July 27, 1943. H. W. CASE 2,325,036

RADIATOR CORE TUBE

Filed July 22, 1941

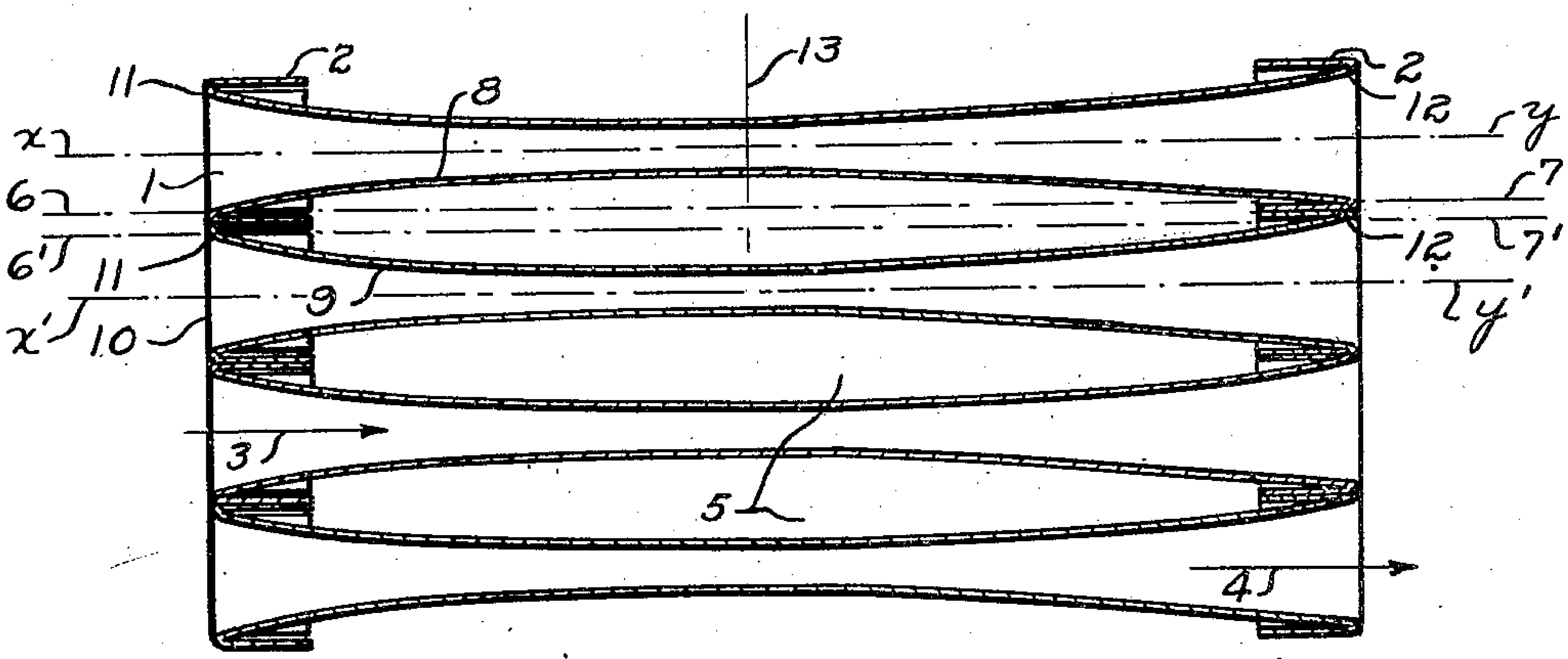

FIG. 3.

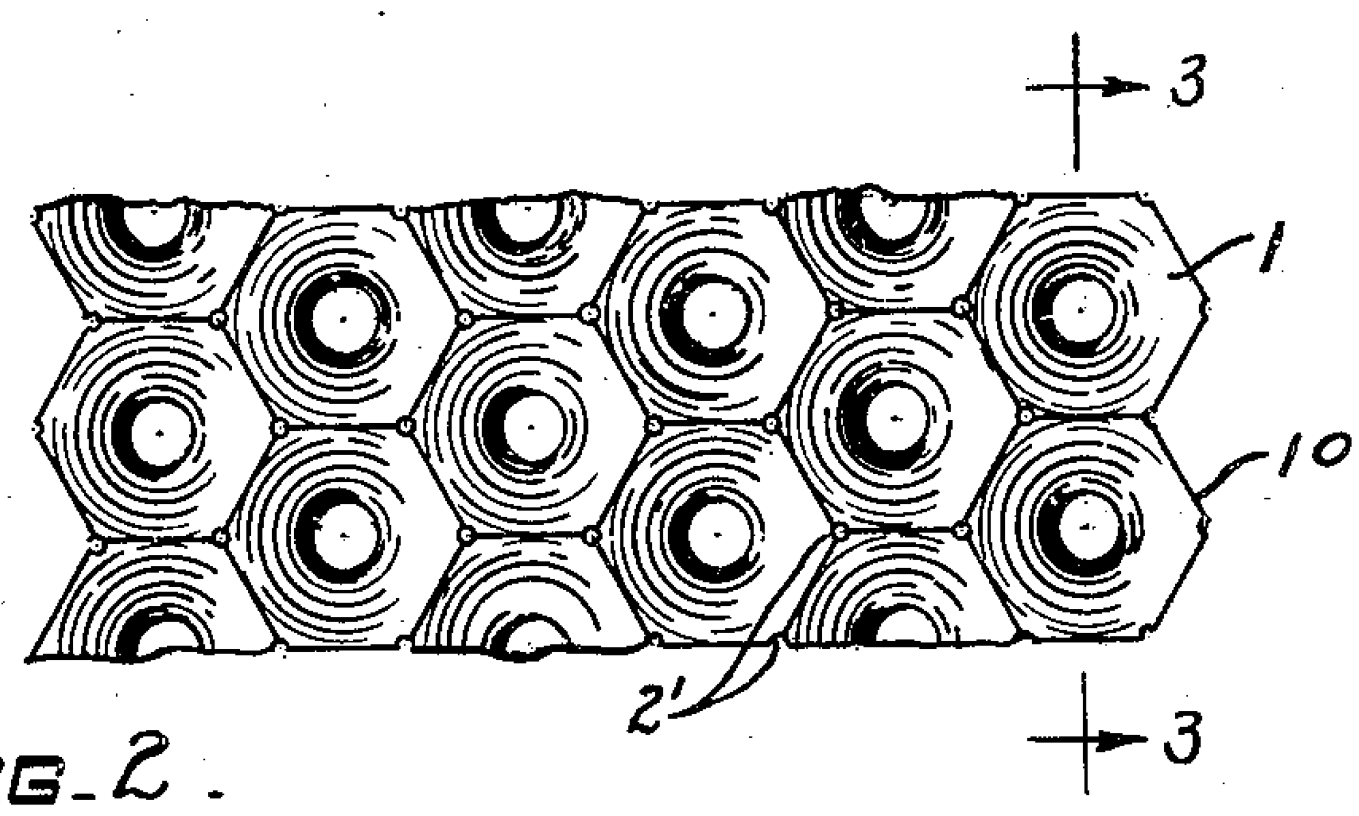

FIG. 2.

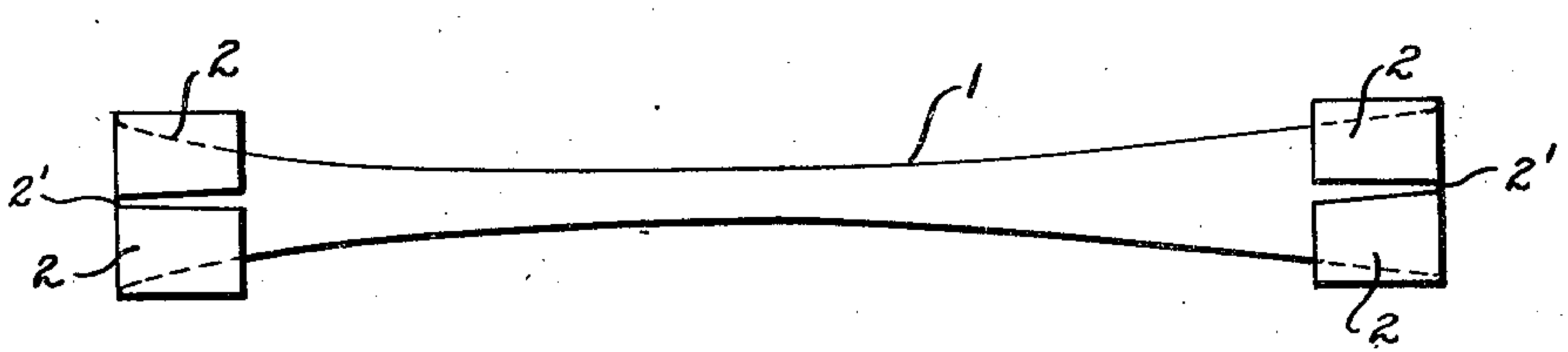

FIG. 1.

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Patented July 27, 1943

2,325,036

UNITED STATES PATENT OFFICE

2,325,036

RADIATOR CORE TUBE

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Application July 22, 1941, Serial No. 403,557

1 Claim. (Cl. 257—262)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to radiator core tubes, and especially to those core tubes which are used in radiators through which the cooling medium travels at very high speeds as, for instance, in a radiator to be used on high-speed aircraft.

The majority of the existing types of core tubes are formed as straight cylinders having upset hexagonal ends for supporting the adjacent tubes when assembled together to form a complete radiator. With the present-day high-powered engines used on aircraft, large numbers of these tubes must be incorporated in a single radiator in order to provide sufficient cooling area to dissipate the large amount of heat developed by the engine. In some instances as many as 27,000 of these tubes are used in the radiators on a single airplane. It is at once apparent, therefore, that even a slight improvement in the form of the tubes so as to reduce the profile drag thereon is extremely important in view of the large number of tubes involved. With the present straight, cylindrical tube, considerable turbulence is created in the air stream both at the entrance end of the tube and also at the discharge end thereof, due both to lack of streamlining and also to expansion of the air as it is heated while passing through the tube. This turbulence and burble is further increased by the presence of the hexagonal mounting sleeve on both the front and rear edges of the tube. With my improved form of radiator core tube I have minimized the profile drag as much as possible by designing the tube so that the cooling air traverses a streamlined channel in passing through the tube, and also by causing the hexagonal mounting sleeves on each end of the tube to extend toward the center of the tube from the front and rear edges thereof so as to thereby eliminate the irregular flow which is caused when these sleeves constitute the leading and trailing edges thereof. By eliminating this irregular flow, the air comes in contact with every part of the interior of the tube. Consequently, the entire area will be "wetted" by the cooling air and the cooling capacity of the radiator will be increased over that possible with the conventional radiator in which turbulence exists in the tubes.

My tube is so shaped that its walls follow the contour of an airfoil, thereby reducing the drag to a minimum. I do not wish to limit myself to any particular airfoil section since the type of section which will offer the minimum resistance to the passage of air will depend upon the speed at which the tube is to be used, and also upon the length of the tube, or, that is, the thickness of the radiator. Information concerning the design of certain desirable high-speed airfoil sections and a method for arriving at the contour of the inner surface of the core tube may be found in N. A. C. A. Report Number 492 entitled "Tests of Sixteen Related Airfoils at High Speeds" written by John Stack and Alfred E. von Doenhoff. This report will be found in the twentieth Annual Report of the National Advisory Committee for Aeronautics published in 1934.

Accordingly, the primary object of my invention is to provide a radiator core tube offering the smallest possible resistance to the air passing through it at predetermined speeds. This is accomplished by patterning the contour of the tube after an airfoil section which has suitable characteristics at the speed for which the radiator is designed.

Another object of my invention is to provide a novel form of core tube which results in a greater cooling capacity for a radiator of given frontal area than has been possible heretofore.

A further object of my invention resides in the provision of a method for determining the shape of a radiator core tube having a reduced profile drag characteristic.

A further object of my invention is to provide a core tube which is simple in construction and which may be extruded rapidly on automatic machines.

Still a further object is to provide a mounting sleeve on the end of a streamlined core tube which will not interfere with the smooth flow of air through the tube.

A preferred embodiment of my invention will be hereinafter described with reference to the accompanying drawing, given merely by way of example, in which:

Figure 1 is a side elevation of an individual core tube formed in accordance with my invention.

Figure 2 is an end view of a section of a radiator incorporating a plurality of these tubes.

Figure 3 is a cross-sectional elevation through a row of tubes taken on the line 3—3 of Figure 2.

The single tube 1 shown in Figure 1 has a streamlined, Venturi-like profile as may be seen from this figure. The tube can be extruded from a suitable metal which will permit forming into the proper shape. During the course of forming these core tubes, the ends are split into six segments which are then flattened and bent back to form the faces 2 of hexagonal mounting sleeves extending rearwardly of the ends of the tube. A slot terminating in a small radius 2' is provided between each of the six segments 2 in order to prevent the metal from splitting back into the tube when the ears are flattened and folded back on the tube. The length and contour of the tube will depend, of course, on the speed and dimension of the radiator for which the tube is designed, and the shape shown here is merely by way of example and is not to be taken as the only shape which may be given to the tube.

The end view of the tube may be seen in Figure 2 where a plurality of these tubes are assembled together to form a radiator core. After assembling the tubes together as shown in this figure, they are soldered at the ends in the same menner as conventional radiator core tubes, i. e., by dipping in molten solder while held in a clamp. The small radii 2' between each of the six segments 2 when mated with the other similar radii on adjoining core tubes appear substantially as small holes 2' as noted in Figure 2. These small holes 2' will be filled with solder during the above dipping operation so as to tightly seal the radiator core and prevent leakage of the liquid or other fluid which is flowing through the radiator.

In Fig. 3, which is a section taken through one row of the tubes, it will be observed that the space formed between any two of the tubes is shaped to substantially conform to the outline of a symmetrical airfoil section. The cooling air proceeds through the center of the tubes as shown by the arrows 3 and 4 while the fluid to be cooled is circulated around the core tubes in the spaces 5 left in-between the tubes. The line 6—7 represents the chord of an airfoil section as does also the line 6'—7'. If the upper contour 8 of the airfoil having the line 6—7 as its chord is rotated about the axis x—y which is substantially parallel to the chord but displaced therefrom on the convex side of the contour 8, the surface thus generated will have the form of a Venturi-shaped tube which constitutes the wall of radiator core tube 1 in Figure 3. If the lower contour 9 of the airfoil having the line 6'—7' as its chord is rotated about the axis x'—y', the surface thus generated will constitute the wall of core tube 10. It will be observed that the space between the walls 8 and 9 has a shape which is substantially that if a symmetrical airfoil. It varies in outline from the contour of such an airfoil by the distance separating the chord lines 6—7 and 6'—7'. Were these lines superimposed, one on top of the other, the resulting outline formed by walls 8 and 9 would then be that of a perfect airfoil section of symmetrical design. It is impossible from a practical standpoint, however, to bring the chord lines entirely together since the segments 2 must be bent back around a smooth radius so as not to fracture the metal. So, while it would be desirable to fold the segments 2 back on the tube with a right angle bend and thus bring the chord lines 6—7 and 6'—7' into registry with one another, still to do so would cause the metal to fracture at that point and result in an unserviceable core tube. The lines 6—7 and 6'—7' are so close together, however, that the air which passes through the two tubes 1 and 10 flows about what is substantially a symmetrical airfoil and the wind resistance of the two tubes closely approximates that of the true airfoil.

The entrance end of the tube through which the air enters is formed with a curve 11 which corresponds to the leading edge radius of the selected airfoil section while the exit end of the tube is formed with a curve 12 corresponding to the trailing edge radius. A line 13 indicates the location of the maximum ordinant of the airfoil section and it will be observed that this line is located near the center of the tube. The reason for this is that the tube is designed for use in high-speed aircraft, it being found that as the speed of the air passing over an airfoil increases, the maximum ordinant should be moved further rearward to secure minimum drag. In the case of a radiator which is designed for slower speed operation, the line 13, representing the neck of the tube, would be moved further toward the left-hand edge of Figure 3.

A tube having a Venturi-like shape in accordance with my teaching has the additional advantage of providing space for the expansion of the air as it picks up heat during its passage through the tube. After the air has passed through the neck of the tube, the increasing size of the tube permits the air to expand as it absorbs heat from the walls of the tube to thereby maintain straight-line flow of the air without any turbulence or burble. The absence of turbulence means, of course, that a greater area of the core tube interior will be in constant contact with, or "wetted" by, the cooling air flowing through it. Hence, better heat transfer will be obtained and the heat dissipating capacity of the radiator will be increased.

While the airfoil sections considered in N. A. C. A. Report No. 492 are of six percent thickness or greater, a section having only three percent or perhaps even as little as one and one-half percent thickness may be designed by use of the formula and other data given in this report. This may be necessary when the radiator design calls for a thick radiator and a correspondingly long core tube. The contour will then have to be flattened out by using an airfoil of small thickness in order to keep the diameter of the tube down to reasonable size at the ends.

It should be noticed that the positioning of the hexagonal mounting sleeves rearwardly of the edges of the tube eliminates the irregular flow of air which would otherwise occur if these elements constituted the leading and trailing edge portions of the tube. Thus the tube is designed for the most efficient possible streamlining and the mounting sleeves are so placed as not to interfere with this result. Consequently, my improved tube will offer the least possible resistance to the air passing through the radiator which, as pointed out above, is an important consideration when thousands of these tubes are used in constructing a single radiator.

While for purposes of illustration I have described my invention as a radiator core tube for dissipating the heat carried away from an internal combustion engine by a liquid cooling system, it is evident that the same tube may be used in an oil cooler for dissipating the heat from the engine oil, or as an inter-cooler for dissipating the heat from the air which is compressed by a supercharger, or for any other purpose where the exchange of heat between a fluid and the surrounding atmosphere is desirable. It is also to be understood that the particular form of the tube shown is for the purpose of illustration only and that I do not intend to be limited by the specific form of tube herein disclosed. For example, the tube may be of square or hexagonal cross-section, or of any other desirable cross-section without departing from the scope of my invention. Also, the mounting sleeves may be made square instead of hexagonal, etc.

What I claim as new and desire to secure by Letters Patent is:

A radiator core element comprising a Venturi-shaped tube of circular cross section having walls which gradually converge from each end of said tube to the throat thereof, and a mounting sleeve surrounding each end of said tube, said mounting sleeves each being comprised of a plurality of flat, rectangular-shaped portions bent off from the end of said tube and back over the outer surface thereof to form a prismatic mounting sleeve which will not interfere with the smooth flow of air through said tube.

HAROLD W. CASE.