

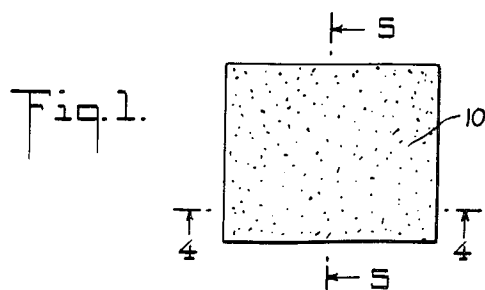
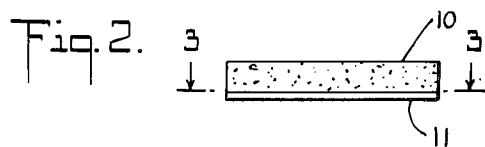
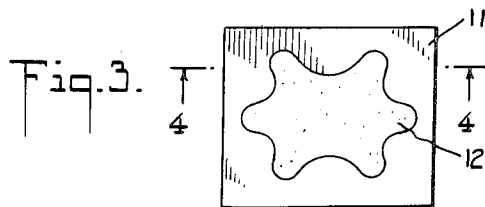
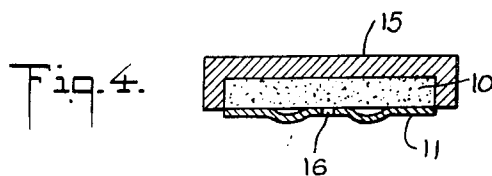
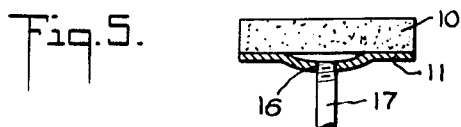
Aug. 21, 1962

E. I. VALYI
GAS PERMEABLE BODY

3,049,795

Filed May 2, 1958

2 Sheets-Sheet 1



INVENTOR.
EMERY I. VALYI
BY 
ATTORNEY

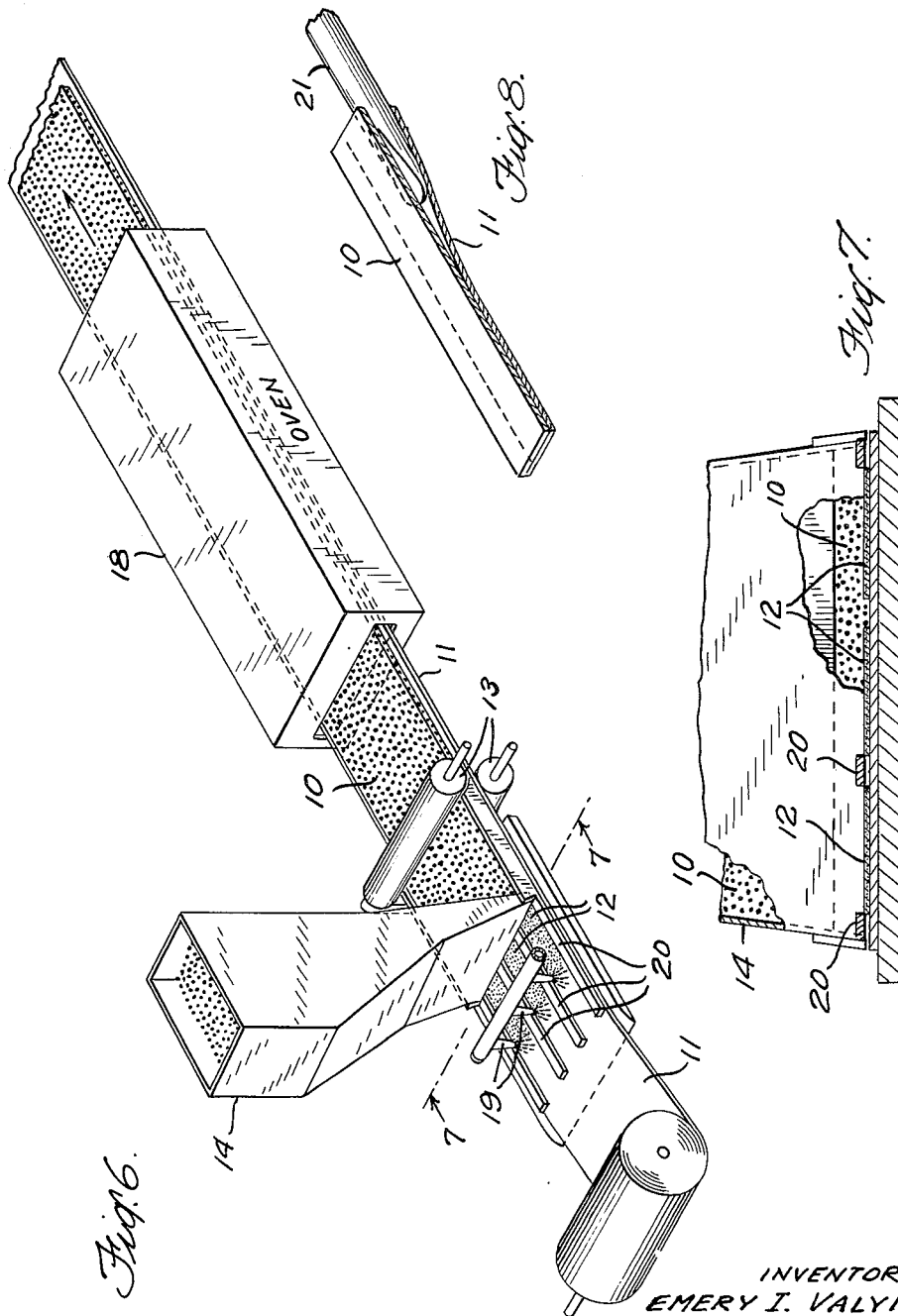
Aug. 21, 1962

E. I. VALYI
GAS PERMEABLE BODY

3,049,795

Filed May 2, 1958

2 Sheets-Sheet 2



INVENTOR
EMERY I. VALYI

BY

Attorney

1

3,049,795

GAS PERMEABLE BODY

Emery I. Valyi, New York, N.Y.

(% A.R.D. Corporation, 20 S. Broadway, Yonkers, N.Y.)

Filed May 2, 1958, Ser. No. 732,663

20 Claims. (Cl. 29—182.3)

This invention relates to a permeable body integral with a supporting metal structure adapted to conduct a fluid to the gas permeable body, usually for distribution of the fluid therethrough, there being provided passages for the movement of the fluid between the permeable body and the supporting metal structure. It will be appreciated that a construction of this particular class and type is well adapted for use in burners whereby a combustible gas may be distributed through such passages, such that it reaches the permeable structure and upon penetrating therethrough, is ignited over a large area. Likewise, such construction is useful in the evaporation of a liquid over a large area whereby again the liquid is conducted to the permeable layer of this construction through said passages, further distributed through the permeable body, to be evaporated from the surface of the permeable body.

This application is a continuation in part of co-pending application Serial No. 586,259, filed on May 21, 1956.

As a feature of the invention, the permeable body is formed of powdered metal that is joined to the supporting metal structure so as to become integral therewith in all areas except where it is intended that channels be formed between the pervious and impervious portions of the structure. Preferably, the powdered metal is sintered while in contact with the supporting metal structure. Through interposition of a weld-preventing substance in the form of a layer or film of a particular pattern between the powdered metal and the supporting metal structure at the time of sintering, it becomes possible thereafter to flex or otherwise deform the supporting metal structure to form passages between the supporting metal structure and the permeable body in accordance with the pattern of the weld-preventing substance.

It has been known in the manufacture of gas burners that are intended to provide evenly distributed heat over large surfaces to employ a gas pervious body through which to conduct the combustible gas such that it will be distributed within the permeable body emanating on the combustion side thereof over most of the surface of that body at a substantially uniform rate, thus producing a flame blanket. It has also been known in the construction of evaporative coolers that an efficient cooling surface may be constructed by using a porous metal body as the means through which to distribute over a large area the liquid which is to evaporate for the purposes of transpiration cooling. The use of powdered metal filters of controlled porosity and permeability is also well known in industry, a structure wherein a liquid carrier is caused to filter through a porous powdered metal body leaving the filtrate on one side thereof.

In all of the uses here described and in many other similar uses, the powdered metal body constitutes a useful structure in that it is capable of production with economical means to satisfy a wide variety of conditions. For example, through appropriate control of the size of the particles from which the powdered metal body is composed, or through the incorporation and intermixing with these particles of a combustible powder such as wood flour, it is possible to produce a wide range of permeabilities which are always determined by the void space left between the powdered metal particles upon pressing and sintering, following well-known methods of powder metallurgy. One of the most important limitations upon the use of powdered metal bodies for purposes such as

2

herein described, resides in the fact that it was very difficult and costly to provide conduits through which to conduct fluids to the appropriate faces of the powdered metal bodies, therefrom to be distributed into and through such powdered metal bodies for the purposes of combustion, evaporation, filtration or other similar purposes. While the techniques and methods of producing pervious bodies from powdered metal have been extensively discussed in the literature such as for example in "Powder Metallurgy" by Dr. Paul Schwarzkopf (The Macmillan Co., New York 1947) and "Powder Metallurgy" edited by John Wulff (The American Society for Metals, Cleveland, 1942), no way appears to have been found thus far to conduct a fluid to these permeable bodies except for example, in instances where the permeable body could form the entire container.

The basic concept of the contribution herein described is the forming of an integral structure of two or more metal layers of differing physical characteristics, at least one layer being porous and pervious to fluids, such as gases or liquids, and the others impervious and solid, the layers being secured together, preferably through a sintering operation, but at times also by brazing and other means, always such that passages are formed in predetermined locations between the layers of the integral structure.

As a feature of the invention a supporting metal structure is utilized, that may have all or a portion thereof in the form of a flat, relatively thin plate, sheet or strip. On this sheet a weld-preventing substance is applied in that particular pattern that it is desired for the gas conducting passages or channels to assume. As the weld-preventing substance a material is chosen which has no deleterious effect upon the metal on which it is deposited, nor upon the powdered metal to be deposited over it and which prevents adherence by welding, diffusion or alloying of the powdered metal to the plate, sheet or strip. Following the application of this weld-preventing substance, a substantial layer of powdered metal is deposited upon the plate thus treated. Subsequently this composite structure is subjected to high pressure thereby to compact the powdered metal and to press it firmly against the solid plate. The object so formed is then exposed to a suitable sintering temperature, taking care to prevent unwanted reactions such as oxidation of the metal. The sintering operation accomplishes the sintering of the powdered metal particle to each other and the sinter-welding of the powdered metal layer to the solid plate.

Alternatively, the powdered metal layer may be separately formed by known powder metallurgy techniques. Again separately, the solid plate is prepared by applying to it the weld-preventing layer in selected areas, and applying to the one side of the powdered metal layer a suitable thin layer of soldering or brazing metal. The powdered metal layer is then superimposed upon the solid plate and the composite subjected to thermal treatment such that the powdered metal layer will braze or become soldered to the plate in all regions except the one previously treated with the weld-preventing substance.

In either event, upon completing the integral body in one of the manners above described, the plate is now flexed away from the powdered metal layer in the areas that had previously been treated with the weld-preventing substance. This can be done by introducing pressure fluid into the narrow unwelded slits formed between the powdered metal layer and the plate, or mechanically, by the insertion of suitable tools into such slits. This flexing away of the plate from the powdered metal layer will produce a channel bounded on the one side by solid metal and on the other side by powdered metal. Usually, that channel will contain the residue of the weld-preventing substance which residue may be left within the channel or

removed therefrom. It may be left there if its nature is such that it will not influence chemically or mechanically the fluid to be conducted through the channel, but if such reaction has to be anticipated, the layer may be readily removed mechanically, or by way of a stream of abrasive substance suspended in the form of a slurry and by other well-known methods frequently used to clean the inside of channels, tubes and pipes.

In the body produced by any one of these methods, the pervious and solid parts may be made of the same metal or alloy, or the pervious and the impervious parts of the integral body may differ in their compositions. For example, both the pervious and solid layers may be made of stainless steel, copper, brass, carbon steel, aluminum or various combinations thereof. The ultimate use of the pervious body will determine in the end what specific alloys are to be selected.

For example, if the structure is to be used to conduct corrosive gases, then stainless steel may be employed. If, in addition to the properties of permeability, the structure is to have good heat conductivity to aid in evaporating a liquid and, if such liquid has no severe corrosive properties, then the structure may be made of copper or aluminum. In some instances, the pervious layer may act as a catalyst in a reaction to which the fluid passing through it is subjected. In such an instance the porous layer may be made of copper or platinum. Some of the important features of the invention having thus been outlined rather broadly, certain specific embodiments of the invention will now be described to illustrate it further and in greater detail and in order that the detailed description thereof that follows may be better understood.

Example 1.—A strip of commercially available oxygen free copper, $2\frac{3}{4}$ " wide and 0.005" thick was flattened by passing through rolls. A $\frac{3}{8}$ " wide layer was painted in the center of said strip with a water suspension of levigated alumina. On the remaining portions of the plate a very thin layer of tin solder was applied. A 2" wide body, of approximately 0.375" thickness of sintered copper, made from powder with an original particle size distribution between -100 and +325-mesh, was then placed upon the plate. The composite was exposed to a temperature of approximately 350° F. Upon removal from the oven and cooling, the powdered metal layer was found to have been soldered to the solid metal, except in the region that had previously been treated with levigated alumina. In that region it was possible to flex away the solid metal which was done, thereby forming a channel. Upon blowing smoke into this channel, it was observed that the smoke would emerge at the outside surface of the powdered metal layer, not only in the immediate region opposite the channel, but also to both sides of the channel, thus proving that the smoke had penetrated the powdered metal layer to the sides as well as through its thickness.

The anticipated uses of this structure may frequently require the production of the metal body here described in the form of long strips, long and wide plates and the like. Such objects would best be produced by rolling rather than on reciprocating presses. Inasmuch as the production of powdered metal articles by rolling is usually more difficult than by pressing, the latter being a conventional, widely known technique in the metal working art, experiments were carried out to prove the value of this invention as it applies to long strips of composite permeable metal bodies. The following examples will illustrate these procedures and their product.

Example 2.—Copper compound strip was produced as follows: $1\frac{1}{8}$ " wide, 0.010" thick copper strip was partially masked on one surface by painting a graphite suspension onto a $\frac{1}{2}$ " wide area down the center of the strip, along its entire length. The same side of the strip was then completely coated with copper powder of low apparent density (1.7 g./cc.) suspended in a thin organic lacquer. The assembly was sintered in a hydrogen atmosphere at 1800° F. for 15 minutes to produce a firmly rooted anchor

for the main porous layer. A second layer of copper powder, about $\frac{1}{16}$ " high, was then gravity sintered on top of the first, using a higher apparent density powder (2.5 g./cc.), sintering 15 minutes at 1600° F. in a hydrogen atmosphere. The compound strip was then rolled to compact it slightly. A tool was inserted into the slit at the edge of the masked area and the channel widened by bending the strip so as to make the channel adaptable for conducting fluids.

Inspection revealed that no adhesion occurred in the masked area whereas in the unmasked area the strip and the sintered layer had become integral.

This compound strip was permeable to hot gases such as steam, but not to water or to smoke blown by mouth into the channel.

Example 3.—The above steps were repeated with the exception of omitting the first short sintering step at 1800° F. and sintering both layers simultaneously for one hour at 1800° F. instead. It was found that the adherence of the sintered layer to the backing strip was still satisfactory.

Following the same above procedure several compound strips were then prepared on solid copper strip, varying first the average particle size of the copper powder and subsequently the particle shape of the copper powder. These compound strips varied in porosity from the one described to a porosity which permitted easy passage of smoke blown into the channels.

The porosities were compared of compound strips produced with -100 mesh copper powder and with an identical powder from which the -325 mesh fraction was removed. The powder lacking "fines" produced a more porous surface, as expected.

Comparative tests were also made with compound strip produced with identical materials and under otherwise identical conditions except for a variation of the rolling pressure. The influence of rolling conditions on the porosity was marked, again as expected, with permeability decreasing as rolling pressure increased.

Example 4.—A type 302B stainless steel strip, 0.010" thick was chosen as the backing material. A $\frac{1}{2}$ " wide passage down the center of the strip was painted with a suspension of Alundum cement. A coat of type 302B stainless steel powder in commercial plastibond was applied on the same side of the steel strip. A layer of about $\frac{1}{16}$ " of dry 302B powder (-100 mesh) was applied above that. Sintering was done at 2000° F. for 30 minutes and at 2300° F. for another 30 minutes. The compound strip was then rolled. The passages were opened mechanically.

Inspection showed a firm bond between the strip and the sintered parts of the body and no adhesion in the areas painted with the weld-preventing substance.

The sample so produced was porous enough to be penetrated by water.

Subsequent variations in particle size of the stainless steel powder and in rolling conditions produced samples of higher or lower density than the above, as expected by anyone familiar with the art of powder metallurgy.

To further illustrate the nature and scope of this invention and better to describe it, the drawings will be referred to, as follows:

FIG. 1 is a plan view of a powdered metal body deposited on a structural metal member in the form of a plate.

FIG. 2 is a vertical view of the powdered metal and an underlying structural metal member in the form of a plate.

FIG. 3 is a section taken along lines 3—3 of FIG. 2 showing the pattern of a separating film lying between the powdered metal and the metal plate of the two parts of the final integral product resulting from the practicing of this invention.

FIG. 4 is a vertical section taken along the lines 4—4 of FIGS. 1 and 3 and showing the deformation or flexing of the metal plate after the sintering of the powdered

metal body to the metal plate, the flexing taking place in the presence of means for maintaining pressure on the powdered metal.

FIG. 5 is a section taken along the lines 5—5 of FIG. 1 after sintering, and after the deformation or flexing of the metal plate showing the application of gas supply means to the metal plate.

FIG. 6 is an isometric view illustrating a continuous method of forming the compound strip.

FIG. 7 is an enlarged section taken on the lines 7—7 of FIG. 6.

FIG. 8 is a longitudinal section of a compound strip with the expanding mandrel partially inserted.

The drawings naturally illustrate the invention in diagrammatic form, it being understood that the nature of the invention is such that the specification and general outline of the invention are of basic importance to an understanding of this contribution to the art, the drawings merely showing a simple physical modification in which the invention may be embodied.

Referring now more particularly to the drawings, a layer of powdered metal 10 is applied to a metal plate 11, the powdered metal being adapted, when sintered, to become integral with the plate 11 where in contact with that plate. The powdered metal 10 may be applied to the plate as a loose metal powder. The nature of that metal powder will be selected with the ultimate use of the structure in mind. Thus, if rapid flow of gas is intended through the powdered metal layer and thus great permeability appears desirable, then coarse particles say, within the mesh size of -60 and +200 may be employed. Alternately, finer powders may be employed, blended with organic particles such as wood flour which, during the sintering operation, combust and leave void spaces. The chemical composition of the metal powders will also depend on the end use of the structure as previously referred to. The plate and the powder will now be subjected to a temperature for a time sufficient to effect pre-sintering. The metal powder will then be compressed as by rolling, so as to take the final shape of the gas permeable body that is required.

Prior to this treatment, plate 11 will have been provided in predetermined regions with a layer of weld-preventing substance 12 that may form a separating film. A wide variety of substances may be employed to prevent welding. However, these substances will have to be chosen so as not to react adversely with the plate 11 or with the powdered metal 10. For example, if graphite or any other carbonaceous substance were to be used in connection with steel or stainless steel, then in the course of the sintering operation, the carbon would diffuse into the steel, thereby not only obviating the purpose of preventing welding, but also damaging the steel by changing its composition in the layer that had received the carbon by diffusion. Thus, in the case of steel, substances will be employed that are inert to steel at the temperatures of sintering, such as alumina, magnesia, silica or boron nitride. In the case of copper and brass, graphite may be used because no adverse reaction will take place, or one may employ any of the aforementioned refractory substances. With aluminum and aluminum alloys, alumina or preferably talc or zinc oxide may be used, but not graphite because upon exposure to atmospheric moisture and certain other chemical influences, the graphite will form a corrosive electrolytic couple with aluminum, causing corrosion of the latter. One will in turn avoid using talc in connection with copper or steel, because, in the course of sintering at the temperatures required for copper or steel, the talc would be converted into steatite which in turn is very hard and cumbersome in the subsequent flexing and forming operation of the channel. Thus, while having a wide scope in the selection of the weld-preventing substance, one must bear in mind some of the limitations here indicated. The manner in which the weld-preventing layer is applied is well known to

those versed in the production of laminated metal structures such as, for example, described in Patent No. 2,690,002, dated September 28, 1954, to Grinnell, wherein weld-preventing areas are applied to solid metal laminated structures by the printing process conventionally known as silk screening.

Other procedures successfully employed were spraying of the weld-preventing substance from a suspension or slurry, painting or mechanically placing the dry weld-preventing powder into grooves provided in the solid metal strip or plate. The separating film or layer so formed will be shaped in accordance with the pattern of the passages through which gas is to be conducted to the powdered metal body 10. Reference number 12 indicates this pattern of a separating film present between the powdered metal body 10 and the plate 11 in FIG. 2 and FIG. 3.

The operation of compressing and sintering can be carried out continuously where the required quantity of the product warrants such a process. This is done, as shown in FIG. 6, by feeding the metal body 11 in the form of a long strip, say from a coil, into the bite of a pair of driven rolls 13 spaced from each other so as to accommodate both the thickness of the plate or strip 11 as well as the thickness of the powdered metal body 10. From a suitable hopper 14 the powdered metal is allowed to flow into the bite of the rolls 13 and from the rolls the composite structure is passed through one or more sintering stations 18 from which the final integral structure emerges. Likewise, the separating film may be impressed upon the plate or strip 11 continuously, say by the use of rotary printing presses or by continuously passing the strip under the orifice of a spray gun 19 while masking the regions not to be covered by the separating layer by means of masks 20 to protect them from the spray. Spray gun 19 and masks 20 are supported by suitable means, not shown in the drawings.

Upon thus producing the composite, the powdered metal will be subjected to an overlying pressure member 15 shaped to conform with the powdered metal body 10. In the particular example illustrated in FIG. 4 the member 15 will have vertical surfaces and a horizontal surface conforming to the configuration of the powdered metal portion 10 of the final structure. With this member 15 applied by pressure against the powdered metal portion of the structure, suitable fluid pressure will be transmitted to the separating film preferably through an opening 16, for example, formed by drilling the metal plate 11 after the completion of the sintering operation. The fluid pressure will naturally act against the metal plate 11 along the pattern of the separating film 12, and will separate the metal plate from the sintered body 10 of the structure so as to contribute passages or channels shaped in accordance with the pattern of the separating film 12. Now, as seen in FIG. 5, the opening 16 may be threaded and a nipple 17 inserted. This nipple 17 will be adapted to transmit a combustible gas or an evaporating fluid to the space formed between the plate 11 and the powdered metal body 10 with which it is integral. The gas will naturally flow through the powdered metal toward the surface thereof for evaporation or burning, as the case may be.

Opening of the passages is of course not restricted to the use of fluid pressure and may also be done, for instance, by introducing a mandrel 21, as shown in FIG. 8.

While it is preferable to utilize powdered metal applied loosely to the plate 11, and in that embodiment it is preferable to perform the operation of applying such powdered metal continuously with rolls as above referred to, all after the separating film had been applied to plate 11, occasionally a powdered metal body 10 is preformed, to be applied in a sintered condition to the plate 11 with the separating film positioned between the sintered body 10 and plate 11 or applied to the underside of body 10. In that case a solder or a suitable brazing

material is interposed between body 10 and plate 11, such as copper powder in the case of the body 10 and the plate 11 being made of steel, and this composite exposed to a brazing temperature sufficient to effect brazing or soldering, as the case may be, of the body 10 to plate 11 in all regions except those treated with the separating layer 12. As a further alternative, but not one that is frequently applied, for reasons of economy a powdered metal body 10 is preformed, to be applied in an unsintered condition to the plate 11 with the separating layer 12 between the unsintered body 10 and the plate 11. Exposure thereafter of the parts to a sintering temperature will act to form the final integral structure, comprising a powdered metal portion and a structural metal portion, thereafter to be flexed or deformed in accordance with the process set forth above.

In practice one may resort to several aids in facilitating the above-described steps. For example, with plates 11 of high polish it is difficult to effect adherence of the powdered metal body 10 without first applying a thin layer of fine metal powder to plate 11 in all areas not coated with weld-preventing substance 12. Such application is performed by stirring the metal powder into a cementing medium, such as an organic lacquer, and applying this suspension including the lacquer vehicle in a film whose thickness is usually less than $\frac{1}{64}$ inch, allowing the lacquer to cement the powdered metal to the plate 11, thus providing an intimate anchor for the remaining powdered metal body 10. At times, the surface of plate 11 was mechanically roughened such as by sand blasting, to further facilitate adherence of the powdered metal body 10.

The thickness of the weld-preventing layer 12 does not appear to be critical inasmuch as a very thin film is sufficient to prevent welding of powdered metal body 10 to plate 11. Such welding is always the result of diffusion of metal from one part into the metal of the other and such diffusion can be prevented by films that are much thinner than the thinnest film resulting from such manufacturing procedures as spraying, painting, etc. which are the inexpensive, obvious choices for this step.

While the above-described figures do not illustrate it, the channels in plate 11 may be formed by pressing or rolling before superimposing the powdered metal layer 10 upon plate 11. In such an instance it will not be sufficient, of course, to apply a thin film 12 to these preformed channels, but instead, it will be necessary to fill such channels flush with the remaining surface of plate 11 so that the unchannelled portions of plate 11 and the exposed surface of the weld-preventing substance are in one plane. If thereafter the steps described above are followed then the resulting object will be essentially the same after sintering as that illustrated in FIG. 4 or FIG. 5.

Those skilled in the art will fully appreciate that through this invention there results an integral sintered metal structure having porous and solid metal portions with fluid conducting channels or passages presented between the porous powdered metal and the solid metal for the purposes set forth.

I claim:

1. The method of making permeable articles having fluid conducting passages therein which comprises interposing a weld-preventing substance in a predetermined pattern between an exposed surface of an impervious metal body and a powdered metal body, sintering said powdered metal body to produce a porous sintered metal body which is bonded to said impervious metal body except in the area of said weld-preventing substance to form a composite structure and deforming one of said bodies so as to separate the impervious and porous bodies in the area of said weld-preventing substance to form fluid conducting passages bounded by said impervious and porous metal bodies.

2. The method set forth in claim 1 in which said pow-

dered metal body is at least partially preformed prior to application to said surface.

3. The method as set forth in claim 1 in which said powdered metal body is preformed and partially sintered prior to application to said surface.

4. The method set forth in claim 1 in which said impervious metal body and powdered metal body are rolled conjointly prior to sintering.

5. The method set forth in claim 1 in which said impervious metal body constitutes a strip which is progressively advanced and said weld-preventing substance and said powdered metal are applied to the strip as it advances and said strip and powdered metal body are disposed in a sintering zone for sintering.

6. The method set forth in claim 1 in which the unbonded area formed by said weld-preventing substance is opened by the application of fluid pressure.

7. The method set forth in claim 1 in which the unbonded area formed by said weld-preventing substance is opened by mechanical means.

8. The method set forth in claim 1 in which the powdered metal body is applied and sintered in two steps, the first step forming a coating over said impervious metal surface and the second step building said coating up to the final thickness.

9. The method set forth in claim 1 in which said porous metal body is held under a confining pressure during the step of opening said passages.

10. The method of making permeable articles having fluid conducting passages therein, which comprises interposing a weld-preventing substance in predetermined areas between an exposed surface of an impervious metal body and a porous sintered powdered metal body and heating the bodies under conditions to join the same at their contacting surfaces except in the areas of said weld-preventing substances to form a composite structure and deforming one of said bodies so as to separate the impervious and porous bodies in the area of said weld-preventing substance to form fluid conducting passages bounded by said impervious and porous metal bodies.

11. The method set forth in claim 10 in which the unbonded area formed by said weld-preventing substance is opened by the application of fluid pressure.

12. The method set forth in claim 10 in which the unbonded area formed by said weld-preventing substance is opened by mechanical means.

13. The method set forth in claim 10 in which said porous metal body is held under a confining pressure during the step of opening said passages.

14. The method of making permeable articles having fluid conducting passages therein, which comprises inelastically deforming an impervious metal body having an exposed surface to produce recesses in a pattern conforming generally to said passages, applying a weld-preventing substance to said recesses and applying a powdered metal body to said impervious metal body and sintering said powdered metal body to form a porous sintered metal body and to cause said metal bodies to bond together except in the area of said recesses.

15. The method set forth in claim 14 in which said powdered metal body is at least partially preformed prior to application to said surface.

16. The method set forth in claim 14 in which said powdered metal body is preformed and partially sintered prior to application to said surface.

17. The method set forth in claim 14 in which the powdered metal body is applied and sintered in two steps, the first step forming a coating over said impervious metal surface and the second step building said coating up to the final thickness.

18. The method of making permeable articles having fluid conducting passages therein, which comprises inelastically deforming an impervious metal body having an exposed surface to produce recesses in a pattern conforming generally to said passages, applying a porous

9

sintered metal body to said impervious metal body and heating the bodies under conditions to join the same at their contacting surfaces whereby said recesses form fluid conducting passages bounded in part by said porous sintered metal body.

19. A compound metal structure comprising a porous sintered metal body bonded to an impervious metal body, said impervious metal body being in the state of having been inelastically deformed to form fluid passages between said bodies along a predetermined pattern bounded on one side by said impervious metal body and on the other side by said porous metal body.

5

10

10

20. A compound metal structure as set forth in claim 19 in which said passages contain a weld-preventing material.

References Cited in the file of this patent

UNITED STATES PATENTS

2,687,278	Smith et al. -----	Aug. 24, 1954
2,946,681	Probst -----	July 26, 1960

FOREIGN PATENTS

731,161	Great Britain -----	June 1, 1955
---------	---------------------	--------------