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FOUNTAIN PEN

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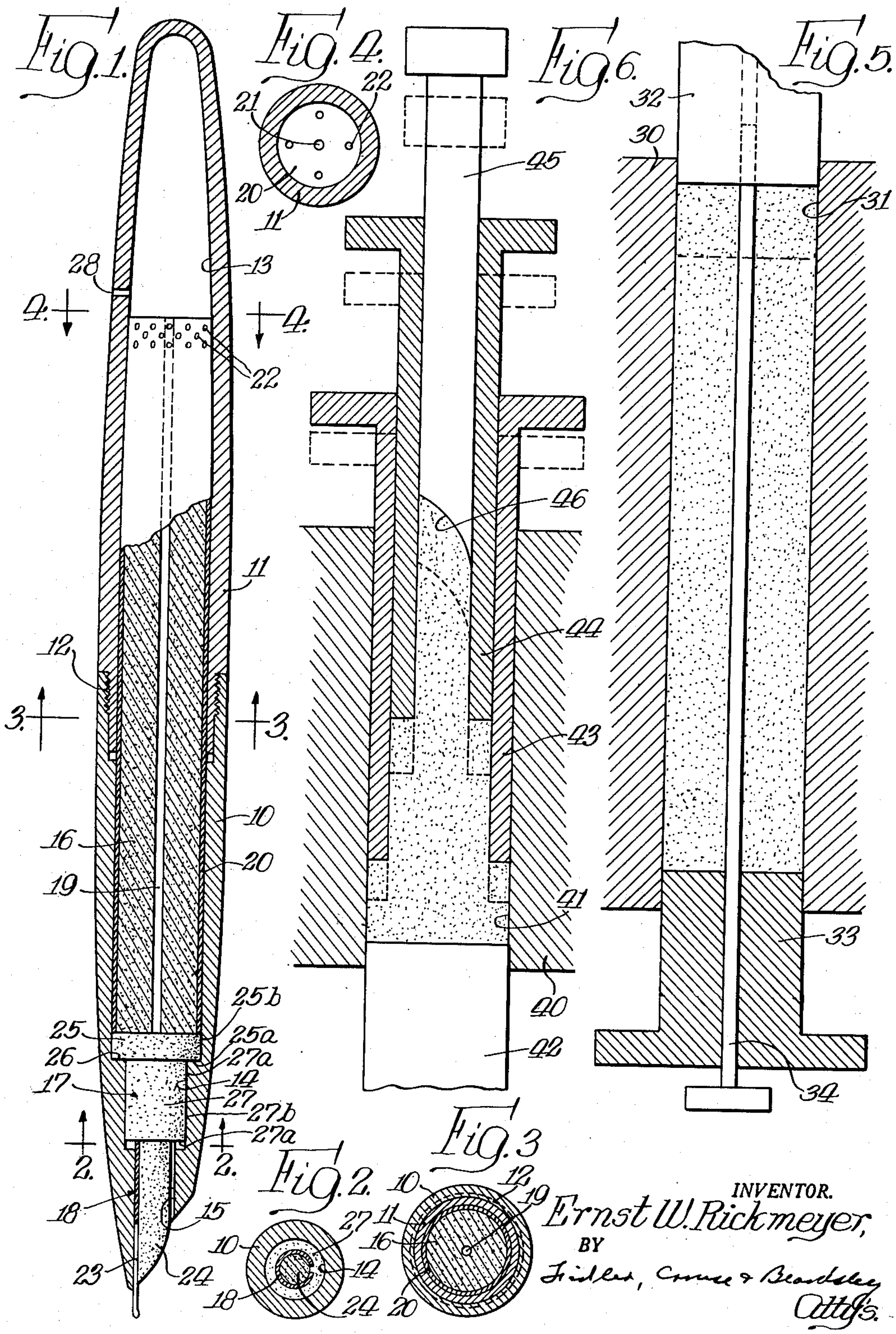

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FOUNTAIN PEN

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4 Claims. (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 member especially well adapted for use in forming a capillary element for a fountain pen and to a method of forming such sintered metal member.

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

Another object is to provide a fountain pen having an improved capillary element, or elements, formed from porous sintered metal for feeding or storing ink, or both, by capillary action.

Another object is to provide a capillary filling fountain pen having a capillary element formed from porous sintered metal and in which member the capillarity is greater in one portion than in another.

Another object is to provide a fountain pen feed element formed from sintered porous metal having a greater capillarity in one portion than in another.

Another object is to provide a fountain pen with a capillary filler and reservoir element in which the capillarity is greater at one end portion than at the other end portion.

Another object is to provide a porous sintered metal capillary element for a fountain pen in which element the capillarity is progressively greater from one portion of the member to another portion.

Another object is to provide a porous sintered metal capillary member having a predetermined capillarity which is greater at one portion of the member than at another.

Another object is to provide a method of forming a porous sintered metal capillary member having a greater capillarity in one portion than in another.

Another object is to provide a capillary filling fountain pen having improved filling and write-out characteristics.

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

Figure 1 is a longitudinal sectional view through a fountain pen embodying my invention;

Fig. 2 is a transverse sectional view taken along line 2—2 of Fig. 1;

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

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

Fig. 5 is a somewhat diagrammatic vertical sectional view taken through a mold employed in forming the capillary filler and reservoir element constituting a portion of the pen of Fig. 1; and

Fig. 6 is a somewhat diagrammatic vertical sectional view taken through a mold employed in forming the feed element constituting a portion of the pen of Fig. 1.

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 a member formed of porous sintered metal. The pores in the metal are of such size that they draw ink in by capillary action and retain the ink therein by capillary action except when it is withdrawn, as in writing. In order to provide such capillary action, the surfaces of the metal which define the pores are suitably wettable by the inks with which the pen embodying such capillary element is adapted to be used. To this end, the metal is one which is suitably wettable

and the metal member is so formed that the surfaces defining the pores are free of any foreign matter which might impair the wettability of the surfaces. The metal also is corrosion resistant and not subject to oxidation at temperatures to which the member is subjected in use.

It will be understood that my invention is not limited to fountain pens but, as will be seen as the description proceeds, it lends itself to other applications where generally similar conditions exist.

The invention is particularly well adapted for application to a pen of the capillary filling type wherein a capillary filler and ink storage, or reservoir, element (hereinafter for convenience designated as the "filler element") is connected in capillary, ink-feeding relation to the writing element, whereby ink is drawn into the pen to fill the pen by capillary action when the filler element is placed in ink feeding communication with a supply of ink, the ink is retained in the filler element by capillary attraction and is supplied to the writing element under capillary control to replace ink which is withdrawn in writing. In a preferred form of my invention, the filler element as well as the feed element which connects the filler element to the writing element is formed of porous sintered metal, although as described more in detail herein, the feed element may be employed with other types of ink storage means.

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 and which includes a forward barrel section **10** and a rear barrel section **11** connected as by a threaded joint **12**. The barrel defines a chamber or bore **13** having preferably a reduced forward portion **14** terminating in a reduced bore **15** and adapted respectively to receive a filler element **16** and feed element **17**, both of which are described more fully hereinafter.

A writing element **18** which extends through the bore **15** preferably takes the form of a nib having a generally cylindrical, split body portion terminating in a tapered writing tip having a longitudinally extending slit in a customary manner.

The filler element in its preferred embodiment is formed to provide a plurality of interconnected spaces of small capillary size adapted to retain ink by capillary action and preferably is formed of porous sintered metal in a manner more fully described hereinafter. The sintered metal element preferably is formed as a single unitary member of elongate, preferably cylindrical shape. The filler element **16** may, for convenience in moulding, be formed as two semi-cylindrical members which are placed in face-to-face abutment to form a single cylindrical structure. The filler element **16** preferably has an air vent passage **19** extending longitudinally throughout its length, which passage is of substantially greater size than the pores in the metal in order to permit air to pass through such passage and into which passage ink normally will not be drawn from the pores.

The filler element **16** preferably is enclosed in an elongate tubular casing or shell **20** open at its front end and having a closed rear end wall. The shell **20** is provided with a central vent opening **21** in its rear wall communicating with the passage **19** and with filling openings **22** in the rear wall and also preferably in the side wall adjacent the rear end thereof. The filler element **16** and shell **20** form a cartridge which is maintained against rearward displacement in the barrel in any suitable manner and conveniently by tapering the wall of the chamber **13** in the rear barrel section **11** so that it wedgingly engages the casing when the rear barrel section is screwed into the forward barrel section.

While the filler element **16** may be employed without the casing, the casing provides a number of advantages. Among other things it prevents damage to the filler element during assembly with the barrel and when the rear barrel section is removed; smearing of ink on the interior of the barrel, and the soiling of the hands of the user when the rear barrel section is removed, as for the purpose of filling the pen from the rear end (as hereinafter described); it also reduces evaporation of ink from the filler element.

The capillary spaces within the filler element 16 are connected in ink-feeding relation to the nib slit 23 by the feed element 17 which, in accordance with the present invention, is formed of sintered metal generally similar to the manner in which the filler element is formed. The feed element 17 preferably is of generally cylindrical shape and includes a feed bar section 24 having a tapered forward end to permit holding the pen at a suitable writing angle to the paper. The feed element 17 also is formed with an enlarged head section 25 adapted to abut at its rear end the forward end of the filler element 16; the head section may abut at its forward portion against shoulder 26 at the juncture of the chamber 13 and reduced portion 14 to prevent forward displacement of the feed element 17. While the feed element may be formed merely with the feed bar section 24 and head 25, preferably an intermediate section 27 is provided between the feed bar section 24 and head section 25.

The pen may be filled by inserting the writing end in a supply of ink to a sufficient depth to immerse the forward end of the feed bar section in the ink. The ink is drawn by capillary action into the feed bar section 24 and rises in the feed element 17 from whence it is drawn into the filler element 16 at the forward end thereof. As the ink rises in the filler element 16, air which was in the capillary pores or spaces is forced therefrom and into the vent passage 19 and passes rearwardly therethrough and through the vent opening 21 into the chamber 13 from which it escapes from the barrel through a vent opening 28 provided at a suitable location.

The pen also may be filled by inserting the rear end of the filler element 16 in the supply of ink after having removed the rear barrel section 11. The rear end of the cartridge is inserted in the supply of ink a sufficient distance to immerse the rear end of the filler element 16, whereupon ink enters the casing 20 through the filling openings 22 and is drawn into the filler element 16. As ink rises in the filler element 16, air which was in the capillary spaces therein is forced therefrom and into the vent passage 19 from which it is forced out at the bottom (rear) end of the cartridge and bubbles up through the supply of ink.

The capillary pores or cells in the filler element and feed element are interconnected and constitute in effect a plurality of passages extending throughout these elements. Ink, therefore, stands in these elements in a plurality of interconnected, continuous columns which are supported by the capillary attraction exerted on the ink 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 fine capillary width, for example, 0.0015", and has a greater capillarity than the capillary spaces in the feed element or filler element. Accordingly, ink will be drawn into the nib slit from the feed bar section 24 so that ink is maintained always in the nib slit and the pen is in condition for instant writing. Whenever ink is withdrawn from the nib slit as in writing, further ink is drawn into the nib slit from the feed bar section and ink is drawn by capillary action from the filler element into the feed element. It will be understood, as this description proceeds, that by reason of the nature of the sintered metal feed bar section, 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 metal. Ink, therefore, stands on the surface of the feed bar section in pools formed by the valleys and by reason of the wettability of the metal may also form a film over the hills. Accordingly, the ink, generally speaking, forms a film of varying thickness on the surface of the feed bar section. Inasmuch as the upper surface of the feed bar section is in close contact with the under surface of the slitted portion of the nib, ink is drawn into the nib slit from the film of ink which stands on the upper surface of the feed bar section.

In order to insure that ink will be drawn from the capillary filler element and toward the nib slit regardless of the position of the pen, preferably the feed element is formed with a capillarity which is greater than that of the filler element, the capillarity of the feed element being less however than that of the nib slit. To this end the pores in the feed element are smaller than the pores in the filler element. Moreover, it has been found generally desirable to form the feed bar section with a capillarity which is greater than that of the remaining portions of the feed element. Where the pen is to be filled from the rear end, it is preferable to form the filler element with a capillarity which is greater at the forward portion than at the rear portion. Accordingly, the pores are made smaller in the forward portion than in the rearward portion. Thus, ink will be drawn from the rearward portion of the filler element toward the forward portion by capillary action both during filling and during writing. On the other hand, where the pen is intended to be filled from the front end, it may be found preferable to so form the filler element with smaller pores at the rear end so that it has a greater capillarity at the rear end than at the forward end.

The filler element 16 and feed element 17 are formed of metal which is satisfactorily wettable by inks of the types with which the pen is to be used. Among the metals which have been found satisfactory are silver, gold, nickel, tantalum or alloys of such metals and stainless steel; however, I prefer to employ silver by reason of its several desirable properties including those herein set forth. I have also found it preferable to employ silver in forming the sleeve 20, although other materials may be employed.

While capillary elements for writing pens may be formed by known metal sintering processes, I have found that elements thus formed are not always satisfactory. The pores in metal elements thus formed are of such shape that a very great capillary attraction is produced in portions of such pores and consequently, while the ink will be drawn readily into the pores by capillary action, it will be so strongly retained in portions thereof that it will not readily be withdrawn when the pen is used in writing. Thus, some or all of the ink in such capillary element will be retained against writing out with the result that the refill capacity of the element is undesirably low. In this connection, it will be understood that in a capillary pen, wherein ink is retained in the capillary system by capillary action, such ink is withdrawn in writing by reason of the fact that the capillarity established between the writing element of the instrument and the writing surface (for example, writing paper) is sufficient to overcome the capillary action which serves to retain the ink in the pen when the latter is not used in writing. In addition, the surfaces which define the pores are generally smooth and are not readily wettable and accordingly the capillary element will not fill rapidly and completely.

In accordance with a preferred embodiment of the present invention, the sintered metal capillary elements are so formed that the interconnected pores therein, which serve as primary liquid storage or feed spaces, are of concave shape and the wall surfaces which define such pores are rough and irregular. Such elements may be formed as disclosed in my co-pending application entitled "Fountain Pens," executed on August 17, 1948, Serial No. 45,823, filed August 24, 1948.

The sintered metal member which is to constitute the capillary element is formed from a suitable powdered metal and for this purpose I have found silver generally preferable, especially where the element is to be used in a pen, 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 metal is prepared in the form of a fine powder, and for forming capillary elements for pens, I use in one embodiment of my invention a powder wherein the particles or granules range in size from −18 to +50 mesh (that is to say, the powder will pass through an 18 mesh sieve but will not pass through a 50 mesh sieve). It will be understood, of course, that the powder sizes may vary considerably, depending upon the size of pores which are desired. The particles or granules preferably are of irregular shapes.

The metal powder is mixed intimately with a material which serves initially to maintain the powder 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; 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 moulding of the powder mixture in a mould 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 moulded under pressure to provide a moulded 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 moulded 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 moulding 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 moulded 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.

In the process just described, the mixture of powdered material is moulded in such manner that when it is sintered the pores in one portion of the member thus formed are of smaller size and greater capillarity than the pores in another portion of the member. To that end, the powder is so moulded that it is compacted to a greater extent in that portion of the powder which is to form the portion having the smaller pores than in the remainder of the mixture. In forming the filler element **16**, for example, the powder is deposited in a mould **30** having a cavity **31** of cylindrical shape open at the top and bottom. A top punch **32** and a bottom punch **33** are mounted for slidable movement into the cavity **31**. The bottom punch **33** is positioned within the cavity whereafter the powder to be moulded is inserted in the cavity and the top punch **32** caused to enter the cavity into contact with the upper end of the mass of mixture. Thereafter the bottom punch **33** is maintained in stationary position and moulding pressure is applied to the top punch **32** to compact the mass of powder in the mould to the desired extent. Since the top punch **32** is moved while the bottom punch **33** is held stationary the powder in the upper portion of the mould is compacted to a greater extent than the powder in the lower portion of the mould. Therefore, when the moulded powder is sintered, as hereinafter described, the resulting porous sintered metal member has pores of smaller size at the end portion formed by the material which was more greatly compacted during the moulding operation than at the other end.

Where it is desired to provide a longitudinally extending vent opening in the filler element, a core rod **34** is provided which preferably extends through the bottom punch **33**, the cavity **31** and into a suitably provided recess in the top punch **32**.

The mixture of powdered material which is to form the feed element is moulded in a generally similar manner to that employed in moulding the powder to form the filler element. That is to say, the powder is compacted to a greater degree in those portions of the mass within the mould which are to form the portions of the feed element of greater capillarity.

To this end, a mould **40** is provided having a mould cavity **41** preferably of generally cylindrical shape and into which a bottom punch **42** is movable to close the lower end of the cavity **41**. Where a feed element having the shape of the feed element **17** is to be formed, two generally cylindrical punches are provided, namely, an outer punch **43** fitting snugly in the cavity **41** and an inner punch **44** telescoping snugly within the outer punch **43**. A center punch **45** of solid cylindrical form is telescoped within the inner punch **44** and is formed with an end face **46** suitably shaped to provide the desired shape at the forward end of the feed bar.

The bottom punch **42** is inserted in the cavity **41** and the punches **43** and **44** inserted in the mould to the positions shown in Fig. 6 of the drawing. The mixture is then deposited in the cavity provided by the mould 40 and punches 42, 43 and 44, whereafter the center punch 45 is inserted within the inner punch 44 and urged against the top of the powder. The bottom punch 42 is held stationary with respect to the mould 40 and the punches 43, 44 and 45 are advanced into the mould from the positions shown in full lines to the positions indicated in broken lines, respectively. The punch 44, however, is moved a greater distance into the mould 40 than the punch 43 and the punch 45 is moved a greater distance than the punch 44. Accordingly, the portion of the powder which lies directly under the lower face of the punch 44 is compacted to a greater degree than the portion which lies directly under the lower face of the punch 43. Likewise, the portion of the powder which lies under the lower face of the punch 45 is compacted to a still greater degree than in the remainder of the mould. The moulded mass is then removed from the mould and sintered as above described.

The feed element thus produced has pores of different sizes in the different portions thereof. The pores in the feed bar section 24 are the smallest and have the greatest capillarity. The pores in the outer portion of the intermediate section are of next larger size and the pores in the outer portion of the head section 25 are of the largest size. Owing to the compacting action exerted by the inner punch 44, material which lies under the inner punch and which forms the central portion of the intermediate and head sections of the feed element is compacted to a greater extent than the material which forms the outer portions of these sections. However, as will be understood from a consideration of the description of the moulding of the filler element, the central portion of the intermediate section has pores of somewhat larger size than the feed bar section and somewhat smaller size than the pores in the central portion of the head section. That is to say, the pores in the feed bar section and in the central portions of the intermediate section and head section increase in size from the forward end of the feed element to the rear end of the feed element.

From the foregoing, it will be seen, therefore, that the feed element has greatest capillarity in the feed bar section and lesser capillarity in the intermediate section and head section. Moreover, the capillarity in the intermediate section decreases outwardly from the central portion thereof as does the capillarity of the head section. Accordingly, when a feed element thus formed is employed in a pen, ink is drawn from the head section into the intermediate section and from thence into the feed bar section; at the same time, ink tends to be drawn from the outer portion of the head section toward the inner portion and likewise from the outer portion of the intermediate section toward the central portion.

I have found in practicing the above described process that it is important that the spacing 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 moulding 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 spacing 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 moulded 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. Moreover, since substantially all portions are of relatively large size, substantially all of the ink therein is withdrawn in writing.

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%.

For certain applications and particularly as a material for use in forming a capillary element, another embodiment of my invention has given excellent results. In this embodiment the porosity of the metal is slightly greater than the porosity formed in accordance with the first described embodiment of my process. The metal produced by the embodiment now to be described has a structure generally similar to the metal resulting from the first described embodiment—that is to say, the metal forms a porous mass which defines interconnected relatively large principal pores—with the important difference, however, that in this second form, the material which defines the principal pores is itself porous, it being provided with 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 1/10 the size of the principal pores.

In practicing this process, I may employ any of the metals above described and for forming capillary members for fountain pens, I prefer to use silver. The metal is employed in the form of a powder approximately ten times finer than the powder employed in the first described process 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.

The porous particles produced as just described may be employed in lieu of solid metal particles for forming a sintered metal member in accordance with the first process hereinabove described.

The metal produced by the foregoing process comprises a unitary porous rigid mass which is provided with relatively small, interconnected pores all of substantially 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 mould, 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 mould removed from the furnace, the sintered member may be readily removed from the mould. On the other hand, where it is found desirable to enclose the moulded member in a metal sheath or casing—as, for example, in forming a unit such as the cartridge described above (consisting of filler element 16 and casing 20)—a somewhat different procedure may be employed advantageously. In the latter case, instead of employing a refractory mould, 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.

In certain applications, it may be desirable to employ a sintered metal member having pores which are substantially smaller than the pores in the material formed in accordance with the foregoing processes. In such instance a metal powder is employed which is considerably finer than either the powder employed in the process first above described or the porous metal particles employed in the second described process. For example, in one specific embodiment I employ a powder of sufficient fineness to pass through a 325 mesh sieve. The metal powder is mixed with ammonium bicarbonate or other equivalent material of a fineness from −18 to +50 and in the proportions above stated, and at the same time approximately 0.25% to 3% of lubricant such as stearic acid is incorporated. These materials are then mixed, moulded and sintered as set forth in connection with the first above described process.

I have found that the porous metal may be made stronger and at the same time somewhat more porous by incorporating in the mixture a relatively small, predetermined percentage of particles which are of a selected, substantially smaller size than the principal particles employed. It will be understood that the smaller particles are all of a generally similar size which is substantially smaller than the size of the larger particles and preferably not substantially more than 1/10 the size of the larger particles. During the sintering operation, these smaller particles find their way to those smaller portions of the spaces between the larger particles which are located adjacent the points of contact of the larger particles and are bonded to the larger particles adjacent the point of mutual bonding of the latter, thus providing a more extensive and stronger bond between the larger particles.

In one illustrative process, I employ a mixture of approximately 10% of silver particles of 325 mesh size and 90% of relatively large particles which range in size from −18 to +50 mesh. The fine particles are first mixed with a lubricant such as stearic acid or a suitable stearate, such lubricant being in the proportion of approximately 1% of the total mixture. Thereafter, this mixture is mixed with the large particles and spacing material and the resulting mixture moulded and sintered in accordance with the process first above described.

Excellent results also have been obtained by employing a mixture of small particles and porous large particles, instead of all porous particles as in the process hereinabove described. In such latter process, the small particles are mixed with lubricant as just above described and the resulting mixture is mixed with porous large particles in the proportion of around 10%, by weight, of small particles and 90% by weight, of large particles. Spacing material is incorporated in the mixture and the mixture is moulded and sintered in a manner similar to that described above for the formation of the sintered material having both large and small pores.

In certain instances, it is desirable to form the sintered metal member with one or more vents or passages of substantial cross-sectional area extending therethrough. One example of such member is the one-piece capillary filler and ink storage element described above having the central vent passage extending longitudinally thereof. This vent or passage may be conveniently formed by the use of a core rod, as above described, which is withdrawn prior to sintering. However, it may be formed by inserting in the blank prior to sintering a rod or wire of such material that when the powdered material and wire are sintered, the powdered material will contract away from the wire and permit the latter to be withdrawn from the completed sintered metal member. The rod or wire is formed of a material to which the powdered metal will not be bonded by the sintering operation and also a material which will not melt at the sintering temperature and will not cause the formation of undesirable deposits on the sintered metal. For example, where silver is employed as the powdered material, the wire may be formed of a nickel-chromium alloy such as nichrome.

While I have disclosed my novel compositions of matter and method of producing the same with particular reference to the use of such material in forming capillary members for writing pens, it is to be understood that my invention is not thus limited, but is capable of use in many other applications where the excellent properties of the porous metal material make its use desirable and especially where the material is to be employed for feeding or storing liquids by capillary action.

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.

I claim:

1. A fountain pen comprising a vented casing having a reservoir section in its rearward portion, a writing element mounted in the forward portion of the casing, a rigid capillary filler and reservoir element removably mounted in said reservoir section and formed of porous sintered metal having interconnected pores of capillary size, said capillary filler and reservoir element having an air vent passage extending longitudinally therethrough of substantially greater transverse dimension than said pores, and communicating with the pores at substantially all points throughout its length, and a rigid capillary feed element removably mounted in the forward portion of the casing and formed of porous sintered metal having interconnected pores of capillary size therein, said feed element being separate from said filler and reservoir element and connected throughout a substantial area to the pores in said capillary filler and reservoir element and said writing element, the capillary pores in the portion of said feed element nearest said writing element being of smallest size and greatest capillarity and increasing in size and decreasing in capillarity gradually, as opposed to step-by-step, toward the other portion of the feed element.

2. A fountain pen comprising a casing, a writing nib having an arcuate body portion and a tapered writing portion formed with a capillary ink feed slit, a cylindrical capillary filler and reservoir element in said casing and defining a capillary ink storage space, and a rigid, self-sustained capillary feed element separate from said filler and reservoir element formed of porous sintered metal defining a plurality of interconnected capillary pores therein in capillary ink feeding relation with said filler and reservoir element and said writing element, said feed element having a cylindrical feed bar section extending into said arcuate body portion and engaging the same throughout a substantial longitudinal and arcuate dimension and in feeding relation to said nib slit, and an enlarged cylindrical head section in feeding relation to said filler and reservoir element, the pores in said feed element increasing in size and decreasing in capillarity gradually, as opposed to step-by-step, from the forward portion of the feed bar section rearwardly to and through said head section, and all of the pores in the feed element being of greater capillarity than the storage space in the filler and reservoir element.

3. A fountain pen comprising a casing, a writing nib having an arcuate body and a tapered writing portion formed with a capillary ink feed slit, a cylindrical capillary filler and reservoir element in said casing and defining a capillary ink storage space, and a rigid, self-sustained capillary feed element formed of porous sintered metal defining a plurality of interconnected capillary pores therein connected to said filler and reservoir element and to said writing element, said feed element having a cylindrical feed bar section extending into said arcuate body and engaging the same throughout a substantial longitudinal and arcuate dimension and in feeding relation to said nib slit, and an enlarged cylindrical head section substantially coextensive with the forward end of said filler and reservoir element and in ink feeding relation therewith, the pores in said feed bar section and the central portion of said enlarged head being of smaller size and greater capillarity than the pores in the peripheral portions of said head section, and all of the pores in the feed element being of at least as great capillarity as the storage space in the filler and reservoir element.

4. A fountain pen comprising a casing, a writing nib having an arcuate portion and a slitted point, a capillary filler and reservoir element in said casing and defining a capillary ink storage space, and a capillary feed element formed of porous sintered metal defining a plurality of interconnected capillary pores therein connected to said filler and reservoir element and to said writing element, said feed element having pores opening to the exterior forming a rough surface thereon, said feed element having an arcuate feed bar section extending into contact with said arcuate portion of the nib throughout a substantial longitudinal and arcuate dimension with the pores in ink feeding relation with the slit in said nib, and an enlarged head section abutting said filler and reservoir element with the pores in ink feeding relation to the storage space in said filler and reservoir element, the pores in said feed bar section and the central portion of said enlarged head section being of smaller size and greater capillarity than the pores in the peripheral portions of said head section, and all of the pores in the feed element being of at least as great capillarity as the storage space in the filler and reservoir element.

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