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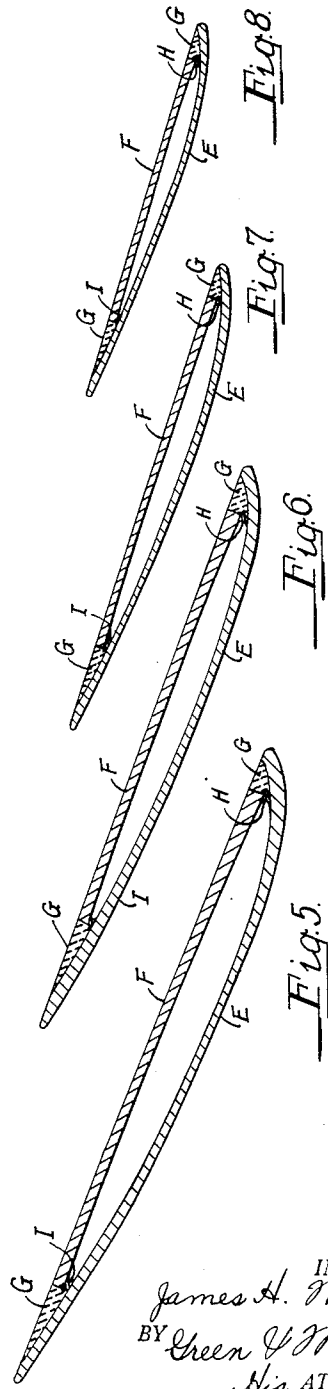
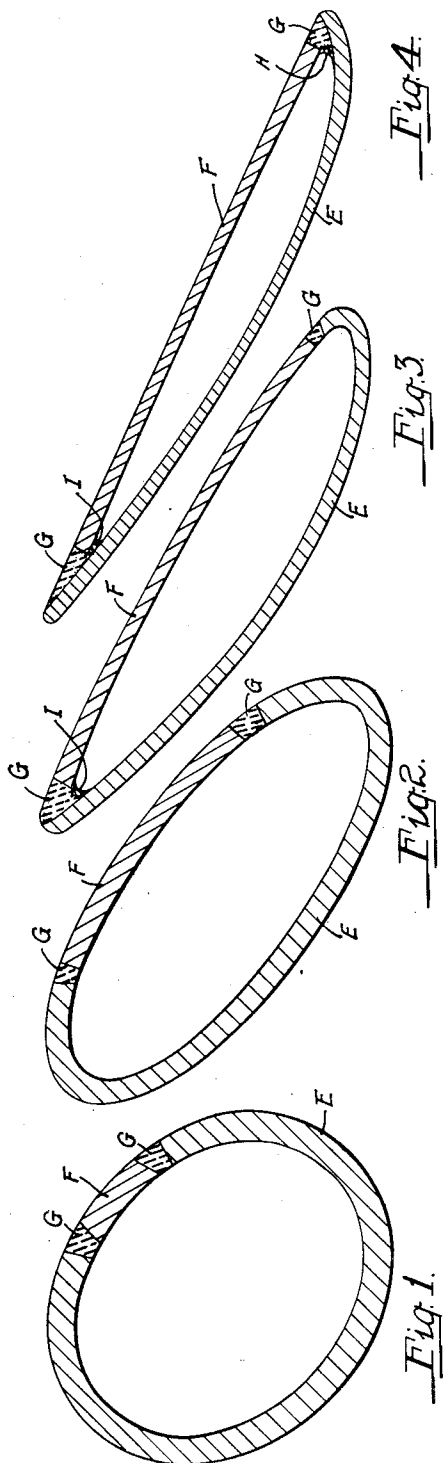
J. H. McKEE

2,280,337

METHOD OF MAKING HOLLOW METAL AIRCRAFT PROPELLER BLADES

Filed Sept. 15, 1937

3 Sheets-Sheet 1



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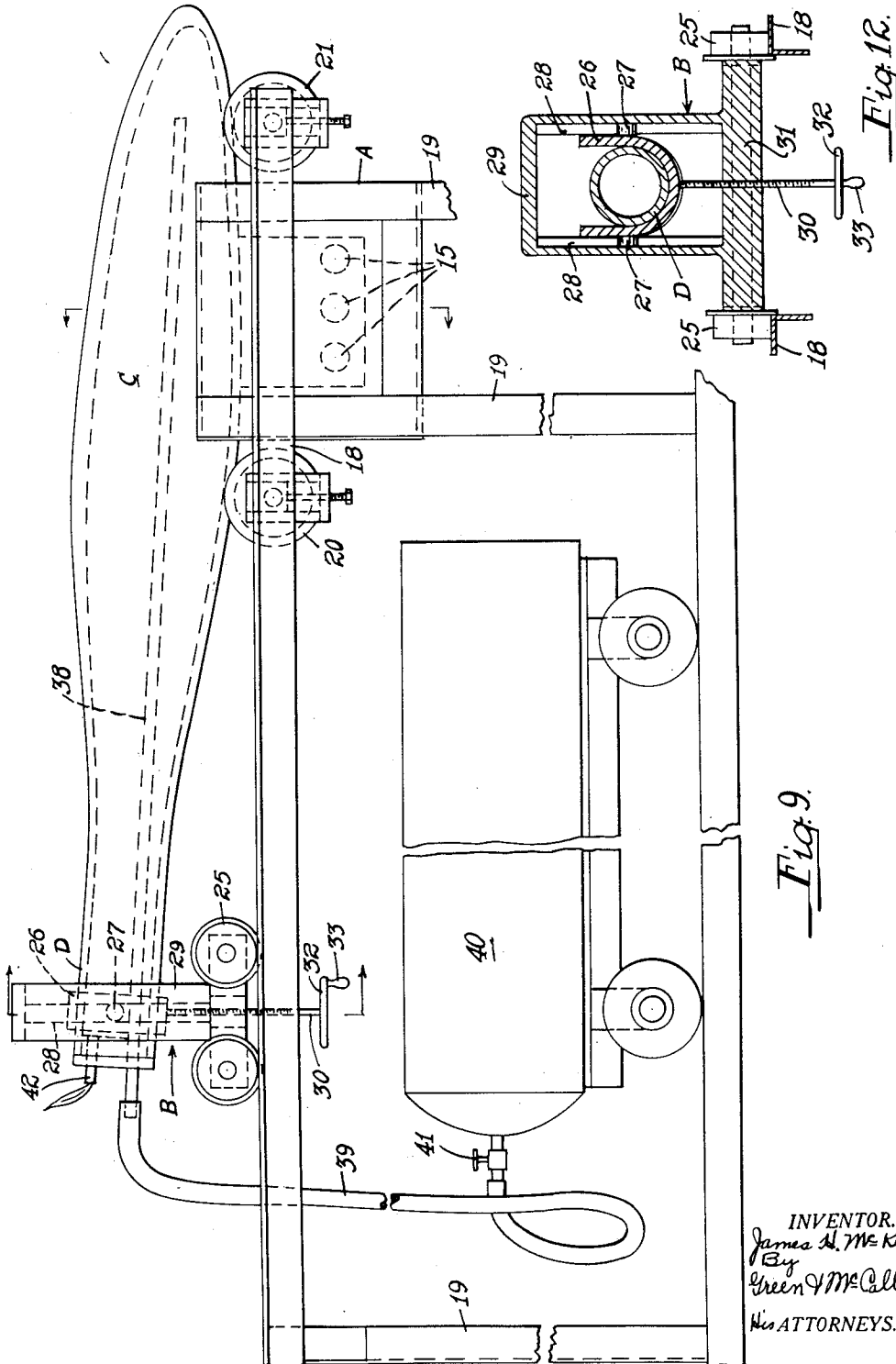
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METHOD OF MAKING HOLLOW METAL AIRCRAFT PROPELLER BLADES

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3 Sheets-Sheet 2



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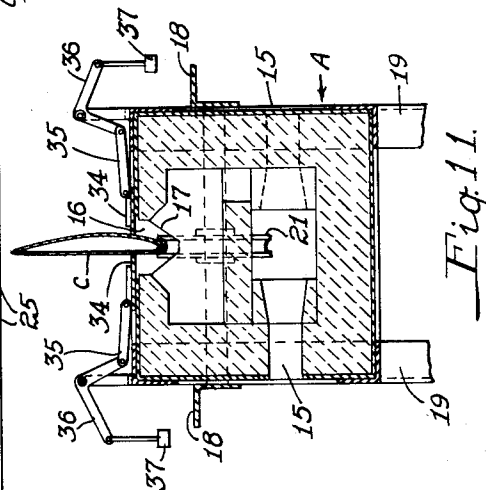
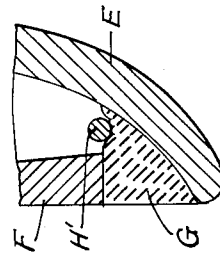
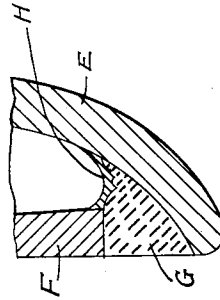
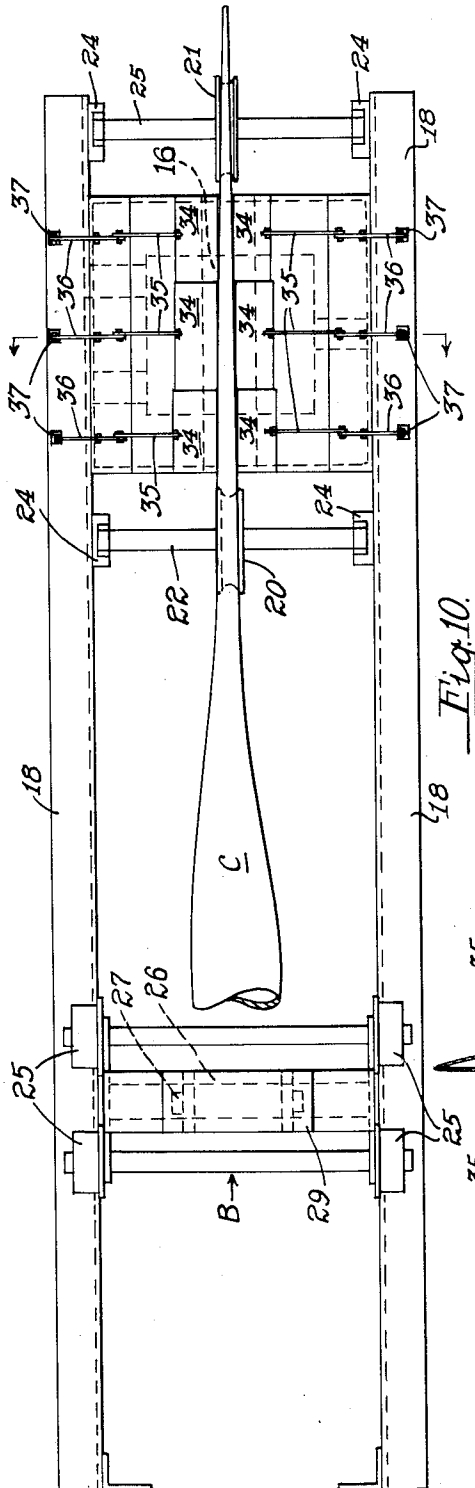
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METHOD OF MAKING HOLLOW METAL AIRCRAFT PROPELLER BLADES

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,280,337

METHOD OF MAKING HOLLOW METAL
AIRCRAFT PROPELLER BLADES

James H. McKee, Pittsburgh, Pa., assignor, by
mesne assignments, to Curtiss-Wright Corpo-
ration, New York, N. Y., a corporation of Dela-
ware

Application September 15, 1937, Serial No. 163,926

2 Claims. (Cl. 113—112)

This invention relates to a method of making hollow metal blades for aircraft propellers and to a method of forming fillets within such blades.

While this invention is applicable to the internal filleting of all types of hollow steel blades, it is particularly applicable to blades constructed from plate-like members which are joined together adjacent the blade edges. A blade of this type and with which this invention is being successfully utilized is disclosed in T. A. Dicks Patent No. 1,713,500 of May 14, 1929.

Blades of the Dicks type include in their make-up two relatively thin steel plate-like members, one of which is formed into a hollow shell-like outer camber member having one open side and with the tubular shank for the blade formed from the same plate-like member, while the other plate-like member is formed into an inner camber member.

The outer face of the outer camber member forms the suction face of the blade while the outer face of the inner camber member forms the major part of the pressure face of the blade. The inner camber member is of substantially the same outline as the opening in the open side of the hollow outer camber member but is slightly smaller than such opening so that when it is placed in the position it is to occupy in the finished blade, a narrow band-like opening or space exists between the adjacent edges of these camber members.

Fused metal of substantially the same analysis as the metal from which the camber members are formed is deposited within this opening until the same is filled. This forms an inlaid metal weld which lies within and completes the pressure face of the blade and bonds the camber members together into a rigid hollow blade structure. This deposited metal provides a thickened bounding edge for the outer camber member and in effect forms an anchoring abutment for the inner camber member.

The deposited weld metal, due to the surface tension characteristics of ferrous metals, is bound to have reentrant curves in that portion of its surface exposed to the hollow space within the blade and particularly at the junction points of the inner faces of the camber members and such exposed weld metal. The sharp corners formed by these reentrant curves provide points for stress concentration, especially for stresses which are transverse to the longitudinal axis of the blade.

An object of this invention is to produce a hol-

low metal aircraft propeller blade wherein such stress concentration points are eliminated.

Another object is to produce a hollow metal aircraft propeller blade having a fillet which extends along its inner peripheral edge throughout the major part of the effective length of the blade.

Another object is to provide a method by means of which fillets can be formed along the inner peripheral edge of hollow metal blades between the inner surfaces of its camber members.

A further object is to provide a method of forming cuprous metal fillets within hollow steel blades.

A further object is to produce apparatus for facilitating the carrying out of my invention of filleting with cuprous metal the inner peripheral edges of hollow steel blades.

These as well as other objects which will appear to those skilled in this particular art I attain by means of the method and apparatus disclosed and claimed in this application.

In the drawings:

Figures 1 to 8 inclusive illustrate transverse sections taken at various stations along a hollow steel aircraft propeller blade made from two relatively thin steel plate-like members in accordance with the teachings of said Dicks patent and having its inner peripheral edge throughout the effective length of the blade filleted in accordance with this invention. This blade also embodies improvements disclosed in applications serially numbered 74,007 (filed Apr. 13, 1936) and 84,698 (now Patent 2,214,338, dated Sept. 10, 1940) heretofore filed by me;

Fig. 9 is a more or less schematic view in side elevation of apparatus suitable for the carrying out of my method of filleting hollow metal blades;

Fig. 10 is a top plan view of portions of the apparatus shown in Fig. 9 and with a portion of the blade of said figure broken away;

Fig. 11 is a transverse section through the center of the furnace portion of the apparatus shown in Figs. 9 and 10;

Fig. 12 is a detail view in section of a part of the blade supporting mechanism of the apparatus of Figs. 9, 10 and 11;

Fig. 13 is a fragmentary view in section of one edge portion of a blade such as disclosed in Figs. 1 to 8 inclusive. This view illustrates the filleting metal in position within this portion of the blade before such metal is melted; and

Fig. 14 is a view similar to Fig. 13 and shows

the fillet formed from such metal in accordance with this invention.

In forming fillets in accordance with this invention, I take advantage of known surface tension characteristics of molten cuprous metals. Because of these characteristics, when cuprous metal in a molten state is brought into contact with notched or pitted ferrous metal surfaces such pits or notches will be filled, provided such surfaces have been put in condition to be wetted by the cuprous metal. If such metal when molten is confined between two upstanding walls of ferrous metal which have been put in condition to be wetted thereby, it will, by capillary attraction, form a fillet between such walls, and the exposed surface of such fillet will take the form of a meniscus curve.

In carrying out the method of this invention, the hollow steel blade to be filleted is supported on one of its edges (the leading or trailing edge as the case may be) so that said edge is down and the other is positioned vertically or substantially vertically above the same.

Within the more or less V-shaped groove formed by the inner faces of the camber members at said lower edge I place the metal from which to form the fillet.

This may be copper, a copper alloy, Monel metal, constantan or a copper-silver alloy. The filleting metal is preferably in the form of sections of wire. It may also be in the form of powder. The filleting metal rests on the upper exposed surface of the weld metal which forms the bottom of the V-groove. If wire is used, it is preferably cut in relatively short sections and placed end to end, the sections varying in diameter in accordance with the amount of filleting metal necessary to form the fillet desired at the particular point where such wire sections are placed. If filleting powder is utilized instead of wire, this is preferably mixed with a suitable binder and the amount of the powder is varied according to the size of the fillet to be produced.

After the filleting metal is in place, I purge the blade of all air and water vapor by filling the same with a strongly reducing atmosphere and this atmosphere I maintain within the blade throughout the entire filleting operation. This reducing atmosphere conditions the exposed surfaces of the weld metal and the inner surfaces of the camber members so as to be capable of being wetted by the molten filleting metal.

The lower edge of the blade is then progressively heated throughout that portion of its length which is to be filleted and the temperature to which the lower edge of the blade is raised is sufficient to melt the filleting metal within the portion being heated. I find that it is desirable to heat short sections, say about six inches of the blade at a time. After one such section is heated, the blade is moved longitudinally and the next section is then heated and so on until all of the filleting metal is melted.

As a new section is heated, the preceding section is allowed to cool and as it cools, the molten filleting metal freezes and forms a perfect fillet.

When the filleting of one edge of the blade has been completed, the blade is turned upside down and supported on the other edge which is then treated in the manner above described.

Since the filleting is done within the blade, the blade itself forms its own chamber for the reducing atmosphere. In order to maintain this atmosphere, I insert a pipe into the blade through the shank end and this preferably ex-

tends to within a short distance of the tip end of the blade. The end of the shank around this pipe may be closed except for a small vent pipe for reducing gas escaping from the interior of the blade. The gas is lighted and the flame forms a visible means for indicating that the desired atmosphere is being maintained within the blade.

I find that by progressively heating short sections of the blade, very little, if any, distortion of the blade takes place.

In carrying out my filleting operation, I make use of a small furnace A which is preferably gas fired. The openings for the burners are indicated at 15. The top of the furnace is provided with a centrally located longitudinally extending slot 16 and the end walls below said slot are provided with V-shaped openings 17 (Fig. 11). It is possible to utilize a relatively small furnace because of the fact that but short sections at a time are heated. The furnace is supported between parallel rail-like members 18 and these are supported at the desired height by support legs 19.

Grooved support wheels 20 and 21 are respectively carried on shafts 22 and 23 journaled for rotation in bearing members 24 carried by rails 18 beyond the opposite ends of the furnace A and in line with the V grooves. A carriage B provided with rail traversing wheels 25 is mounted on rails 18 for rolling movement toward and from the furnace A. This carriage is provided with a blade shank supporting saddle 26. Trunnions 27 secured to opposite sides of this saddle are mounted for vertical sliding movement in grooves 28 of a yoke member 29. This yoke member is mounted on and forms part of the carriage. The saddle rests on the upper end of an adjustment screw 30 which is threaded through base member 31 of the carriage. The lower end of screw 30 is provided with a wheel 32 and offset handle 33 by means of which the screw may be raised and lowered to adjust the position of the saddle.

The edge of the blade C to be filleted first (either the leading or the trailing edge) is placed within the grooves of rollers 20 and 21. The shank of the blade is supported within saddle 26 as shown in Figs. 9, 10, 11 and 12. Adjusting screw 30 is manipulated so that the edge portion of the blade within the furnace may be kept substantially level during the progressive movement of the blade through the furnace.

As before stated, the elevated temperature zone of the furnace is about six inches in length and the slot in the top of the furnace which is made wide enough to accommodate the largest blades has its effective width automatically adjusted during the filleting operation by means of asbestos or other suitable refractory pads 34 and a system of links 35, bell crank levers 36 and weights 37. Pads 34 are mounted for sliding movement on top of the furnace. The weights through the links and bell crank levers yieldingly hold the inner edges of these pads in contact with the outer opposite side faces of the blade being filleted. These pads to a large extent localize the heating to that portion of the blade positioned within the furnace.

Since the success of this method depends in large measure on the effectiveness of the molten filleting metal to wet the weld metal and the inner adjacent surfaces of the camber members the composition of the atmosphere in which the welding procedure is carried on is of particular

importance. This atmosphere must be strongly reducing and free from water vapor.

After the blade has been mounted for the filleting operation with one of its edges supported in grooved rollers 20 and 21 and its shank supported in saddle 26 the filleting metal is placed within the blade so that it rests on the upper exposed surface of the weld metal along that portion of the inner peripheral edge of the blade to be filleted. Before any portion of the blade edge is raised to the temperature at which the filleting metal melts, a metal pipe 38 is inserted into the blade through the open shank end and, as shown in Fig. 9, this extends to within a short distance of the tip end of the blade. The outer end of this pipe by means of a suitable hose 39 is connected to a source of supply of strongly reducing gas. This may be a tank 40 containing hydrogen or some other strongly reducing gas and the tank outlet is controlled by a valve 41. It will be seen that control of the atmosphere during the filleting operation is a relatively simple matter since the blade itself serves as the gas chamber within which the filleting is carried on. If desired, the shank end of the blade can be provided with a vent pipe 42 for escape of the excess reducing gas. Before the first section of the blade reaches brazing temperature the blade by means of reducing gas is purged to remove all traces of oxygen and water vapor and a constant flow of gas into the blade is maintained during the entire filleting operation and as said, the excess which flows out through the vent is lighted, serving as a visible indication that the desired atmosphere is maintained within the blade.

While I prefer the method of filleting set forth above, it is possible to take advantage of certain features of my invention and obtain cuprous metal fillets within hollow steel blades without maintaining a reducing atmosphere within such blades during the filleting operation.

In carrying out such modified method, I support the blades in the same manner as above described and incrementally heat the blade edges to the same temperature as in the preferred method. In order to place the exposed surfaces of the weld metal and the adjacent inner faces of the camber members in condition to be wetted by the filleting metal, I either apply a suitable brazing flux to such surfaces and then place the filleting metal in position or I mix with the copper or copper alloy filleting powder a suitable brazing flux. This may serve as a binder for the powder or an additional binder may be used.

The preferred method obviates the necessity of using a flux and my experience has been that I

can obtain more uniformly satisfactory filleting by using the preferred method.

It is to be understood that this invention is not limited to the internal filleting of blades of the Dicks type since both the preferred and the modified method may be used in internally filleting any type of hollow ferrous metal aircraft propeller blade formed from ferrous metal plate-like members where such members are joined together either within or adjacent the leading and trailing edges of the blade throughout at least a portion of the effective blade length.

A transverse section of the tubular shank of the blade shown at D in Figs. 9 and 12 is not included in Figs. 1 to 8 inclusive. This is formed by rolling or otherwise converting to tubular form the shank forming portion of the plate-like member from which the hollow outer camber member is formed. In Figs. 1 to 8 inclusive and in Figs. 13 and 14, E denotes the hollow outer camber member, F the inner camber member, G the inlaid metal weld, H the fillet adjacent the leading edge of the blade and I the fillet adjacent the trailing edge of the blade. These fillets meet at the blade tip. H' denotes the filleting metal in place within the blade but before the same is melted and by capillary attraction gives the fillet the form in which its exposed surface is a true meniscus curve as shown in Fig. 14.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of forming non-ferrous fillets along the inside runs of previously formed seams of a ferrous hollow body which consists in placing brazing spelter along said seams, maintaining a continuous flow of reducing gas through the hollow of body under greater-than-atmospheric pressure, providing a restricted exit opening for outflow of said gas, and in locally heating, from outside the body, portions of the body seam to a temperature sufficient to fuse the spelter to form an internal seam fillet.

2. In the process of forming internal cuprous fillets along a previously formed seam between components of a substantially closed hollow body, wherein spelter is applied along the seam and wherein heat is applied externally and progressively to short sections of the seam to fuse the spelter, the step of fluxing the brazed joint during its formation which consists in continuously feeding a reducing gas into the body hollow at a greater-than-atmospheric pressure, and in providing a restricted vent in the body through which surplus reducing gas may pass from the body.

JAMES H. MCKEE.