

Feb. 22, 1949.

S. H. SMITH

2,462,136

HEAT EXCHANGER AND METHOD OF MAKING SAME

Filed May 24, 1945

2 Sheets-Sheet 1

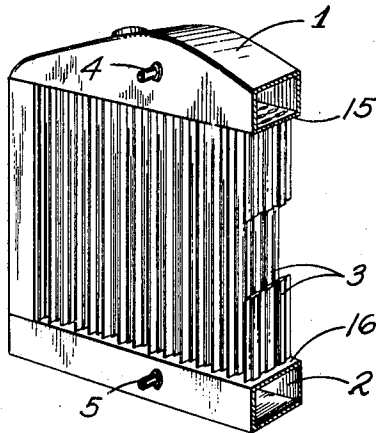


Fig. 1

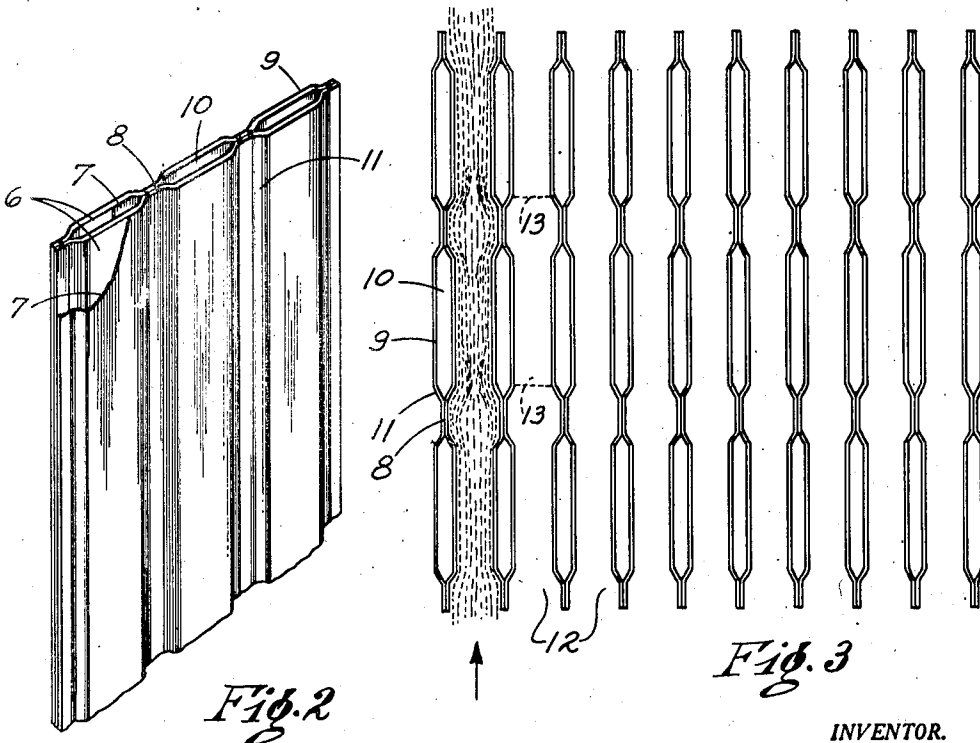


Fig. 2

Fig. 3

INVENTOR.
SAMUEL H. SMITH

BY

Richey Watts
ATTORNEYS

Feb. 22, 1949.

S. H. SMITH

2,462,136

HEAT EXCHANGER AND METHOD OF MAKING SAME

Filed May 24, 1945

2 Sheets-Sheet 2

Fig. 4

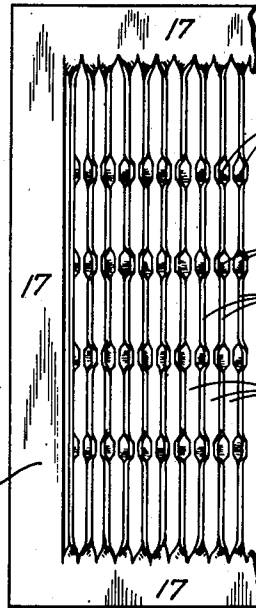
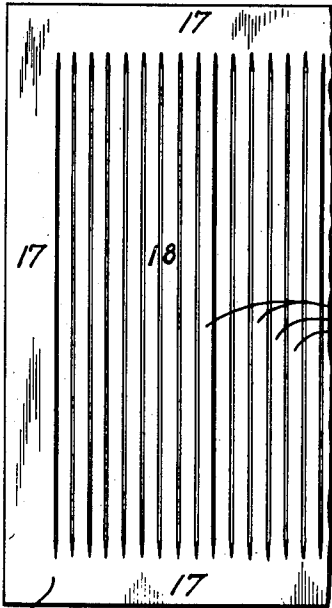


Fig. 5

Fig. 6

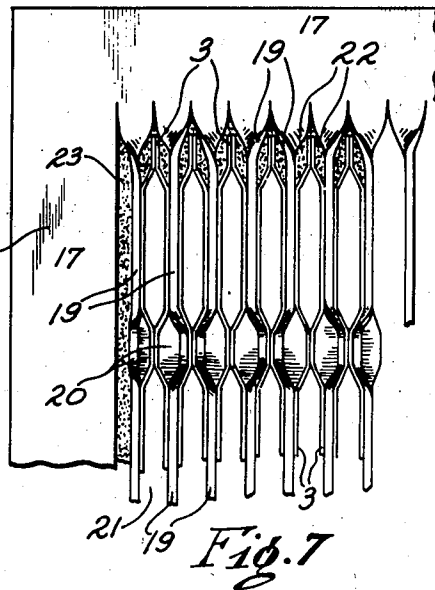
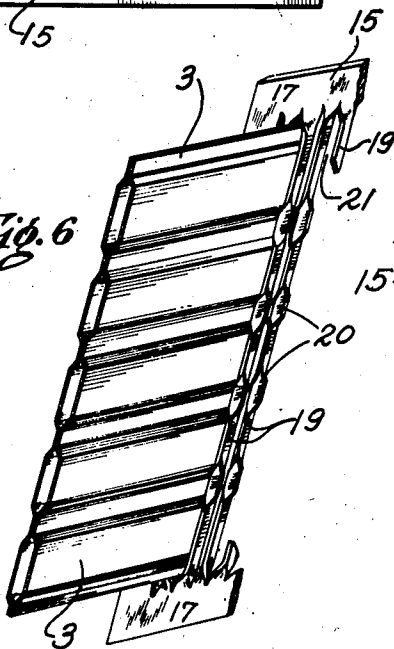


Fig. 7

INVENTOR.
SAMUEL H. SMITH

BY

Riehey & Watts
ATTORNEYS

UNITED STATES PATENT OFFICE

2,462,136

HEAT EXCHANGER AND METHOD
OF MAKING SAME

Samuel H. Smith, Bucyrus, Ohio

Application May 24, 1945, Serial No. 595,502

10 Claims. (Cl. 257—130)

1

This invention relates generally to heat exchangers and more particularly to radiators for use with internal combustion engines.

Heat exchangers, especially those of the type of radiators for internal combustion engines, as made heretofore, have included hollow members which connected spaced cooling liquid tanks and which were provided with external heat radiating fins. Such hollow members were usually constructed of copper, partly because it was resistant alike to corrosive influences of the cooling liquid and of the cooling gas, and partly because of the satisfactory rate at which the copper absorbed heat from the liquid and then gave it up to the air or gas which moved past the copper tubes and fins.

Altho it has been proposed frequently to construct of metals other than copper heat exchangers which are to be exposed to the elements and to corrosive liquids, no satisfactory heat exchanger has ever been so produced from ferrous metals such as iron or steel, so far as I am aware. Nor am I aware of any radiator for an internal combustion engine which was free from heat radiating fins on the hollow members or fillers in the air spaces between such members.

Theoretically, a ferrous metal heat exchanger would be unsatisfactory because of its short life due to corrosion both inside and outside; and its efficiency, i. e., the rate of cooling of the liquid therein, would be too slow because the rates of heat absorption, emission and conduction of steel are less than the corresponding rates of copper. Thus, a proposal to substitute a ferrous metal radiator for a copper radiator would be contrary to theory in these several respects; and the requisite amount of cooling effect could not be obtained except possibly by enlarging the radiator correspondingly and such an enlargement could not be tolerated in many instances because the radiator is already large enough to occupy all the space available for it.

By the present invention I have provided a ferrous metal heat exchanger which, contrary to current theory, not only possesses substantially all the advantages of a copper heat exchanger but which is devoid of external heat radiating fins. The manner in which I have achieved these new and unexpected results may be briefly described as (1) making the hollow members of a heat exchanger of thin, low carbon steel with the inner and outer surfaces thereof coated with corrosion resisting metal such as copper, zinc or the like, (2) making in each hollow member a plu-

2

and separated from each other by depressions that serve to agitate air passing between the members, and (3) positioning such tubular members side by side in such spaced relation that air or gas passing between them will be agitated and quite uniformly heated by contact with the walls of the liquid passages with resultant efficient cooling of the liquid. The hollow members may be straight or curved from front to rear.

I believe that the surprising and contrary-to-theory results obtained with my heat exchangers are traceable to the facts that the steel is coated with metals which not only protect against corrosion but absorb and emit heat rapidly and that the steel is so thin that heat is transmitted thru it in a very short space of time, and that due to the shape and the spacing of the hollow members the removal of heat from the hollow members is much more rapid than in prior constructions.

In the drawings accompanying and forming a part of this specification,

Figure 1 is a fragmentary, perspective view of an automobile radiator embodying the present invention;

Figure 2 is an enlarged fragmentary, perspective view of one of the hollow members of the radiator of Fig. 1;

Figure 3 is a fragmentary, transverse, horizontal, sectional view taken thru the hollow members of Fig. 1 and illustrating the flow of cooling gas between said members;

Figure 4 is a fragmentary plan view of a header for one end of the tubes of Fig. 1 and showing a preliminary step in the manufacture of the radiator of that figure;

Figure 5 is a view similar to Fig. 1 but showing a subsequent step of the present method;

Figure 6 is a perspective, fragmentary view showing the assembly of a tube in the header of Fig. 3; and

Figure 7 is an enlarged, fragmentary, plan view of the radiator of Fig. 1 showing tubes disposed in one of the headers and the manner of joining the tubes to the header.

The radiator shown in Fig. 1 comprises upper and lower cooling liquid compartments 1 and 2 and a plurality of hollow members 3 which connect the interiors of said compartments. Liquid inlet and outlet openings 4 and 5 are connected respectively to compartments 1 and 2. The compartments 1 and 2 and tubular members 3 are composed of ferrous metal, such as iron or low carbon steel and are suitably protected against corrosive influences by coatings of non-ferrous metal such as copper, zinc or the like. When

copper or zinc is the coating metal it may be applied electrolytically. One metal, such as copper, may coat the inner surfaces and another metal, such as zinc, may coat the outer surfaces. While zinc might be applied by dipping, I prefer to apply it by electrodeposition for by that method a very thin film may be produced. Both copper and zinc protect the iron against corrosion. Other metals and coatings commonly used to protect iron may be substituted for the copper or zinc.

Each hollow member 3 is composed of two pieces 6 of thin metal, preferably iron or low carbon steel, each having coatings of corrosion resisting metal 7, such as copper, zinc or the like on its surfaces. Each piece 6 is made from a plane sheet or strip of steel by deforming it to provide spaced projecting portions. When two such pieces are assembled the latter portions abut each other. Each member 3 has a plurality of parallel, lengthwise extending, opposed portions 8 which are connected to each other by any suitable means such as welding, brazing or the like, and portions 9 which are disposed between adjacent portions 8 and which are spaced apart to form liquid passages 10. These passages are wide enough in cross-section so that substantially all the liquid flowing thru them will be in contact with the side walls thereof for most of their length, and are sufficiently long in cross-section so that the desired amount of liquid may flow thru the passages in a given length of time.

Preferably the operation of joining together the projecting, abutting portions is carried out under such conditions that the coating metal will not be vaporized so as to leave the steel exposed to the cooling liquid. One suitable method is that of welding by applying narrow roller electrodes on opposite sides of portions 8 and passing a current of high rapid heating capacity therethru for a very short time. This method welds the abutting portions together without vaporizing much, if any, of the coating metal and without melting enough of the metal to expose the steel where the cooling liquid can contact it.

The outer surfaces of each hollow member 3 are smooth and plain both in the portions 8 and 9 and there are no fins or the like projecting from any of these surfaces. The surfaces 11 connecting portions 8 and 9 are disposed angularly thereto for the purpose of agitating the streams of cooling air or gas as will presently be explained.

When a plurality of members 3 are assembled as shown in Figs. 1 and 3, the spaces 12 between adjacent pairs of those members is free from fins, fillers or other parts and air or gas may flow freely therebetween. As is indicated in Fig. 3, each passage 12 is alternately wide and narrow and may be regarded as being made up of a plurality of aligned, connected, Venturi-like parts. This alternate widening and narrowing, or this repeated Venturi-like shape of the passage, serves to agitate the stream of air as it moves thru the passage. The air entering one of those passages is alternately squeezed into narrower compass between the opposed portions 9 and then is allowed to expand between opposed portions 8. When the air stream moves from between portions 8 to between portions 9 of the outer layers of the air are deflected inwardly by the inclined walls 11. By properly positioning two members 3 the air stream passing therebetween may be thoroughly agitated repeatedly and sufficiently so that the temperature of the air stream will be substan-

tially uniform on any line across the air stream near the front end of each pair of opposed portions 9, for example, as shown on the dotted line 13 of Fig. 3.

It is important that the spacing between members 3 should be properly correlated with other factors, such as the volume of heat to be extracted from the liquid, the velocity of the cooling air thru the radiator, and the difference in thickness of portions 8 and 9. If members 3 are placed too close together, not enough air or other cooling gas can be moved therethru to accomplish the desired amount of cooling in a given time with a given pressure drop. On the other hand, if the members 3 are spaced too far apart the agitation of the air will not be sufficient to equalize the temperature across the air stream and inefficient cooling will result because the air in contact with the portions 9 will become more highly heated than the air in the midst of the stream.

I have found that the matter of dimensions, or at least relative dimensions, is quite important in obtaining the maximum benefits of the present invention. By way of illustration, but not limitation, I may say that I have obtained quite satisfactory results with a radiator for an internal combustion engine which was constructed in accordance with this invention and was of substantially the same overall dimensions as one composed of copper with cooling fins on the tubes thereof. In my radiator each hollow member 3 was composed of two sheets of low carbon steel about .01" thick, and coated on each surface with a film of copper which was a few thousandths of an inch thick. The portions 9 containing the liquid passages were each about $\frac{5}{64}$ " thick overall and about $2\frac{1}{2}$ " long, both in cross-section. These hollow members were constructed substantially as shown in Figs. 1 and 2 of this application and were arranged as shown in Fig. 3, with a space of about $\frac{3}{64}$ " between the outer surfaces of opposed portions 9, that is, there were about $7\frac{3}{4}$ of these members 3 to the inch. It will be understood that thinner steel may be used, that the overall thickness of the portions 9 may be decreased, the care should be taken to avoid passages which are too small to pass the necessary amount of liquid in a given time, and the hollow members may be spaced closer to each other and, under certain conditions, farther apart.

Where larger or smaller quantities of liquid are to be cooled the members 3 may be enlarged or decreased in fore to aft dimensions, as by providing the member with more or less liquid passages or possibly by increasing the widths of the liquid passages; or, alternatively, two or more banks of hollow members 3 may be employed with the hollow members of one bank aligned either with the members or the air passages of the other bank, as desired.

In the radiator of Fig. 1 the upper and lower fluid receptacles 1 and 2 have opposed walls 15 and 16, respectively, which hereinafter will be referred to as headers. These headers, as will be seen, define sides of the receptacles 1 and 2 and have openings to receive the tube members 3.

The headers 15 and 16 are alike and hence the description of one will serve for both. The header 15 consists of a thin, flat piece of metal of the width and length required by receptacle 1. The first step of converting such a piece of metal into the header of Fig. 1 is that of slitting the metal substantially as shown in Fig. 4 so as to leave an unslit marginal portion 17 and to provide a central portion 18 composed of a plurality of parallel

5

strips 19 connected at their ends to the marginal portion. Preferably, these strips are wider than the thickness of the piece of metal and in certain instances each strip may be twice the width of tube 3.

After the piece of metal has been slit, as is shown in Fig. 4, the strips 19 are turned bodily about their longitudinal axes at right angles to the plane of the marginal portion 17 and the plane of the ends of these strips. Fig. 5 shows the strips 19 after they have been so turned or twisted. The turning of these strips, as by suitable dies, twists the strips adjacent their ends. As indicated at 20 on Fig. 5, the dies upset or twist short parts of the strips at places corresponding to the narrow parts of tube members 3. The space 21 between two adjacent strips is sufficiently long and wide to receive a tube member 3 and to lie closely adjacent to the outer surfaces thereof.

It will be noted by reference to Figs. 5, 6 and 7, that every other strip 19 has been twisted so that its original top surface faces toward the same end of the metal piece; or, considering the matter from another standpoint, the twisted strips are arranged in pairs, the strips of each pair having their original upper surfaces opposed to each other. Since the strips are wider than the thickness of the strips, the twisted strips serve as narrow spacers between adjacent tubes 3 and the spaces between each pair of twisted strips is wide enough to accommodate the widest parts of the tubes. Furthermore, by twisting the strips in pairs the twisted end portions of the strips afford good anchorage for the metal 22 which is to fill the several spaces between the ends of the strips and the adjacent ends of the tubes 3.

By selecting metal of suitable thickness for use as the headers the spacing between the sides of adjacent tubes 3 may be controlled, that is, these spaces between tubes may be wide or narrow depending on the thickness of the header stock or the extent, less than 90°, thru which the strips are turned. For example, when the header stock is about $\frac{2}{64}$ " thick that will be the distance between the nearest parts of two adjacent tubes. Similarly, by varying the thickness of strips 19, tubes 3 of various widths may be accommodated. For example, when the strips are $\frac{1}{64}$ " wide and the tubes are $\frac{5}{64}$ " wide, one such tube will fit between two turned strips, and the tube and one strip will occupy a space $\frac{7}{64}$ " wide; and there may be about nine tubes per inch. In this manner it is possible to vary the number of tubes per inch, to vary the spaces between adjacent tubes, and to vary the width of tubes which may be accommodated by the header.

When headers 15 and 16 have been assembled with tubes 3 in the several spaces 21 of each header and with the ends of the tubes 3 projecting thru and preferably slightly beyond the headers, the tubes and headers may be connected to each other and the remaining spaces between the tubes and headers may be filled by low melting temperature metal. Figure 7 shows the header 15 assembled with tubes 3 in the spaces 21 between strips 19 and shows at 22 this space-filling and parts-connecting metal. It will be noted that in Fig. 7 the tubes 3 have a close fit with strips 19, while the narrow portions of tubes 3 are spaced apart from the strips. The metal 22 fills the parts of spaces 21 which are not occupied by the tubes 3 and surrounds the ends of tubes 3 on the sides of the headers which are the inner surfaces of the receptacles 1 and 2. It

6

will be noted that between the marginal portion 17 and each end strip 19 a narrow space 23 will exist after the tubes have been assembled in the header, but these spaces are also filled with the molten metal during assembly of the tubes and headers.

Various methods may be employed for bringing the metal 22 into the said spaces and completely sealing the header against leakage of liquid along the tubes, but a preferred method is described as follows: When the headers and tubes have been assembled as has been described above, with the tube ends projecting a short distance beyond each header, the ends of the tubes are closed against entry of liquid thereinto. Such closing or sealing may be done by crimping the ends of the tubes or by plugging them with a suitable material, preferably a material having a higher melting temperature than that of the metal 22. Then the assembly is coated with flux and dipped into the molten, low melting temperature metal 22 which, for example, may be tin solder, and when the assembly is withdrawn from the molten metal, the metal will adhere to the assembly and will fill the spaces between the header and the tubes and will coat the surface of the header and the adjacent ends of the tubes. This metal will quickly cool in place and will prevent any leakage of liquid between the header and tubes. After the spaces of both ends of the tubes have been similarly filled with the low melting temperature metal the projecting sealed ends of the tubes may be severed or ground off close to the header and the crimped or plugged parts thereby removed, leaving the tubes fully open. Then the headers may be brazed, soldered, or connected in any other suitable manner to the parts constituting the remainder of the receptacles 1 and 2.

While the present invention makes it possible to construct radiators readily, quickly and inexpensively from ferrous metal, it will be understood by those skilled in the art that heat exchangers may be made by the present method from other than ferrous metals.

The present invention makes it possible to construct simply, readily and cheaply, a radiator having tubes of the new and improved shape, composition and construction.

Radiators constructed in accordance with this invention have proven to be more efficient in comparative tests than conventional copper tube radiators.

Having thus described the invention so that others skilled in the art may be able to understand and practice the same, I state that what I desire to secure by Letters Patent is defined in what is claimed.

What is claimed is:

1. The method of making heat exchangers comprising the steps of making a plurality of elongated parallel slits in the central part of a piece of thin, flat metal, thereby forming a plurality of strips connected at their ends to the marginal portion of the piece of metal, turning said strips alternately in opposite directions through approximately right angles about their longitudinal center lines for approximately their full lengths and thereby bringing the side surfaces of each strip opposite to surfaces of adjacent strips which were originally parts of the same surface of the metal piece, assembling in each opening defined by a pair of such adjacent, turned strips an elongated hollow member which comprises a plurality of spaced parallel flat tubes and approximately fills said opening, and con-

7

necting said tubes and the adjacent strips and filling the spaces therebetween by bringing molten metal into said spaces.

2. The method of making heat exchangers comprising the steps of making a plurality of parallel slits in the central part of a piece of thin, flat metal, thereby forming a plurality of strips connected at their ends to the marginal portion of the piece of metal, alternately turning said strips about their longitudinal axes thru approximately a right angle for approximately their full length so that the strips of each pair of strips will have their original upper surfaces opposed to each other, assembling in each opening defined by said strips an elongated hollow member which comprises flat, spaced, parallel tubes and which approximately fills said opening, and connecting said tube and the adjacent strips and filling the spaces therebetween by bringing molten metal therinto.

3. The method of making heat exchangers comprising the steps of making a plurality of parallel slits in the central part of a piece of thin, flat metal, thereby forming a plurality of strips connected at their ends to the marginal portion of the piece of metal, turning said strips about their longitudinal axes thru approximately a right angle for approximately their full length, the opposed surface of each pair of strips having originally been part of the same surface of said metal piece, deforming said turned strips at spaced intervals corresponding to the spaces between the tubes in a hollow member, assembling in each opening defined by said strips a tube member which comprises flat, spaced, parallel tubes and which approximately fills said opening as defined by adjacent turned strips and deformations thereof and projects beyond the headers, closing the projecting ends of said tubes against entry therinto of molten metal, connecting said tube and the adjacent strips and filling the spaces therebetween by dipping said closed ends of the tubes and the header into molten low melting point metal and cooling the metal in said spaces, and opening the closed ends of said tubes.

4. A heat exchanger comprising tanks for liquid and hollow members, each of said members including a plurality of parallel, spaced tubes connecting said tanks, each tank including a tube sheet consisting of a thin piece of metal having a flat marginal portion and a central portion comprising a plurality of parallel, separate strips disposed at substantially right angles to the plane of, and integrally connected at their ends to, said marginal portion, said strips having short deformed portions at spaced intervals therealong; pairs of said strips forming elongated spaces therebetween to receive, and be substantially filled by, said hollow members with said deformed portions lying between the tubes of the hollow members, and metal filling the openings between, and connecting, said tubes and headers.

8

5. The combination set forth in claim 4 in which the said strips are wider than the thickness of the said piece of metal.

6. The combination set forth in claim 4 in which the said strips are wider than said hollow members and wider than the thickness of said piece of metal.

7. The combination set forth in claim 4 in which the strips are arranged in pairs with the surface originally on the same side of the piece of metal opposed to each other and to a hollow member therebetween.

8. A heat exchanger comprising two liquid tanks and a plurality of hollow members connecting said tanks, each of said hollow members having side walls defining therebetween a plurality of separate, flat, parallel tubes, spaced apart by depressions in said walls, each tank including a header consisting of a piece of metal not more than $\frac{3}{16}$ " thick and having a flat marginal portion and a central portion comprising a plurality of parallel strips disposed at substantially right angles to the plane of, and integrally connected at their ends to, said marginal portion, said strips forming elongated spaces to receive said hollow members and position them relative to each other to provide Venturi-like passages therebetween not in excess of $\frac{3}{16}$ " in width, and metal filling the openings between and connecting said hollow members and headers.

9. The combination set forth in claim 8 in which the thickness of the metal of the tube sheet is between $\frac{3}{16}$ " and $\frac{1}{4}$ ", the width of the spaces for the hollow members between the strip is between $\frac{3}{16}$ " and $\frac{1}{4}$ " and the width of the tubes is about $\frac{3}{16}$ ".

10. The combination set forth in claim 8 in which the strips are wider than their thickness and wider than the hollow members.

SAMUEL H. SMITH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
748,669	Valentine	Jan. 5, 1904
992,673	Fedders	May 23, 1911
1,208,022	Schlacks	Dec. 12, 1916
1,703,682	Modine	Feb. 26, 1929
1,704,409	Scott	Mar. 5, 1929
1,747,115	Higgins	Feb. 11, 1930
1,804,191	Whittam	May 5, 1931
1,821,702	Freeman	Sept. 1, 1931
1,892,607	Bundy	Dec. 27, 1932
2,366,224	Warp	Jan. 2, 1945

FOREIGN PATENTS

Number	Country	Date
274,906	Great Britain	Nov. 3, 1927
703,758	Germany	Mar. 15, 1941

65