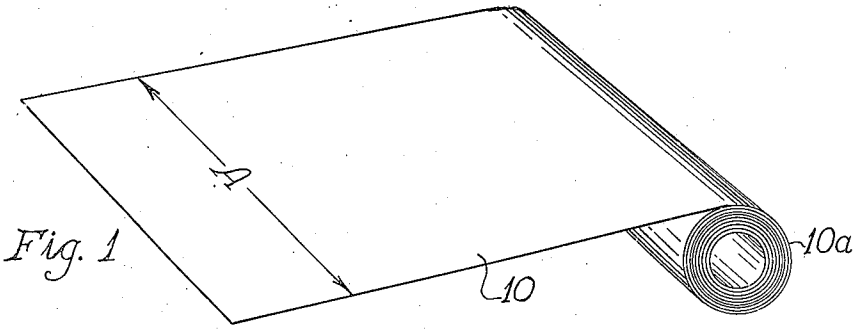


Fig. 2

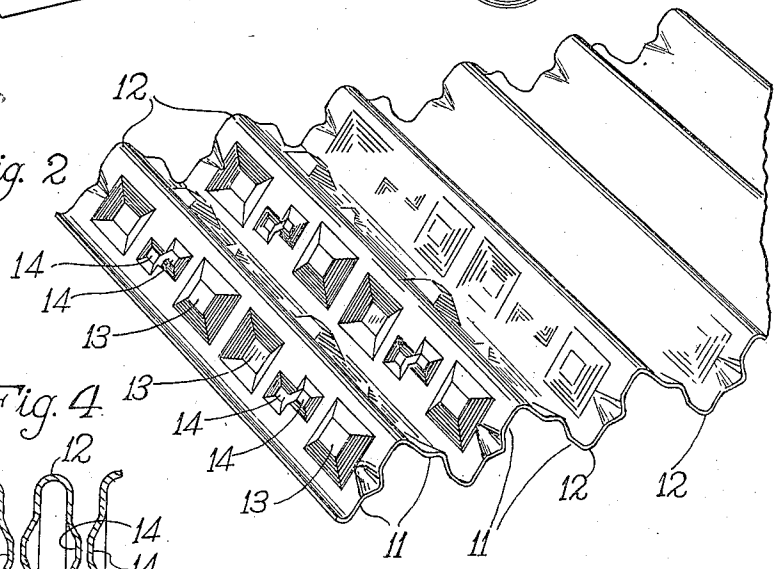


Fig. 3

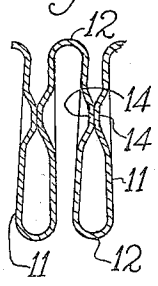


Fig. 4

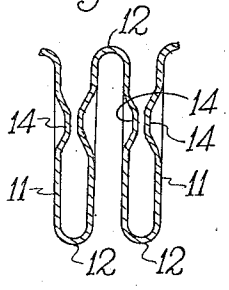
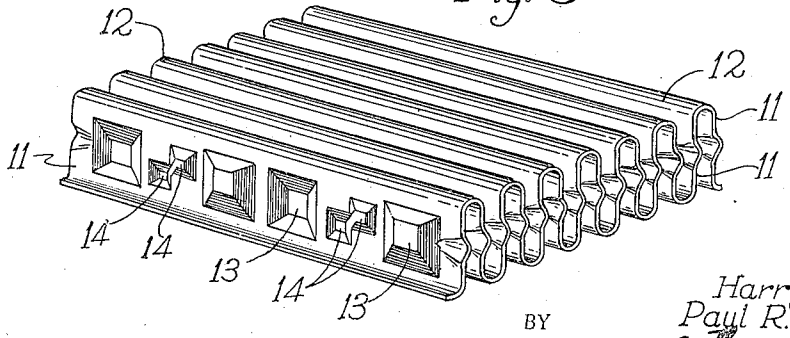


Fig. 5



INVENTORS
Harry E. Schank
Paul R. Seemiller
BY Anthony B. Saunders
Attorney.

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APPARATUS FOR MAKING HEAT-EXCHANGE ELEMENTS

Original Filed Nov. 16, 1939 3 Sheets-Sheet 2

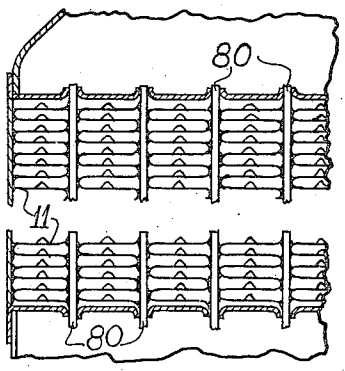


Fig. 6

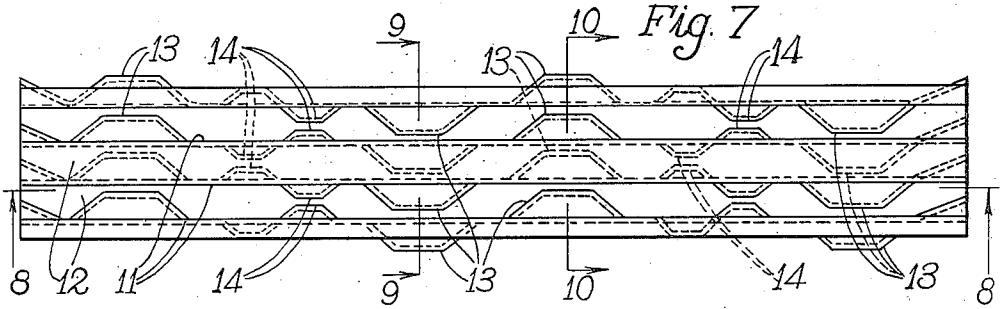


Fig. 7

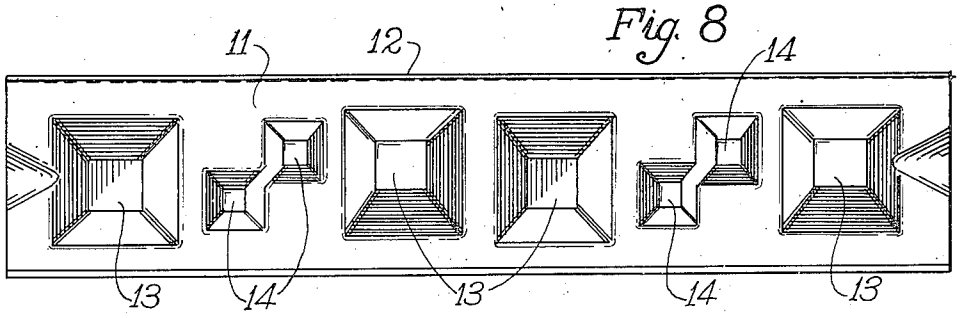


Fig. 8

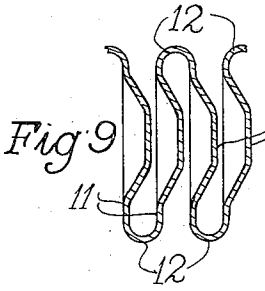


Fig. 9

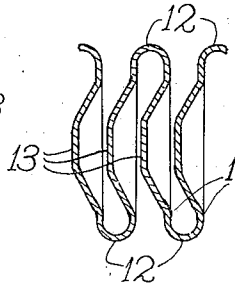


Fig. 10

BY

INVENTORS
Harry E. Schank
Paul R. Seemiller
Anthony F. Saunders
Attorney.

Sept. 21, 1943. H. E. SCHANK ET AL 2,329,789

APPARATUS FOR MAKING HEAT-EXCHANGE ELEMENTS

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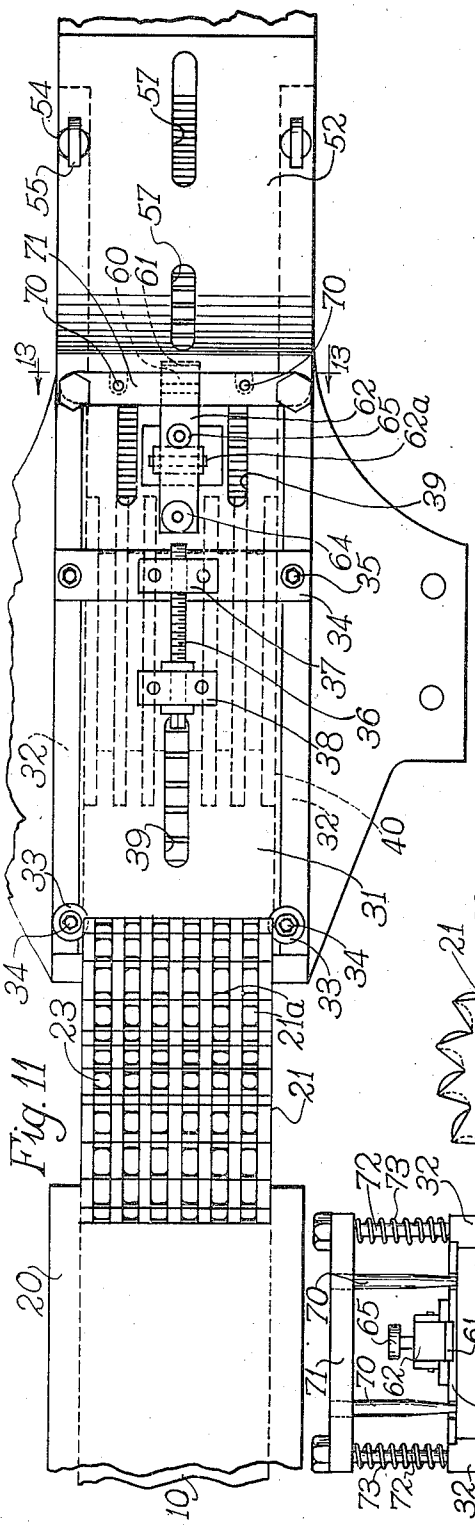


Fig. 11

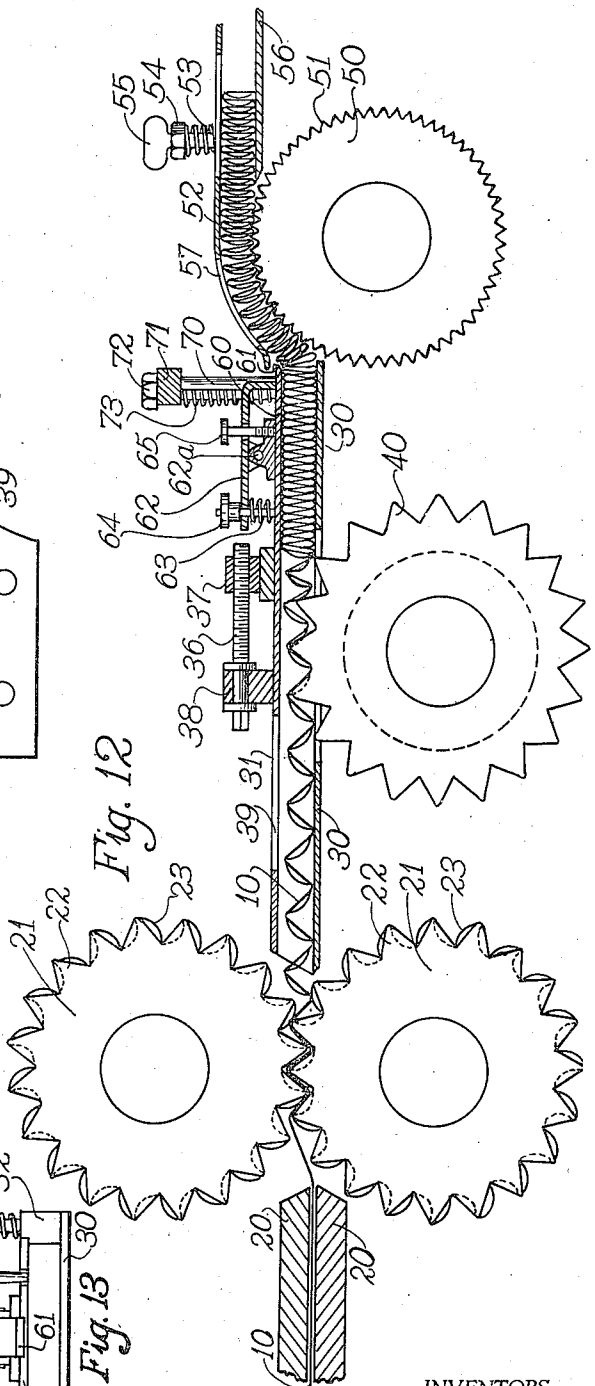


Fig. 12

Fig. 13

INVENTORS
Harry E. Schank
Paul R. Seemiller
BY
Anthony N. Saunders
Attorney.

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2,329,789

APPARATUS FOR MAKING HEAT-EXCHANGE ELEMENTS

Harry E. Schank and Paul R. Seemiller, Detroit, Mich., assignors to McCord Radiator & Mfg. Co., Detroit, Mich., a corporation of Maine

Original application November 16, 1939, Serial No. 304,656. Divided and this application July 11, 1941, Serial No. 401,896

4 Claims. (Cl. 153—68)

This invention relates to an apparatus for making a heat-exchange element. The heat-exchange element has been developed for use in radiator cores but it may be used in cooling apparatus as well. For convenience, it will be referred to as a "fin element" because it performs heat dissipating functions such as performed by fins.

The object of the invention is to provide an improved apparatus for making a heat exchange element.

Other objects and advantages of the invention will appear from the following specification and drawings.

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

Figure 1 is a perspective of a roll of sheet metal such as used to make the fin element.

Fig. 2 is a perspective view of the metal sheet after it has been subjected to the first forming operation.

Fig. 3 is a partial cross-section of a portion of the heat-exchange fin section showing how its folds can be pressed together in the process of making it.

Fig. 4 is a section similar to Fig. 3 showing the folds in the completed condition of the fin section.

Fig. 5 is a perspective view of the completed heat-exchange fin element.

Fig. 6 is a partial view of a radiator core showing how the fin element is employed.

Fig. 7 is a top plan view of two sets of folds of the fin element illustrating more clearly how the projections are formed therein.

Fig. 8 is a side elevation of one of the folds of the fin section, the view being taken along the line 8—8 of Fig. 7.

Fig. 9 is a section along the line 9—9 of Fig. 7.

Fig. 10 is a section along the line 10—10 of Fig. 7.

Fig. 11 is a top plan view of an apparatus that may be used to practice the process.

Fig. 12 is a side elevation and section of the apparatus shown in Fig. 11.

Fig. 13 is a detail cross section on the line 13—13 of Fig. 11.

The present application is a division of Serial No. 304,656, filed November 16, 1939, now issued as United States Letters Patent No. 2,252,209, dated August 12, 1941.

Heat-exchange fins are used by placing them in contact with the walls of a passage through which a heated medium is being passed in order that heat may be conducted from the walls to the fins and thus provide more surface over which air may be passed to dissipate the heat. This general type of construction has come into very extensive use in automotive, refrigerating, heating, ventilating, and allied industries with the result that heat-exchange fins must be rapidly produced in enormous quantities. The problem involved is to produce a fin element that can be conveniently and easily assembled in the article with which it is to be used; one that is efficient in its heat-exchange action; one that is made of a minimum amount of metal; and one that can be made by an inexpensive process on a quantity production basis.

Heat-exchange fin elements have heretofore been made out of relatively stiff, hard metal of appreciable thickness. The metal employed is what is known as "silver-bearing copper," the supply of which is limited and the cost higher than that of ordinary copper. The silver in the copper gives it the required stiffness. The metal has had to be relatively thick in order that it might be stamped or drawn into shape which is the process that generally has been employed to make elements of this kind. And the metal has had to be hard and stiff in order that the finished article will hold its shape. The result has been that the fin elements have been made out of heavier metal than is really necessary for heat-exchange purposes but the use of this heavy, hard and stiff metal has been forced by the process and apparatus used in making the heat-exchange elements and the nature of the elements themselves.

The present invention involves a fin element that is made out of very thin, soft metal but which, nevertheless, is made in such a way that the finished element has ample strength for assembly in the article for which it is used and at the same time has the required heat-exchange characteristics. It is not necessary to use a silver-bearing copper. Instead, ordinary and less expensive copper may be employed. And, as will presently appear, the element may be made by an improved apparatus that is both rapid and simple. The result is that a fin element is produced in which the amount of material used is substantially less than that heretofore employed, thereby reducing costs, and the element may be produced by an apparatus that enables it to be very rapidly and inexpensively made in large quantities. The invention will be explained by first describing the process of and an apparatus for making the element, after which the element itself and its advantages will be described.

The element is made out of a thin strip of sheet metal 10, shown in Fig. 1, which is preferably in the form of a continuous strip or roll 10a as illustrated. Preferably this strip has a width in the direction A (Fig. 1) equal to the thickness of the core with which the heat exchange element is to be assembled. For example, if the element is to be used in a radiator core on an automobile, the width of the metal strip 10 is equal to the thickness of the core.

The metal usually employed is ordinary soft copper although brass and similar metals may also be used. Instead, however, of using relatively hard and stiff copper, a soft pliable copper having a thickness of about three thousandths (.003) of an inch is used as compared with the former practice of using hard, stiff copper of at least four thousandths (.004) of an inch thick which thickness has heretofore been considered the minimum possible to employ in commercial practice. While the difference in actual fractions of an inch is not great, this difference is a very decided one in its effect on the amount of metal consumed when quantity production of these elements is considered.

The first operation is to form the strip into the shape shown in Fig. 2. This forming operation is a continuous one and it is a rolling operation as distinguished from stamping, the strip of copper being fed continuously between rollers, as later will be explained.

In this first step, the strip is reversely folded or rolled to a shape in which the folds 11 are substantially at right anles to one another and not in the final condition desired. This angle should be as close to 90° as possible but can be as low as 80°. It is to be observed that the bends 12 are not along sharp lines but are gradual, rounded bends which enable the metal to be rolled to shape without requiring that it be drawn, and avoiding splitting and cracking as might occur with the extremely thin metal employed. The bends also have a substantial width to provide ample areas of contact with the tubes to which the fin elements are attached.

At the time the strip is roll-folded to the shape of Fig. 2, a plurality of indentations or bumps 13 of substantial depth are also formed in it. These are about three-thirty-seconds of an inch ($\frac{3}{32}$) deep and in the shape of truncated pyramids and they alternate across the width of the strip both as to the direction in which they are formed and as to their height relative to the edges of the folds. For example, referring to Fig. 5, the first bump or indentation 13 on the right-hand end of the first fold is toward the upper edge of the fold and it extends toward the person viewing the figure, while the next bump to the left is positioned toward the bottom of the fold and extends away from the person viewing the figure. The bumps or indentations thus alternate in direction and location across the width of the fold. The purpose of these bumps or indentation will be explained at the time the completed heat-exchange element is described.

Also, at the time the metal strip is roll-folded to the shape of Fig. 2, a plurality of spacing bumps 14 may be formed for use in a subsequent step in one form of the process of making the element. These bumps or indentations also alternate as to their direction with respect to the faces of the folds, as will be clear from Figs. 2 and 5. The bumps are located so that those on one fold are in position to contact those on the fold immediately adjacent, as indicated in Figs. 3 and 4. From these figures it might be inferred that the spacing bumps would act as to every other bend only but the fact is that, if another sectional view were taken through the next set of spacing bumps, the bumps that space the middle bends of Figs. 4 and 5 would appear. In other words, there are spacing bumps between each fold to control each bend of the element. While these spacing bumps may be formed as illustrated and just described, it is also possible to form them so that, instead of having one spacing bump on one fold contact a spacing bump on another fold, the spacing bump on one fold is made deep enough so that it may contact the surface of the adjacent fold without said surface being provided with a bump for contacting the first bump.

The next step in the process consists in compressing the reversely folded strip of Fig. 2 to move the folds toward one another with the ultimate object of having the folds substantially parallel to one another as shown in the completed element illustrated in Fig. 5. The degree and nature of the compression determines the spacing of the folds and it is in this connection that the spacing bumps 14 can be employed. During the second forming operation, the folds are compressed together until the spacing bumps 14 contact one another as shown in Fig. 3, the final form of the element being determined by the height of the bumps. It has been found, for example, that, with the folds made out of .003" soft copper, when the folds are compressed until the bumps 14 contact one another, as shown in Fig. 3, if the folds are then released they will spring apart to a position such as shown in Figs. 4 and 5. By varying the height of the spacing bumps 14, the degree to which the folds are compressed together can be regulated and the width or space between the folds after they have sprung apart can be governed. The frequency of the folds is usually about ten per lineal inch, but this may be varied, preferably being kept, however, between nine and twelve per inch for the best results.

The above process provides an easy and convenient means of determining the final spacing of the folds, but this spacing can be otherwise determined by regulating the degree to which the folds are pressed together as presently will be explained, the spacing bumps being especially useful in forming narrow fin sections. The spacing bumps are also useful in maintaining the folds spaced from one another during the assembly of the fin elements in a core, particularly in the cellular type of radiator core.

Having referred to the process which is carried out by the apparatus of the present invention, one form of this apparatus will now be described with particular reference to Figs. 11 to 13, inclusive.

Referring to Fig. 12, the metal strip 10, out of which the heat-exchange element is formed, is passed between guides 20 to two intermeshing, toothed, forming rolls 21. These rolls are made up of a series of disks 21a (Fig. 11) and they have teeth 22 formed in them with suitable humps 23 so that, as the strip 10 passes between the rolls, it is rolled or formed to the reverse-folded shape illustrated in Fig. 2. Not all the bumps are shown in Fig. 11 because of the confusion of lines that would result. The edges of the teeth are rounded and the teeth join one another by curved surfaces to make the bends in the metal rounded or curved and of substantial width. It is to be noted that

this operation is primarily a rolling operation as distinguished from drawing or stamping though a slight drawing occurs during the rolling. This permits the element to be formed out of soft copper of a thickness of three-thousandths of an inch (.003") and the bumps to be formed of substantial depth ($\frac{3}{32}$") without tearing holes in the metal or cracking it and, at the same time, the folds can be made of almost any depth, for example up to two inches (2"), though the depth rarely exceeds three-fourths of an inch ($\frac{3}{4}$") for ordinary purposes. A depth of seven-sixteenths of an inch ($\frac{7}{16}$") is average for automobile radiator cores. These depths have not heretofore been considered possible in a rolling operation with metal as soft and thin as that employed in the present invention.

As the partially formed strip 10 issues from the rolls 21 and 22, it passes into a guide having a bottom plate 30 (Fig. 12) and a top plate 31 supported by side rails 32 (Fig. 11). The top plate 31 is slidably mounted in grooves in the side rails 32 and releasably held in position near its front end by washers 33 that may be clamped against the top plate by bolts 34 screw-threaded into the side rails. The top plate is held in position toward the rear by a crossbar 34 bolted to the side rails by the bolts 35. The top plate may be adjusted longitudinally by means of an adjusting screw 36 one end of which is screw-threaded into a block 37 fixed to the crossbar 34. The other end of said screw is journaled in a block 38 fixed to the top plate 31, suitable collars being provided to prevent longitudinal movement of the bolt in the block 38. The top plate 31 is provided with sight openings 39 at front and rear to enable the operator to observe the partially formed strip as it issued from the forming and gathering rolls.

A gathering roll 40 is journaled in position under the guide 30—31 as shown in Fig. 12, the axis of said roll being substantially in the same plane as the axis of the lower forming roll 21. The gathering roll 40 is of the same size and general construction as the forming rolls 20 and 21 except that the alternate disks (Fig. 12) which, in the forming rolls, have humps 23 on them, are made of small diameter so as not to engage the fin element. They act as spacing disks leaving the other disks to advance the fin element. This reduces the cost of the gathering roll and, at the same time, provides a construction that will advance the fin element without deforming the humps already formed in it. The gathering roll is driven at the same speed as the forming rolls and positioned so that its teeth project through an opening in the bottom guide plate 30 (Fig. 12) where they enter the spaces between the folds of the partially formed strip 10 as it passes through the guide. The gathering roll picks up the partially formed strip and positively feeds it rearward through the guide 30—31.

Positioned to the rear of the gathering roll 40 is a spacing roll 50 whose periphery extends above the path of the fin as shown in Fig. 12. In the embodiment disclosed, this is obtained by having the axis of the roll 50 in a higher plane than that of the gathering roll 40. This spacing roll is driven in synchronism with the gathering roll but at considerably slower speed. It is a toothed roll but the number of teeth 51 is considerably greater than the number in the gathering roll and the teeth are smaller, as shown in Fig. 12. The gears for driving the several rolls have not been illustrated as these merely comprise the necessary spur gears to drive the forming rolls and the gathering roll at the same speed, with the spacing roll driven in synchronism, but at a slower speed, and with provisions for varying the speed of the spacing roll 50 relative to the other rolls. In fact, the diameter of the spacing roll 50, its speed, and the number of teeth in its circumference are factors that can be varied to suit the spacing requirements of the fin element being formed.

Positioned above the spacing roll 50 is a curved guide 52 that conforms generally to the curve of the spacing roll. This guide is supported by the side rails 32 which are elevated for the purpose at the rear of the machine. The guide 52 is resiliently held in position by springs 53 bearing against the guide and against nuts 54 on bolts 55 that are threaded into the side rails. A plate 56 extends to the rear of the machine to receive the finished fin element strip. The curved guide 52 has sight openings 57 (Fig. 11) to permit the operator to observe the fin element on the spacing roll in a finished condition.

Keeping in mind that the spacing roll 50 moves at a slower speed than the gathering roll 40 it will be clear that, as the reverse-folded strip moves rearward, the spacing roll will retard it while the gathering roll will keep feeding it rearward at a greater speed. The fin element is gathered at the same speed at which it is delivered by the spacing roll, the difference in speed of the two rolls causing the gathering. The result is that the folds of the fin strip are continuously moved or compressed toward one another and the degree of this compression depends, of course, upon the relative speed of the gathering and spacing rolls. When the spacing bumps 14 are formed on the fin strip, the folds are pressed together until the spacing bumps contact. When no spacing bumps are used, the folds are compressed together until they contact each other as shown in Fig. 12. In all cases, the metal has sufficient resiliency which, combined with the fact that the bends between folds are rounded and not sharp, enables the folds to spring apart sufficiently to their proper parallel position.

When the strip, after being gathered as above explained, is released, the folds will spring apart with a reasonable degree of accuracy that is sufficient in some cases, but provision is made for insuring that the folds will be accurately spaced to the desired number of folds per inch.

Referring to Fig. 12, the top 31 of the guide through which the fin strip passes is provided with a finger 60, preferably made of spring steel, which projects beyond the rear end of the guide top 31. This finger is of substantial width and its free end 61 is curved as shown in Fig. 12, said curved end extending downward slightly beyond the top plate 31 of the guide. The spring finger is held in position on the top plate 31 by a lever 62 pivoted at 63 to a bearing block on the plate 31. The left-hand end of said lever (Fig. 12) is urged upward by a spring 63 and the other end of the lever is turned down so as to engage the spring finger 60. The effective tension of the spring 63 may be regulated by a thumb screw 64 which is threaded into a block on plate 31 and provided with a collar bearing against lever 62. The spring finger 60 is held in position on the plate 31 by a thumb nut 65.

For use in starting operations, two fingers 70 (Fig. 13) and provided which are carried by a head 71 slidably mounted on bolts 72 threaded

into the side rails 32 and urged upward by springs 73. In normal position, the pins 70 are in the position of Fig. 13 where they are out of the path of the fin element. When the apparatus is started, the operator presses down on the head 71 to move the pins 70 into the path of the fin element where he holds them until the folds have been compressed to the desired degree, which the operator observes through the sight openings 39 at the rear of the plate 31. He soon learns about what this compression should be, after which he releases the pins 70 and the process of forming the fin element then goes forward as a continuous one. The starting operation above described, while a convenient and useful one is connection with the apparatus, is to be considered more of a starting operation than a part of the continuous process.

Assuming that operations have been started, as the fin element issues at the rear of the guide, the spring finger 60 engages one of the upper folds and retards the element, this retarding action being a measurable one because the curved end of the spring 60 narrows the exit from the guide and tends to hold the fold against the bottom plate 30 of the guide. The spacing roll 50 picks up the lower bend of one of the folds and moves it to the position shown in Fig. 12, the lower bend seating in one of the spaces between the teeth of the spacing roll. The illustration of the fin element at the right-hand end of Fig. 12 is necessarily diagrammatic because of the small space available for lines of the drawings. As this occurs, the resistance to the rearward movement of the fin element is governed by the spacing roll and the spring finger 60, said spacing roll moving considerably slower than the gathering roll 40. But, as the spacing roll continues to rotate and as increased pressure is exerted by the gathering roll, the fold of the fin element moves past the spring finger into the guide 57. It will be noted that resistance to the rearward movement of the fin element is exerted both at the top and at the bottom of the element, the resistance at the top being by the spring finger 60 and that at the bottom by the spacing roll 50. The amount of this resistance can be regulated to a considerable degree by varying the position of and the tension on the spring finger 60. Where greater variations are desired, the speed and number of teeth in the spacing roll 50 can be changed.

Where spacing bumps, such as the bumps 14 are provided, the folds can never be compressed beyond a certain amount determined by said spacing bumps although the degree of compression may be less than necessary to tightly compress the bumps together.

When no spacing bumps are employed, the spacing of the folds is determined entirely by the degree of their compression, regulated as above explained. Where the compression is relatively high, the radius of the bends between the folds is slightly less than where the compression is smaller. This variation is very small in actual dimensions, owing to the fact that there are usually at least ten folds per inch, making five top bends and five bottom bends over which the changes in radius are distributed. The spacing, as between nine and twelve folds per inch, can be regulated by using different spacing rolls 50 for the different spacing. Also, the spacing can be varied to the extent of at least one-half a fold by means of the spring finger without changing the spacing roll 50.

The spacing is further regulated by the action of the spacing roll 50 and the curved guide 52 in first bending the fin element upward as it issues from the guide 30—31 and then bending it downward so that it issues horizontally on the discharge guide 56. As the fin element, with its top bends yieldingly held against rearward movement by the finger 61, issues from the guide 30—31, it is bent upward by the spacing roll 50. This bending tends to separate the bottom bends from one another and to open up the top bends to an extent determined by the adjustment of the finger 61. The bottom bends are held separated by the spacing of the teeth on the spacing roll 50. As the fin element is bent downward again to a substantially horizontal position by the curved guide 52 and the spacing roll, the top bends are separated from one another and the bottom bends are opened. This occurs because the bottom bends are held in spaced relation by the teeth of the spacing roll, and the yielding of the fin element to the reverse bending opens up the bottom bends. This opening of the top and bottom bends can be regulated by the adjustment of the spring finger 61 and by the spacing of the teeth on the spacing roll. It depends also upon the location and diameter of the spacing roll which, of course, determines the curvature of the bending in both directions.

Thus, while the resiliency of the metal tends to separate the folds after they have been pressed together, the above makes it possible to regulate this separation so as to get a fin element with its folds accurately spaced to the desired degree and with the folds substantially parallel to one another.

The completed fin strip issues onto the guide 56 and passes through a cutter (not shown) which may be employed to cut the strip into desired lengths.

A completed heat-exchtnge element produced by the foregoing apparatus is shown in Figs. 5 to 10, inclusive. It comprises a pleated element in which the folds are substantially parallel to one another, in which the edges of the folds are rounded and have a substantial width for contact with the walls of the passages from which the element is to conduct heat, and in which the folds have a frequency of at least nine per inch and a depth of about seven-sixteenths of an inch. The bumps in the folds of the section are of substantial depth and the folds are imperforate. The bumps in one fold register with the indentations in the adjacent fold and the location of these bumps or indentations is such that an undulating passage for the air is provided that undulates not only in a vertical but also in a horizontal plane, or, to put it another way, a passage wich undulates in two planes which are at right angles to one another.

The manner in which the heat-exchange element may be used is shown by way of example in Fig. 6 where the element is positioned between the tubes 80 of a tubular type of automobile radiator core. The substantial width of the edges of the folds enables ample contact to be made between the fin elements and the sides of the tube, and the soft copper facilitates the making of intimate contact at the time the core is assembled. This creates an improved degree of air turbulence as distinguished from an undulating passage in one plane only, and gives a greater area for air contact with the fin than where openings are punched.

It is to be understood that the invention has been shown and described by way of illustration only and that changes may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

We claim:

1. Apparatus for forming reverse bends in a metal strip comprising driven forming rollers having intermeshing teeth with the faces of each tooth making relatively wide angles with each other, said toothed rollers engaging opposite sides of said strip to fold said strip transversely as it moves between them, means for guiding said strip between said rollers, other guiding means for limiting motion of the folded strip perpendicularly to its path of travel after it leaves said rollers, said last-named guiding means having an opening in one side thereof, a toothed feeding roller projecting through said opening and engaging said folds for feeding said folded strip endwise through said guiding means, means associated with said guiding means for retarding the motion of said folded strip and thereby compressing said folds, a third rotatable toothed roller engaging the folds at one side of said folded strip beyond said guiding means for controlling the separation of the bends of said folds at one side of said folded strip, and stationary means engaging said folds at the other side of the folded strip opposite said last-named toothed roller for controlling the separation of the folds at the other side of said folded strip.

2. In a machine for progressively forming a long folded strip of metal into loosely spaced substantially parallel folds, means for moving the folded strip endwise of the strip, means for compressing the folds into close-spaced relation, a spacing roller having teeth engaging the folds at one side of the moving folded strip, and a stationary guide frictionally engaging the folds at the other side of the moving folded strip to guide the strip about said roller and then away from said roller.

3. In a machine for progressively forming a long folded strip of metal into loosely spaced substantially parallel folds, of means for moving endwise and compressing into close spaced relation the folds of a metal strip which is transversely folded in zigzag fashion, a rotatable member having a portion of its periphery located in alignment with the path of movement of said folded strip during said compression and having teeth engaging the folds at one side of the strip whereby the folds at one side of the strip are partially opened up as the strip changes its direction of movement to pass partially around said rotatable member, and a guide engaging the folds at the other side of said strip as said strip engages said rotatable member and engaging said strip beyond said rotatable member for controlling the partial separation of the folds at the other side of said strip as it passes partially around said rotatable member.

4. In a machine for progressively bending a long strip of metal into loosely spaced substantially parallel folds, means for progressively folding the strip transversely in zigzag fashion, means for moving the folded strip endwise and compressing the folds into close-spaced relation during said motion, and means comprising a pair of members engaging opposite sides of the folded strip to cause it to move along a curved path and arranged to supplement each other in bending the folds of the strip and partially opening up said folds first at one side of the folded strip and then at the other side of the folded strip as said folded strip continues its endwise movement.

HARRY E. SCHANK.
PAUL R. SEEMILLER.