July 5, 1955 E. W. RICKMEYER 2,712,299

FOUNTAIN PEN

Filed Aug. 24, 1948 2 Sheets-Sheet 1

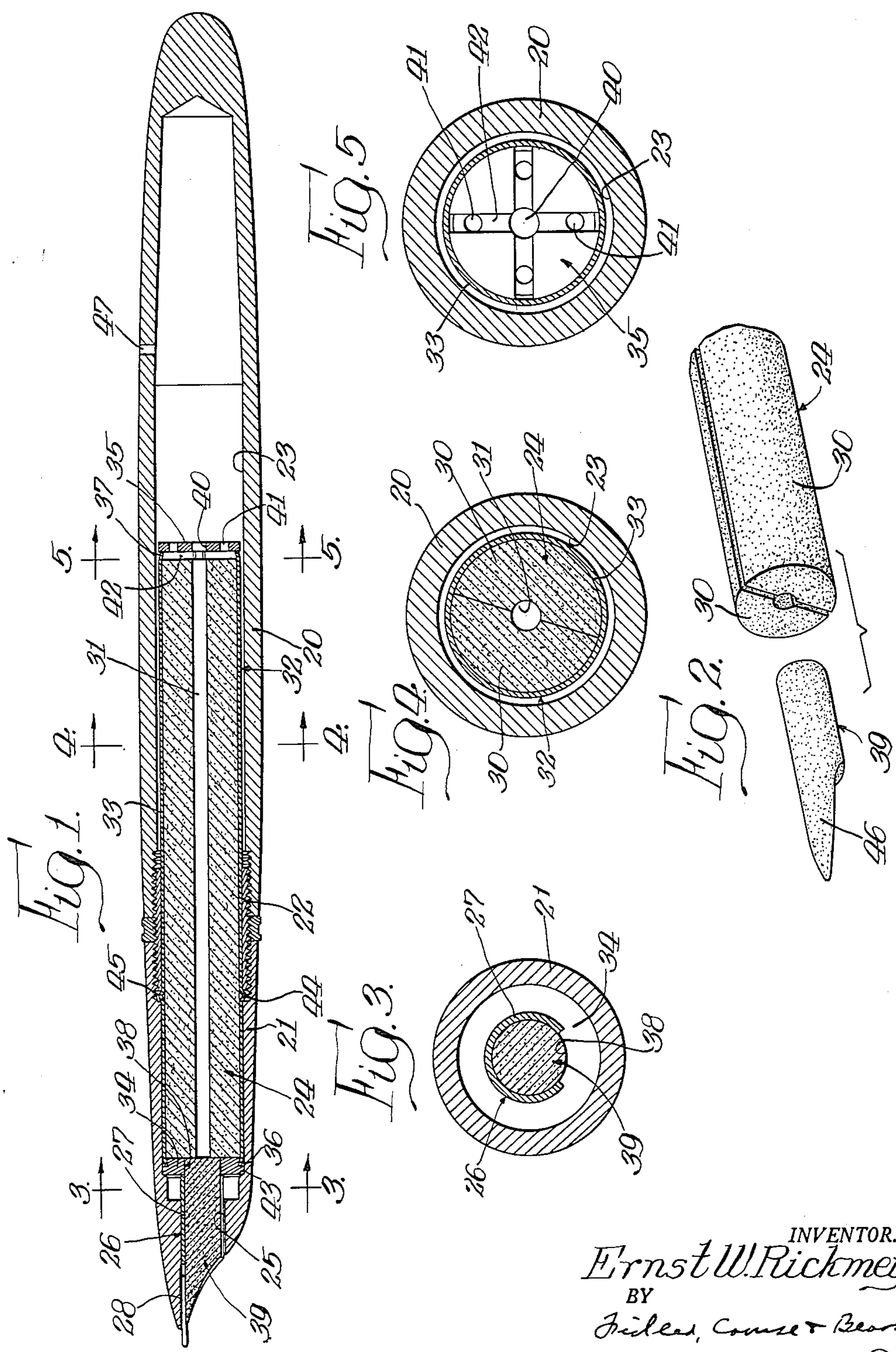

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Fig. 6.

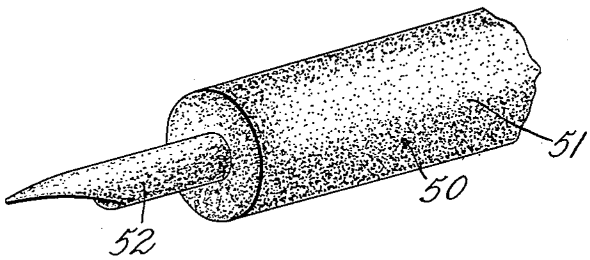

Fig. 7.

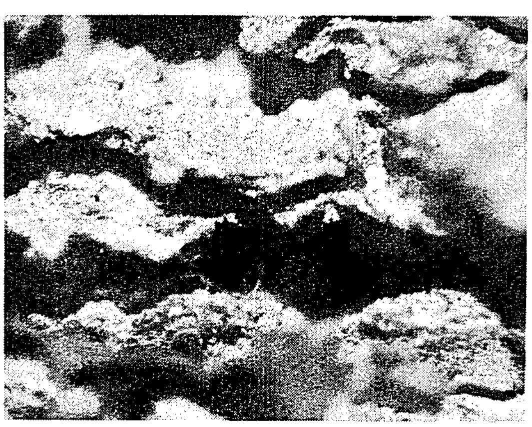

Fig. 8.

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FOUNTAIN PEN

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Application August 24, 1948, Serial No. 45,823

1 Claim. (Cl. 120—50)

This invention relates generally to fountain pens and has to do particularly with capillary feed and filler means therefor. It also relates to a sintered metal especially well adapted for use in forming a capillary element for a fountain pen.

An object of this invention is to provide a new and improved fountain pen.

Another object is to provide an inexpensive capillary fountain pen.

Another object is to provide a capillary fountain pen having a capillary reservoir element wherein—

(*a*) The reservoir element is of porous sintered metal, and more particularly sintered metal whose mass defines relatively large interconnected pores but is itself provided with interconnected pores smaller than the first pores;

(*b*) The nature and size of the pores may be closely predetermined to insure desirable capillary characteristics, and controlled to provide pores of concave shape and rough surfaces;

(*c*) The sintered metal of the reservoir element is free of scale and other foreign matter;

(*d*) The surfaces defining the pores exhibit a high degree of wettability by aqueous inks;

(*e*) The sintered metal has substantial mechanical strength.

Other objects and advantages of my invention will appear from the following description taken in connection with the appended drawings, wherein:

Figure 1 is a longitudinal sectional view of one embodiment of a fountain pen constructed in accordance with my invention;

Fig. 2 is an exploded fragmentary perspective view of the feed bar and capillary filler and reservoir element of the pen of Fig. 1;

Fig. 3 is an enlarged transverse sectional view taken along line 3—3 of Fig. 1;

Fig. 4 is an enlarged transverse sectional view taken along line 4—4 of Fig. 1;

Fig. 5 is an enlarged transverse sectional view taken along line 5—5 of Fig. 1;

Fig. 6 is a fragmentary perspective view of a modified form of capillary filler and reservoir element having an integral feed bar;

Fig. 7 is a reproduction of a photomicrograph of a specimen of material made in accordance with my invention; and

Fig. 8 is a reproduction of a photomicrograph of the specimen of Fig. 7 but turned approximately 90°.

In accordance with the present invention, a fountain pen is provided in which at least a portion of the structure by which the ink is stored and delivered to the writing element is defined by an element formed of porous sintered metal adapted to retain the ink therein by capillary attraction. Such sintered metal element is formed as an integral metal body provided with interconnected pores of such size that they draw in ink by capillary action and retain the ink therein by capillary action except when it is withdrawn in writing.

It will be understood that my invention, in certain of its aspects, is not limited to fountain pens but, as will be seen as the description proceeds, it lends itself to other applications where generally similar capillary characteristics are desired.

Referring now particularly to Fig. 1 of the drawings, the pen comprises a hollow barrel or casing formed of suitable material such as a plastic or a metal, which barrel preferably includes a rear barrel section **20** and a forward barrel section or shell member **21** secured to the rear barrel section **20** as by an externally threaded nipple **22**. The barrel **20** and shell **21** together define a chamber **23** terminating in a reduced bore **25** at the forward end of the shell **21** and adapted to accommodate, respectively, a filler element **24** and a writing element **26** both of which will be described more fully hereinafter. The writing element **26** preferably takes the form of a nib having a generally cylindrical split body portion **27** terminating in a tapered writing tip which is formed with a longitudinally extending slit **28** in a customary manner.

The filler element **24**, so called for convenience, serves as a capillary filler and ink storage element, or reservoir element.

The filler element **24** is formed of porous sintered metal which is described more fully hereinafter and which defines a large number of interconnected cells or pores of capillary size. The sintered metal element may be formed as a single member of elongate, preferably generally cylindrical form, although for convenience in making it, I prefer to form it as two semi-cylindrical members **30** which are assembled in firm face-to-face relation to provide a cylindrical member. For purposes of venting the filler element, a vent passage **31** is provided which extends longitudinally and, preferably, throughout the entire length of such element. This passage is of greater than capillary size in order to permit air to pass freely therethrough, but into which passage ink ordinarily will not enter.

The filler element **24** preferably is enclosed in a casing which forms therewith a unitary cartridge **32** which may be inserted into or removed from the pen barrel as a unit. The casing preferably takes the form of a cylindrical shell or sleeve **33** which fits closely around the filler element **24**, and end plugs **34** and **35** secured to the sleeve as by crimping them into the sleeve as indicated at **36** and **37**, respectively. The forward end plug **34** is formed with a bore **38** extending therethrough adapted to receive a feed bar **39**. The rear end plug **35** is formed with a central opening **40** registering with the vent passage **31** and with filling openings **41** communicating with channel slots **42** extending across the inner face of the plug **35** and communicating with the central opening **40**. The casing may be formed of silver, as is the filler element, as will be brought out more fully later; the end plugs **34** and **35** may be formed of a suitable plastic.

The cartridge **32** is positioned in the barrel in a suitable manner, as by abutting the forward end against a shoulder **43** provided in the barrel and by clamping between a shoulder **45** formed in the barrel and the nipple **22**, a bead **44** formed on the sleeve **33**.

While it will be understood that the filler element **24** may be employed without the casing just described, the casing serves several desirable purposes. The casing prevents damage to the filler element both during assembly with the barrel and when the rear barrel section is removed; moreover, the casing prevents smearing of ink on the interior of the barrel and soiling of the hands when the rear barrel section is removed, as for the purpose of filling the pen from the rear end (as hereinafter described). The casing also serves to retain the several sections of the filler element in assembled relation, where the filler element is formed in several sections; in addition, the casing provides convenient means for supporting the feed bar where the latter is formed separately from the filler element and also may serve to maintain the separate feed bar in feeding relation to the capillary filler element. Furthermore, the casing serves to reduce evaporation of ink from the filler element.

The capillary spaces within the filler element **24** are connected in ink feeding relation to the nib slit **28** by the feed bar **39** which, in accordance with the present invention, is formed of sintered metal preferably similar to the metal from which the filler element **24** is formed. The feed bar is of generally cylindrical shape and preferably is provided with a tapered forward end **46** to permit holding the pen at a suitable writing angle to the paper. The rear end of the feed bar **39** extends through the opening **38** in the forward end plug **34** and firmly abuts the forward end of the filler element **24** to place the capillary spaces of the feed bar in ink feeding communication with the capillary spaces of the filler element **24**. The nib **26** is of such size that it firmly grips the feed bar **39** and is maintained thereon with the under face of the top of the nib in firm contact with the upper surface of the feed bar so that the slitted portion of the nib is held in close contact with the feed bar. Preferably, also, the nib is firmly held frictionally in the bore **25** so that the nib and feed bar are prevented from being displaced during use. The bore **25** may be relieved above the slitted portion of the nib **26** to permit flexing of the nib, although, if desired, the nib may be firmly held against flexing. In order to insure firm contact between the slitted portion of the nib and the corresponding surface of the feed bar, either the nib or feed bar may be formed with a slightly oval cross section so arranged that, when the nib is telescoped over the feed bar, the nib is distorted slightly to cause the upper portion to bear firmly against the corresponding portion of the feed bar.

The pen may be filled by inserting the writing end in a supply of ink to a sufficient depth to immerse the forward portion of the feed bar in the ink. Ink is drawn by capillary action into the feed bar **39** and from thence into the filler element **24**. As the ink rises in the capillary filler element **24**, air which was in the capillary spaces is forced therefrom and passes out through the vent passage **31** and vent opening **40** into the chamber **23** from which it escapes through a vent opening **47** provided at a suitable location in the barrel. The pen also may be filled by inserting the rear end of the filler element in the ink after having removed the rear barrel section **20**. The rear end of the cartridge **32** is inserted in the supply of ink a sufficient distance to immerse the rear of the filler element **24**, whereupon by reason of the communication provided by filling openings **41** and slots **42** ink enters the casing **32** and contacts the rear end of the filler element **24**. As ink rises in the filler element **24**, air which was in the capillary spaces is forced therefrom and into the vent passage **31**, from which it is forced out at the bottom (rear) end of the cartridge and bubbles up through the supply of ink.

Since the capillary cells or spaces in the filler element and feed bar are interconnected, they constitute a plurality of passages extending throughout the filler element and feed bar. Ink, therefore, stands in the filler element and feed bar in a plurality of interconnected continuous columns, which are supported by the capillary attraction exerted by the capillary spaces.

The capillary spaces in the filler element are of such size as to lift the ink to the top of the filler element when the pen is held in a vertical position in filling. While this size may differ under different conditions, excellent results have been obtained by employing a filler element having spaces of approximately 0.005″ maximum wall-to-wall size. The nib slit is of smaller width than the capillary spaces in the feed bar or the filler element and preferably is approximately 0.0015″ in width. Accordingly, ink will be drawn from the feed bar **39** into the nib slit so that ink is maintained always in the nib slit and the pen is always in condition for instant writing. Whenever ink is withdrawn from the nib slit, as in writing, further ink is drawn by capillary action into the nib slit from the feed bar and ink is drawn by capillary action from the filler element into the feed bar. It will be understood, as this description proceeds, that by reason of the nature of the sintered metal feed bar, the exterior surface is not microscopically smooth but is formed with innumerable hills and valleys, the latter of which are supplied with ink by reason of being connected with the capillary cells or pores within the porous metal. Ink therefore stands on the surface of the feed bar in pools formed by the valleys and by reason of the wettability of the metal may also form a film over the hills. Thus, the ink, generally speaking, forms a film of varying thickness on the surface of the feed bar. Inasmuch as the upper surface of the feed bar is in close contact with the under surface of the slitted portion of the nib, ink is drawn from the film of ink which stands on the upper surface of the feed bar. Preferably the capillarity of the feed bar is greater than that of the filler element, and the capillarity of the nib slit is greater than that of the feed bar.

Where, as in the above described embodiment of my invention, the pen is constructed so as to permit rear end filling, and it is desired to employ such method of filling, the forward, exposed surface of the feed bar may be sealed to prevent evaporation of ink therefrom and to prevent soiling the fingers or clothes of the user should they come in contact therewith. Such sealing may be conveniently provided by burnishing the surface to be sealed, this being readily accomplished inasmuch as the feed bar is formed of metal which at its surface may be worked sufficiently by pressure to cause it to seal those pores which extend through the surface of the member.

While I prefer to form the filler element **24** and feed bar **39** separately, primarily because of convenience in sintering, these members may be formed integrally as illustrated in Fig. 6 of the drawings. In such case, the member **50** which is formed of sintered material, constitutes both the filler element of the capillary system and the feed bar or feed element. An integrally formed member of this construction is advantageous in that the necessity of maintaining the abutting relationship between the feed portion and the reservoir portion is eliminated. The integral member **50**, as will be understood, may be provided with a longitudinally extending vent passage (not shown) which extends throughout the reservoir portion from the rear end thereof to at or near the juncture of the reservoir portion and the feed bar portion.

The mass of the material forming the filler element is actually sintered and resintered—small particles are sintered to form larger particles which are therefore porous, and the larger particles are themselves sintered to form larger pores, and the finished mass then has small interconnected pores distributed substantially uniformly throughout the metal mass and connected to the large pores. The small pores have a maximum wall-to-wall dimension which is only a fraction of that of the principal pores and the former may be as small as ⅒ the size of the principal pores.

In practicing this process, I may employ any of the metals designated hereinbelow and for forming capillary members for fountain pens, I prefer to use silver. The metal is employed in the form of a fine powder, and preferably is sufficiently fine to pass through a 325 mesh sieve. The metal powder is mixed with a suitable lubricant such as stearic acid or a suitable stearate, and the mixture rolled out in a layer from approximately 0.010″ to approximately 0.020″ thick on a smooth surface defined by a refractory material, such layer being several particles thick. Where silver is employed, material thus in layer form on a plate or other refractory member is sintered at a temperature of from around 550° C. to around 650° C. in the presence of normal atmospheric air for approximately ½ hour to agglomerate the particles. Where other metals than silver are used, it is important that such sintering be carried out in a suitable atmosphere to insure that no deposit is formed on the surface of the metal.

The sheet thus formed is broken up in a suitable manner to form porous particles which are at least as coarse as 100 mesh particles and which may be as coarse as 20 mesh. In other words, the porous particles formed by breaking up the agglomerated sheet are from 3 to 10 times as large as the powdered particles initially employed in forming the sheet.

It is preferred that the sintered metal member be formed of silver, because of the ease of sintering silver and the desirable wettability by inks of the types customarily used in pens. However, other metals such as gold, nickel, tantalum or alloys thereof, and stainless steel are satisfactory. Among the alloys which have been found satisfactory are gold alloys including gold-copper, gold-silver, and gold-silver-copper alloys; silver alloys including silver-nickel, silver-nickel-copper, and silver-nickel-copper-gold alloys; and nickel alloys including nickel-gold, nickel-silver, and nickel-copper alloys. While an 18-8 stainless steel alloy may be employed, I prefer to employ one containing a somewhat higher percentage of nickel in order to provide a somewhat greater wettability characteristic.

The porous particles thus produced are mixed intimately with a material which serves initially to maintain the particles in a relatively open mass, which material is driven off during the sintering operation, and without adversely affecting the sintering operation, to leave interconnected pores or spaces of the desired size when the metal particles are integrally joined as a result of the sintering operation. This added material is for convenience designated as a "spacing" material. For this purpose, I employ a solid material which will be driven off during the sintering operation in gaseous form or in the form of a gaseous product or products resulting from the heating. This material is one which is driven off at a relatively low temperature and which will not leave any deposit or residue on the metal. In order to permit intimate mixing between the filler material and the metal powder, the former material is employed in finely powdered condition. One material that has been found to give excellent results as a filler material is ammonium bicarbonate; but it is to be understood that any known material having the essential characteristics mentioned may be employed.

The filler material is employed in sufficient proportion and in such degree of fineness as will provide the desired pore size, and in a preferred process for forming a capillary element for a pen, I use approximately 67.5%, by weight, of silver powder and 32.5%, by weight, of ammonium bicarbonate, although excellent results have been obtained within the range of 60% silver powder and 40% ammonium bicarbonate to 75% silver powder and 25% ammonium bicarbonate. Excellent results have been obtained by using ammonium bicarbonate of a size from −18 to +50 mesh.

In addition to the powdered metal and filler material, I prefer to employ a lubricant for permitting ready molding of the powder mixture in a mold under pressure in order to form a member having the desired shape and size. For this purpose, I include approximately 1%, by weight, of a suitable lubricant in the mixture, which upon heating will not leave any undesirable residue. While various lubricants may be employed, in accordance with known sintering practice, I prefer to use stearic acid or a suitable stearate such as zinc stearate, copper stearate, aluminum stearate or cadmium stearate. The lubricant is employed in finely powdered form and preferably is substantially finer than the other materials with which it is mixed. The metal powder, filler material and lubricant are mixed or blended to effect as uniform as possible an intermixture.

The mixture is then molded under pressure to provide a molded mass or blank having the shape desired in the finished article and a size which upon sintering will produce an article of the desired size, taking into consideration the shrinkage resulting from the sintering operation, as will be well understood in the art. The mixture is molded in accordance with known practice under a sufficient pressure so that the blank will retain its shape until the sintering operation has been completed, and to compact the mass to bring the metal particles into mutual contact. In the preferred embodiment of my invention, a molding pressure of from 3 to 7 tons per square inch is employed. It will be noted in this connection that the pressures employed are substantially lower than the pressures employed in conventional sintering practice which are several times the pressures here employed.

The molded mixture or blank is sintered at a suitable temperature and for a sufficient length of time to unite the particles integrally but without melting them. Also, in the course of such heating, the spacing material is driven off in gaseous form. Preferably the sintering is carried out at a temperature approximately ⅔ of the melting point of the metal and in the present process where silver is employed as the metal, the sintering is carried out at a temperature of from around 550° C. to around 650° C. for a period of approximately one hour. It will be understood, of course, that where other metals than silver are employed, the temperature and time will be selected correspondingly to effect the desired results. The sintering preferably is carried out in an electric furnace although other heating methods may be employed, as will be understood. Where silver is employed as the metal, excellent results have been obtained by sintering in the presence of normal atmospheric air inasmuch as silver does not oxidize under such conditions. However, where other metals are employed which oxidize at the temperatures used in sintering, a suitable inert atmosphere must be employed in accordance with known practice in order that the surfaces (both external and internal and especially the external surfaces) of the sintered metal member will be free of any foreign deposit such as oxides.

It should further be explained at this point that care should be taken through the process to insure that no deposit is formed on the metal which would reduce the wettability. Accordingly, great care should be taken to insure that the starting materials are sufficiently pure and free of foreign matter and that during each phase of the process no foreign matter is introduced which would cause an undesirable deposit on the metal surfaces.

I have found in practicing the above described process that it is important that the filler material be in a dry state both preliminary to mixing it with the other ingredients of the mixture and after the mixing has been accomplished and the molding step performed. Inasmuch as ammonium bicarbonate is quite hygroscopic, it is essential that even where this material is initially in dry condition, the various steps in the process be carried out without undue delay in order to prevent absorption of moisture by the ammonium bicarbonate and resulting adverse effects.

I have found that the above described difficulties resulting from the use of ammonium bicarbonate may be eliminated by employing in lieu of such material a material which is not hygroscopic, whereby the several steps in the process may be performed at wider spaced intervals, if desired. I have found that amorphous carbon may be used with excellent results as a filler material. In addition to its non-hygroscopic properties, carbon lends itself more satisfactorily to blending than ammonium bicarbonate.

The process above described may be practiced using amorphous carbon in lieu of ammonium bicarbonate. The silver powder may be of the same mesh and in the same proportion and the carbon may also be of approximately the same mesh, although excellent results have been obtained using carbon powder of a size from −18 to +70 mesh. These materials are mixed with the lubricant and molded as described. Likewise, the sintering is carried out in a manner similar to that described, with the exception that the mixture is maintained at the sintering temperature for a longer period of time, and preferably from two to three times as long as where ammonium bicarbonate is employed. The carbon, of course, does not sublime upon sintering but does form gaseous oxides which pass out of the metallic mass when the mass is sintered. It is essential that where carbon is employed, the sintering be carried out in an oxidizing atmosphere.

I have found also that a high melting point hydrocarbon wax selected from those having melting points of from around 180° C. to around 200° C. may be employed as a spacing material in lieu of ammonium bicarbonate or amorphous carbon.

The metal resulting from the process thus far described contains interconnected pores which are concave in shape and have rough irregular surfaces. The pores are substantially entirely interconnected so that there are a minimum number of closed isolated pores or voids in the metal. Moreover, the surfaces of the metal defining such interconnected pores are clean and free of any deposit so that they exhibit a wetting characteristic substantially equivalent to that of the metal before sintering. It will be understood, of course, that the surfaces of the metal which define the pores are very rough and irregular and for that reason are somewhat more wettable than would be smooth or polished surfaces of the same material. The pores thus fill rapidly and completely.

The porosity of the material resulting from this process is very high, thus insuring a relatively large ink storage capacity in an element of any particular size. For example, where 60% of silver and 40% ammonium bicarbonate is employed as above described, the sintered metal has a porosity of around 82%; where 67.5% silver is used, the porosity is around 78% and where 75% silver is used, the porosity is around 75%.

A photomicrograph of a specimen of material made in accordance with the process just described is reproduced in Figs. 7 and 8 of the drawings. Fig. 7 shows generally the faces of the particles, whereas Fig. 8 shows generally the edges, the specimen having been turned approximately 90°.

Alternatively, excellent results may be obtained by omitting the spacing material. In such case, the porous particles are mixed with a suitable lubricant, as for example stearic acid or a suitable stearate. The lubricant may be employed in an amount of from around 0.25% to around 6% of the total mixture. The mixture is inserted in a cavity of suitable shape formed in a mold or other suitable container. The cavity is progressively filled while vibrating the mold or container, either continuously or intermittently, in order to suitably orient the porous particles; that is to say, the porous particles are caused to arrange themselves, in general, with their flat faces substantially parallel. No molding pressure is applied to the mixture but preferably a light pressure is applied to lightly compact the particles in the mold. The mixture in the cavity is then sintered at a suitable temperature and for a suitable time to bond the particles into a unitary porous mass. Where the particles are formed from silver, the mixture is sintered in air at a temperature of from around 550° C. to around 650° C. for approximately one hour.

The metal produced by the foregoing process comprises a unitary porous rigid mass which is provided with relatively small, interconnected pores all of sustantially the same order of size and distributed throughout the mass. Such porous mass itself defines larger pores which are several times—for example, up to ten times—the size of the small pores. The large pores are of suitable capillary size to draw ink therein by capillary action and to retain the ink by capillary action except when withdrawn, as in writing. Since the small pores are of substantially greater capillarity than the large pores, ink will be drawn from the large pores into the small pores. It will be understood, of course, that the large pores, because of their nature, are directly interconnected with one another, and in addition, they are connected by means of the small pores in the porous mass. Accordingly, when ink is withdrawn from the sintered metal member, the large pores first are emptied and thereafter the small pores. Inasmuch as the small pores communicate extensively with the large pores, any ink which is in those portions of the large pores having a relatively small wall-to-wall distance and which therefore exhibit a capillarity greater than the effective capillarity of the larger portions of the large pores, is drawn from such smaller portions of the large pores by reason of the greater capillarity of the small pores. Therefore, substantially no ink will be retained in the large pores against the capillarity established between the writing element and the writing paper, even though the capillarity of those portions of the large pores which have the smallest wall-to-wall dimension may be so great as to prevent withdrawal of the ink therefrom were it not for the provision of the small pores. In other words, the structure of the metal of this embodiment of my invention provides a plurality of large interconnected channels to which are connected interconnected channels of smaller size and greater capillarity which latter channels serve effectively to exhaust the ink from all portions of the large channels.

The provision of the small pores serves still another desirable function, namely, that of imparting a high degree of wettability of the large pores which insures rapid filling of the member by capillary action. The small pores being of relatively great capillarity will lift the ink from the source of supply to a relatively great height with substantial rapidity. The ink thus stands at the orifices of such small pores where the latter open into the large pores. Since the small pores are relatively closely spaced, the plural menisci at such orifices provide closely spaced liquid surfaces along the walls defining the large pores. Therefore, when ink is drawn into the large pores, it contacts such ink surfaces and bridges across the metal surface between such ink surfaces and thus the ink rises more rapidly along the walls of the large pores than it would were the walls defined solely by the solid metal. The small pores thus constitute pilot passages which are first filled with ink and which cause ink to stand at the surfaces of the large pores so that such latter surfaces will be rapidly wetted by the ink entering the large pores with the result that the large pores are rapidly filled. Thus, the small pores provide the initial lifting action on the ink and the large interconnected pores permit rapid rise of a relatively large volume of ink in the porous metal member.

The mixture of porous particles and lubricant may be deposited in a cavity formed in a refractory mold, in which case, upon sintering, the mass of particles shrinks away from the walls of the cavity and, when the sintering has been completed and the mold removed from the furnace, the sintered member may be readily removed from the mold. On the other hand, where it is found desirable to enclose the molded member in a metal sheath or casing—as, for example, in forming a unit such as the cartridge 32 described above—a somewhat different procedure may be employed advantageously. In the latter case, instead of employing a refractory mold, a metal tube is provided which defines the cavity and into which the powdered mixture is deposited. The metal tube is formed of a material to which the porous metal particles will be bonded during the sintering operation. Preferably, therefore, the tube is formed of the same material as the metal forming the particles. In this process, the particles adjacent the metal tube will become bonded to the tube by the sintering operation with the result that upon completion of the sintering operation a unitary structure is provided consisting of a porous metal mass enclosed within and bonded to a thin metal enclosing shell.

The expression "sintered metal" as used herein will be understood to mean a metal formed by sintering powdered metal. Except where otherwise expressly stated herein or indicated by the context of the description, it will be understood that the term "metal" includes not only a single elemental metal but also alloys of two or more such metals.

In preparing each of the photomicrographs reproduced herein, specimens of the material made in accordance with the described process were fractured to expose the interior of the material and the photomicrographs were taken at a magnification of 50 ×.

I claim:

A fountain pen comprising a casing, a writing element mounted in the casing, a capillary filler and reservoir element mounted in the casing and comprising a member formed of sintered and re-sintered metal wherein the re-sintered metal is composed of sintered particles, and wherein the re-sintered metal has interconnected spaces between the sintered particles and each of the sintered particles has interconnected spaces of smaller size than the first mentioned spaces, said spaces being defined by relatively rough wall surfaces, and means connecting said spaces in capillary ink feeding relation with said writing element.

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