March 1, 1949. H. H. ZODTNER 2,462,929

FOUNTAIN PEN

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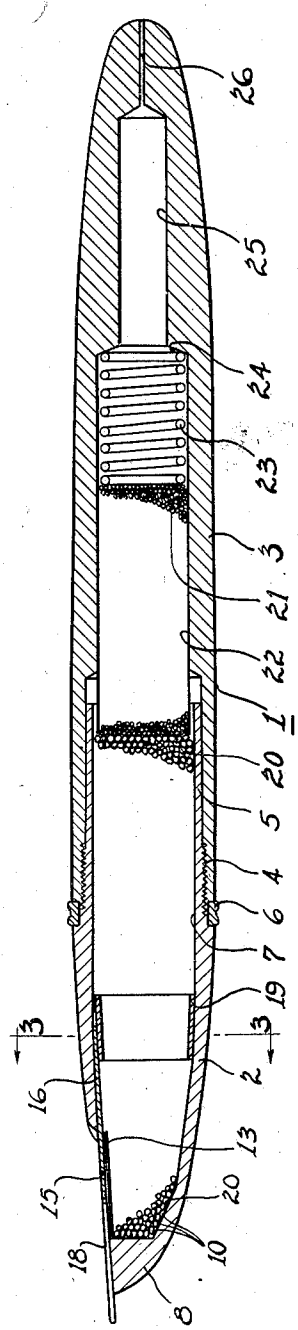

Fig. 1

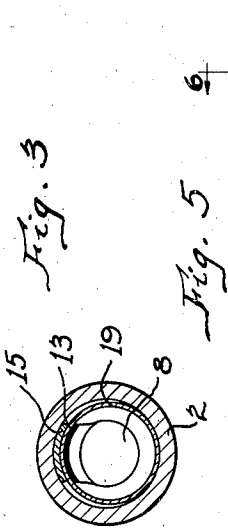

Fig. 3

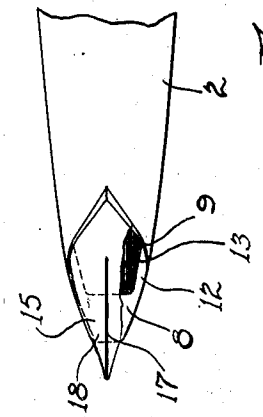

Fig. 2

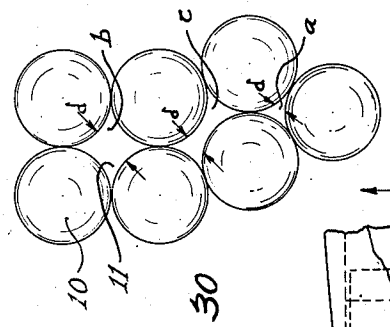

Fig. 30

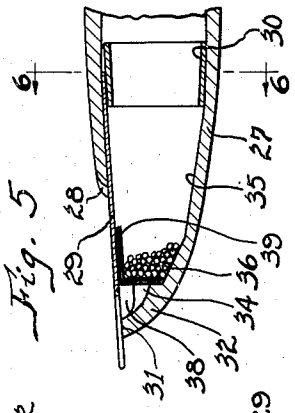

Fig. 5

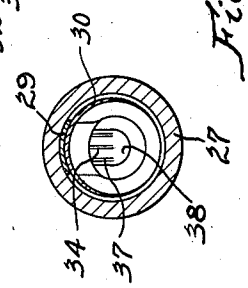

Fig. 6

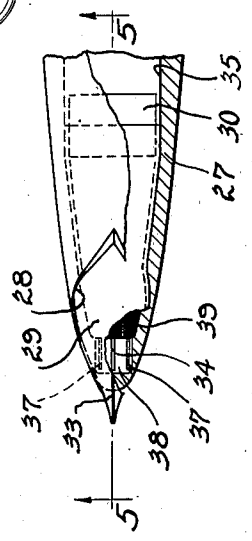

Fig. 4

INVENTOR.
Harlan H. Zodtner
BY
Fidler & Crouse
ATTORNEYS.

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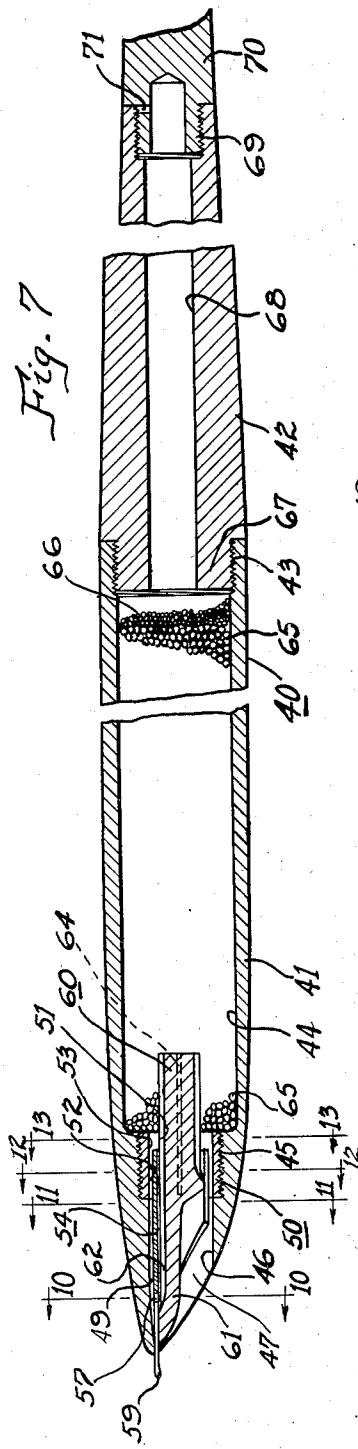

Fig. 7

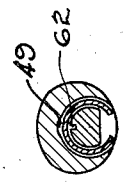

Fig. 11

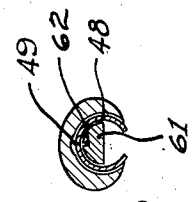

Fig. 10

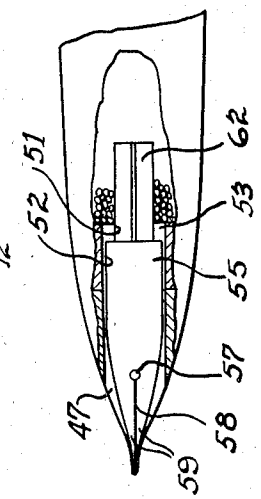

Fig. 8

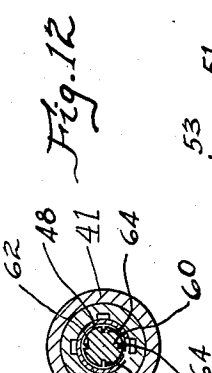

Fig. 12

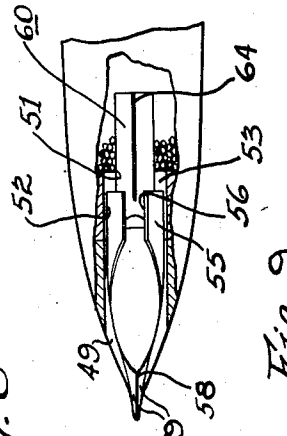

Fig. 9

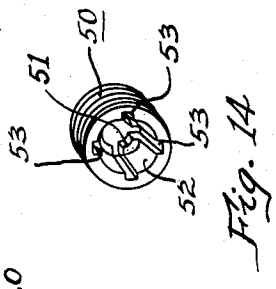

Fig. 14

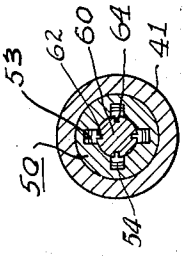

Fig. 13

INVENTOR.
Harlan H. Zodtner
BY Fidler & Crouse
ATTORNEYS.

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Fig. 15

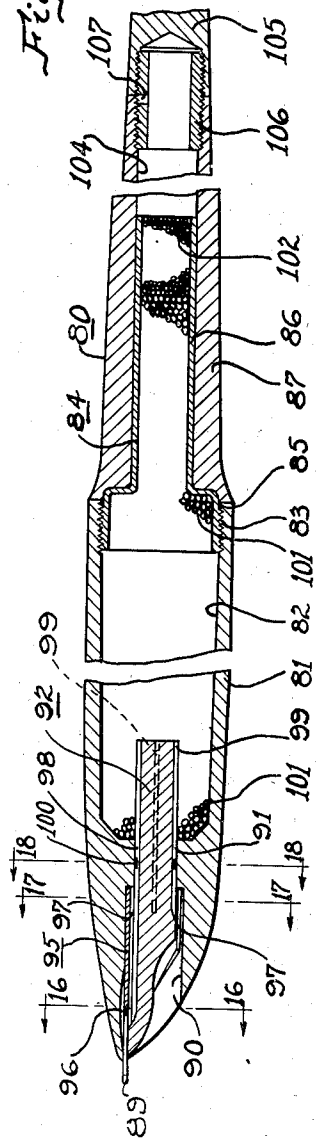


Fig. 17

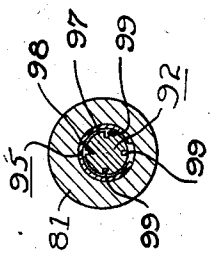


Fig. 19

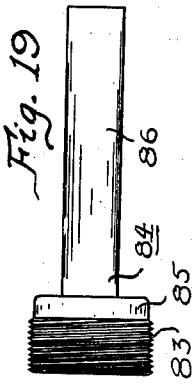


Fig. 16

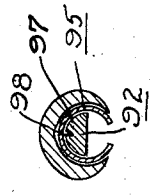
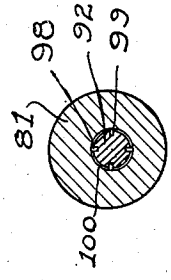


Fig. 18



INVENTOR.
Harlan H. Zodtner
BY Fidler & Coarse
ATTORNEYS.

March 1, 1949. H. H. ZODTNER 2,462,929

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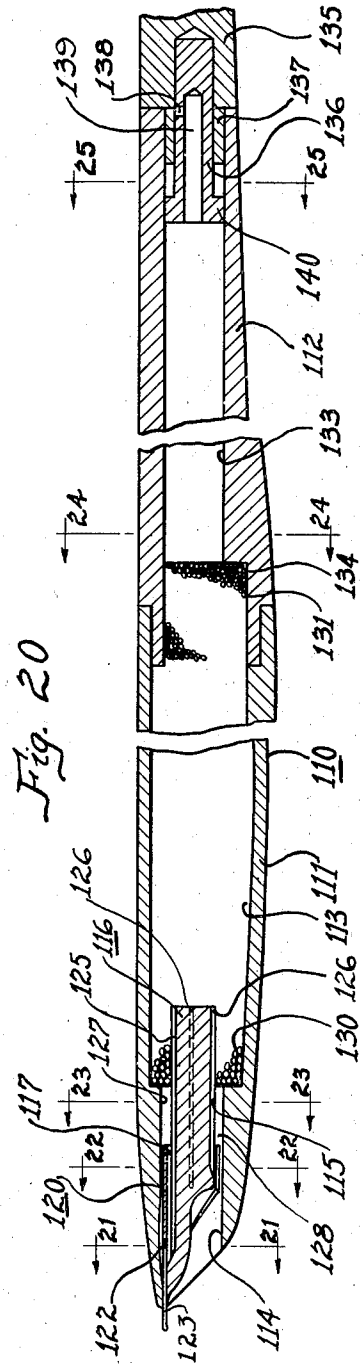

Fig. 20

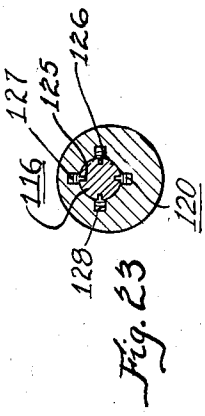

Fig. 23

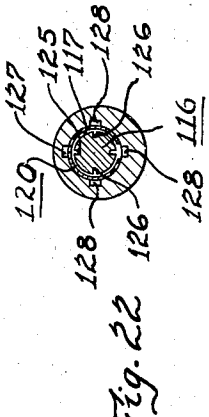

Fig. 22

Fig. 21

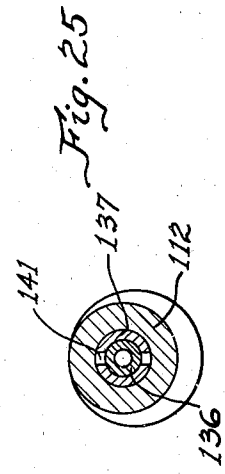

Fig. 25

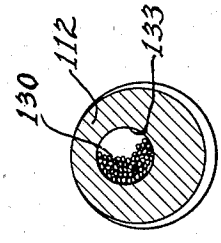

Fig. 24

INVENTOR.
Harlan H. Zodtner
BY Fidler & Crouse
ATTORNEYS.

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Fig. 26

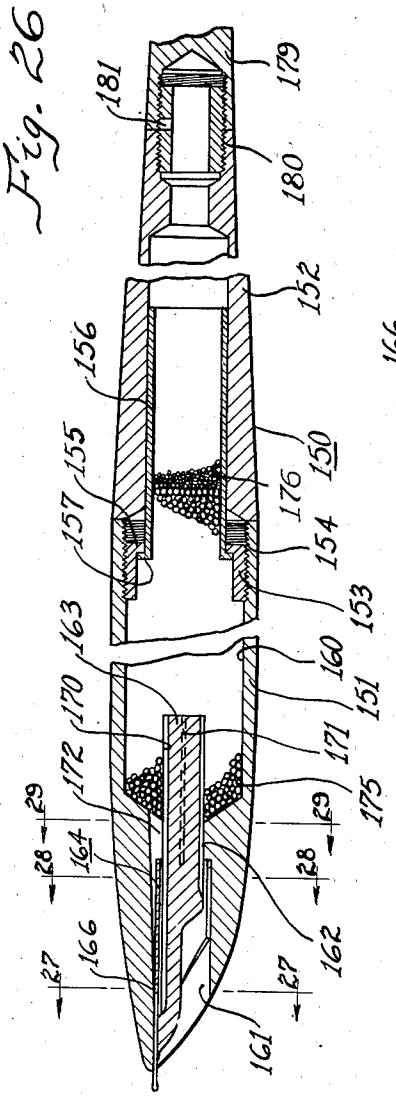


Fig. 27

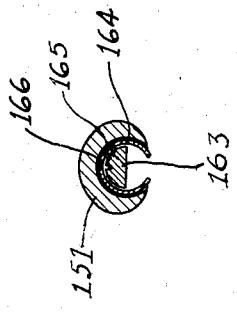


Fig. 29

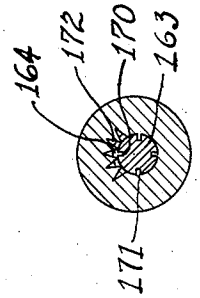
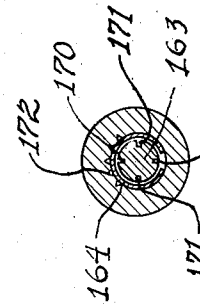


Fig. 28



INVENTOR.
Harlan H. Zodtner
BY Fidler & Crouse
ATTORNEYS.

Patented Mar. 1, 1949

2,462,929

UNITED STATES PATENT OFFICE

2,462,929

FOUNTAIN PEN

Harlan H. Zodtner, Janesville, Wis., assignor to The Parker Pen Company, Janesville, Wis., a corporation of Wisconsin

Application July 17, 1946, Serial No. 684,148

35 Claims. (Cl. 120—50)

1

This invention relates to fountain pens and more particularly to fountain pens having improved means for filling the ink reservoir and for feeding the ink from the reservoir to a writing surface.

One of the objects of the invention is to provide an improved fountain pen of the type adapted to be filled by capillary action which is simple in construction, easy to manufacture and assemble and which will last almost indefinitely without repair or replacement of parts.

A further object of the invention is to provide an improved fountain pen of the capillary filling type which can be filled rapidly, which has a relatively large ink capacity and which is capable of writing out a relatively high percentage of ink taken in during filling.

Another object of the invention is to provide an improved capillary filler element for filling the ink reservoir of a fountain pen.

Another object of the invention is to provide improved means for feeding ink from the reservoir of a fountain pen to the writing surface.

A further object of the invention is to provide a fountain pen having an efficient capillary filler element which can be easily and inexpensively produced from inexpensive materials without requiring time consuming or expensive forming or assembling operations.

Another object of the invention is to provide a capillary filler element formed of small spheres or beads arranged in a compact mass and defining a plurality of interconnected ink holding spaces, the size of the spheres being such as to provide capillary spaces which will draw in ink during filling and will permit ink to be withdrawn during writing.

Another object of the invention is to provide a fountain pen having a capillary filler element which can be easily formed to provide in one portion thereof capillary ink passages constituting ink filling, storage and feeding spaces and in another portion to provide air vent passages communicating with the ink spaces and which will allow air to pass freely but will prevent the entry of ink.

A further object of the invention is the provision of a fountain pen of the capillary filling type having improved air venting means which insures the maintenance of atmospheric pressure within the pen and which insures against leakage of ink through the air venting means.

A further object of the invention is the provision of the fountain pen adapted to be filled by capillary action and having capillary passages

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which are defined by wall surfaces having a high degree of wettability by the inks with which the pen is adapted to be used.

A further object of the invention is the provision of a fountain pen having an air vent passage leading from the ink reservoir and defined by walls which are relatively non-wettable by the ink with which the pen is used.

Further and more specific objects of the invention are to provide a fountain pen having a capillary filler element of simple construction in which the capillarity of the ink passages can be closely predetermined and controlled; to provide a capillary filler element which has a large number of interconnected feed passages extending through the length and breadth of the ink reservoir; to provide a capillary filler element effective to fill the ink reservoir rapidly; to provide an improved capillary filler element having feed passages so arranged as to prevent air locks either during filling or feeding; and to provide improved means for supporting a nib and feed bar in accurately disposed relation to the pen body and to the ink reservoir.

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

Figure 1 is a view of a vertical, longitudinal section taken through a fountain pen constructed in accordance with the invention;

Fig. 2 is a fragmentary top plan view of the nib end of the pen of Fig. 1;

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

Fig. 4 is a fragmentary top plan view of the nib end of a pen generally similar to the pen of Fig. 1 only having a modified front end construction, certain of the parts being broken away and in section;

Fig. 5 is a longitudinal, sectional view taken along line 5—5 of Fig. 4;

Fig. 6 is a fragmentary transverse cross-sectional view taken along line 6—6 of Fig. 4;

Fig. 7 is a vertical longitudinal, sectional view through another embodiment of the invention;

Fig. 8 is a fragmentary top plan view of the nib end of the pen of Fig. 7;

Fig. 9 is a fragmentary bottom plan view of the nib end of the pen of Fig. 7;

Fig. 10 is a transverse, sectional view taken along line 10—10 of Fig. 7;

Fig. 11 is a transverse, sectional view taken along line 11—11 of Fig. 7;

Fig. 12 is a transverse, sectional view taken along line 12—12 of Fig. 7;

Fig. 13 is a transverse, sectional view taken along line 13—13 of Fig. 7;

Fig. 14 is a perspective view of the nib and feed bar mounting collar of Fig. 7;

Fig. 15 is a vertical, longitudinal, sectional view through another embodiment of the invention;

Fig. 16 is a transverse, sectional view taken along line 16—16 of Fig. 15;

Fig. 17 is a transverse, sectional view taken along line 17—17 of Fig. 15;

Fig. 18 is a transverse, sectional view taken along line 18—18 of Fig. 15;

Fig. 19 is a side elevational view of the body connecting sleeve of the pen shown in Fig. 15;

Fig. 20 is a vertical, longitudinal, sectional view through a further embodiment of the invention;

Fig. 21 is a transverse, sectional view taken along line 21—21 of Fig. 20;

Fig. 22 is a transverse, sectional view taken along line 22—22 of Fig. 20;

Fig. 23 is a transverse, sectional view taken along line 23—23 of Fig. 20;

Fig. 24 is a transverse, sectional view taken along line 24—24 of Fig. 20;

Fig. 25 is a transverse, sectional view taken along line 25—25 of Fig. 20;

Fig. 26 is a vertical, longitudinal sectional view through a further embodiment of the invention;

Fig. 27 is a transverse, sectional view taken along line 27—27 of Fig. 20;

Fig. 28 is a transverse, sectional view taken along line 28—28 of Fig. 20;

Fig. 29 is a transverse, sectional view taken along line 29—29 of Fig. 20; and

Fig. 30 is an enlarged somewhat diagrammatic view showing possible arrangements of a few of the beads forming the capillary filler element.

Referring now particularly to Fig. 1 of the drawings, the fountain pen comprises a body 1 which includes a front section 2 and a rear section 3 formed of suitable material, such as, hard rubber or other plastic and secured together as by a threaded joint 4. The front section 2 may have an extension 5 which extends rearwardly a substantial distance from the joint for a purpose which will hereinafter appear.

A clutch ring 6 may be secured to the front section 2, preferably adjacent the joint 4, for the purpose of securing a cap (not shown) when the pen is to be used as a pocket pen or for seating the pen in a socket of a desk set (not shown) when the pen is used therewith. It will be understood that the present invention is applicable, with appropriate modifications in structural details, to pocket pens, desk pens or pens which are convertible for use either as pocket pens or desk pens.

The front section 2 is hollow and has a chamber 7 defining an ink reservoir space extending throughout a substantial portion of the pen body and closed at its front end by a thickened end wall 8 having a curved outer surface shaped to prevent contact with the writing surface when the pen is held at a writing angle thereto. Formed in the front end of the upper wall of the front section 2 is a nib opening 9 adapted to receive a nib 15.

The nib 15 preferably is formed with an arcuate body 16 having a slit 17 dividing it into two nib sections 18. The nib 15 is held in position by a nib holder 19 which preferably is formed as a thin, resilient metal ring frictionally fitted into the barrel 2 to wedge the nib 15 against the inner

wall of the front section 2. The nib 15 is positioned so that the forward portion rests on the nib seat with the nib sections 18 projecting beyond the end of the front section 2 suitably for writing, and the nib slit 17 extending rearwardly of the end wall 8. The nib opening 9 may be cut away at its rear end as in the shape of a V to expose a substantial portion of the nib 15; this imparts flexibility to the nib and presents a novel and attractive appearance to the nib end of the pen.

Disposed in and substantially filling the chamber 7 is a capillary filler-and-reservoir element or cell structure 20 which takes the form of a porous mass providing a plurality of passages or interconnected cells of capillary sizes to draw ink into the pen solely by capillary action during filling, retain ink therein against leakage, and permit ink to be fed to the nib when the pen is used in writing. The passages or cells thus constitute ink storage spaces. The capillary filler-and-reservoir element 20 (also referred to herein as the "filler element") preferably is formed of a material which is capable of being wetted readily by the usual inks but which is relatively inert to such inks and will not react therewith to detrimentally affect either the ink or the capillary filler element. Among the materials found suitable for this purpose are glass, hard rubber, metal, such as silver, or plastics such as Lucite (methyl methacrylate resin) or Saran (vinylidene chloride type).

A preferred method of forming the filler element is to provide a plurality of separately formed solid particles 10 of suitable material, and to dispose them in intimate relation with adjacent particles abutting. The particles are of such size or sizes that the voids 11 defined therebetween are of suitable capillary dimensions. Preferably, the particles or "beads" are of spherical shape for reasons which will hereinafter appear. Since abutting beads are in mutual contact over very small areas, adjacent capillary spaces are in mutual communication, and, in effect, form a series of capillary passages extending longitudinally and transversely throughout the stacked mass of beads.

The beads, after being inserted in the chamber 7, are compacted as by shaking the front section 2 so that substantially all of the beads are caused to abut adjacent beads and provide a compact mass having voids of the character above described. The beads are maintained in compact relation by a closure plug 21 firmly seated in the end of the front section 2 and which may extend into a chamber 22 formed in the rear section 3 and be resiliently pressed against the beads by a spring 23 seated against a shoulder 24 formed in the rear section 3. It will be noted that the extension 5 of the front section provides a continuous smooth interior side wall extending beyond the end of the stack of beads and adapted to receive slidably the closure plug 21.

The beads may be formed into a unitary cellular structure in which each bead is attached to the adjacent beads at the point of mutual contact. The unitary cellular structure thus formed may be secured in the chamber in any suitable manner, as by the plug 21 and spring 24. The beads may be joined to form the unitary structure by arranging them in a stacked mass with adjacent beads in mutual abutment and then heating them just sufficiently to cause the beads to fuse at their points of mutual contact enough

to maintain them in fixed, stacked relation. It will be understood that the beads preferably are not heated enough to cause them to lose their spherical shapes or to increase the mutual area of contact more than is necessary merely to join them; thus no substantial change is made in the shape, size or arrangement of the voids. By way of example, in one particular case, very satisfactory results were obtained by forming beads of "lime glass" consisting of soda, lime, and silica; the beads being approximately 0.6 mm. in diameter. The beads were thoroughly cleansed to remove all adherent foreign matter and placed in a heavy steel mold having a cavity of generally cylindrical shape and of a size to provide a cylindrical mass of beads approximately the size and shape of the pen reservoir chamber. The mold was inserted in a furnace heated to an initial temperature of 1350° F. The beads were maintained in a non-oxidizing atmosphere by maintaining carbon dioxide in the interior of the oven surrounding the mold. The heat supplied to the furnace was maintained but owing to the insertion of the mold the former cooled within 3 minutes to around 1240° F. After approximately 4 more minutes the temperature of the furnace again reached 1350° F. and this temperature was maintained for approximately 5 minutes more, after which the mold was removed from the furnace and allowed to cool in air. The resulting cell structure was firm and rigid with adjacent beads securely joined and with void spaces between the beads substantially the same size and shape as in the initial stack of beads.

The chamber **7** is continuously vented to the atmosphere in order to permit air to escape therefrom during filling, to equalize air pressure exerted on the ink in the capillary filler element and to admit air to replace ink which is withdrawn from the pen in writing. Any suitable venting means may be employed which provides communication between the interior of the pen body and the atmosphere. In the embodiment illustrated, the vent is formed by a passage **25** extending from the chamber **22** and a smaller passage or vent opening **26** extending from the chamber **25** and extending through the pen body at the rear of the chamber **25**. In order to prevent the ink from escaping from the capillary filler element **20** and finding its way through the vent **26**, the retaining plug **21** may be of such construction that it will permit air to pass therethrough but will not permit the passage of ink. The retaining plug conveniently may be constructed by forming a compact mass of clean glass beads and fusing them together in a manner generally similar to that described above in connection with the formation of the unitary filler element. The beads forming the plug, however, preferably are of much smaller diameter and may be approximately 0.5 mm. in diameter. After fusing the beads to form a unitary plug of the appropriate size and shape, the surfaces of the beads are treated to make them relatively non-wettable by the usual inks. In one successful process for rendering the plug non-wettable by ink, the plug was formed in the manner above described and was immersed in "dry film" (methyl silicone chloride) at atmospheric temperature and pressure to thoroughly wet the surfaces of all of the beads. The plug was then removed from the "dry film," allowed to dry in air and was then ready for assembly in the pen. The plug thus formed passed air relatively freely and provided an entirely satisfactory air venting plug but repelled ink and no ink passed through the passages formed by the voids between the joined beads.

Instead of providing a separate plug for preventing the passage of ink and permitting the passage of air at the rear end of the filler element, the plug may be omitted and its function may be performed by beads similar to those forming the filler element. In such an arrangement, a sufficient number of layers of the beads at the rear end of the filler element are treated to make them non-wettable by the usual inks; this preferably is accomplished in a manner similar to that described above in connection with the formation of a separate plug. The separate plug preferably is omitted only where the beads forming the filler element are joined to form a unitary structure in the manner described hereinbefore; in this case the beads at the rear end of the structure are made non-wettable by dipping only the rear end of the structure in the treating material. However, if desired, the beads forming the rear layers of a filler element in which the beads are not joined may be treated to make them non-wettable. In the latter case means (not shown) such as a screen, perforated plug or the like are provided for retaining the beads in place and for permitting the passage of air to and from the filler element. This mode of retaining the ink and providing for venting of the filler element is well adapted for incorporation in the other embodiments of the invention hereinafter described.

In order to insure that ink is at all times maintained at the nib **15** so that the pen is instantly ready for writing and in order to replace ink which is drawn off during writing, a feed element having feed passages of greater capillarity than the remainder of the cells and passages may be provided immediately adjacent the nib **15**. This may be accomplished by disposing adjacent the nib sufficient layers of beads which are of such smaller size than the remaining beads to provide passages of the desired greater capillarity.

As used in this application the term "capillarity" designates the tendency of a fluid to advance into a capillary space or passages. If, for example, two capillary passages lead from a common reservoir containing a liquid, the capillary passage into which the liquid advances to the greater height against the force of hydrostatic pressure is referred to as having the "greater capillarity." With similarly shaped capillary passages having identical surface compositions that capillary passage with the smallest effective diameter would produce the greatest capillary ascension and thus could be said to have the greater capillarity. On the other hand, with two capillary passages of identical effective diameters but different surface properties, the one having such surface properties as would produce the greater rise of liquid therein would be referred to as having the greater capillarity.

In lieu of, or where desired, in addition to the provision of smaller beads, the feed element may be formed by a pad or wick **13** which may be interposed between the nib **15** and the adjacent portion of the filler element. The pad **13** may be formed in any suitable manner which will provide the necessary capillary passages therethrough, some degree of flexibility and preferably resistance to deterioration by the usual inks. I have found that highly satisfactory results can be obtained with pads formed from matted or woven glass, or nylon fibers, woven wire screen or hair felt, although other materials having the

necessary characteristics may be used. One embodiment of pad which was found satisfactory was formed by matting 70 denier nylon fibers to form a pad approximately 0.030" in thickness and of sufficient breadth to extend entirely across the undersurface of the pen nib and sufficient length to extend from the wall 8 to a point rearwardly of the rear end of the pen nib slit. The pad 13 is sufficiently flexible to fit against the beads of the adjacent layer and adjacent the nib so as to provide a series of capillary passages connecting the endmost capillary cells of the cell structure with the capillary passage provided by the nib slit 17. The pad 13 is of considerable value in connection with a capillary cell structure of the unitary type, since in such a structure the endmost beads adjacent the nib are not entirely free to adjust themselves to the contour of the nib, and adjacent portions of the chamber 7, and consequently the contact between the end of the cell structure and the nib may be insufficient to provide the desired feeding connection. On the other hand, where loose beads are used, the pad provides means for retaining the beads in the reservoir and preventing them from entering the space between the nib and the adjacent portions of the body.

To fill the pen, the end of the nib 15 and the adjacent end of the front section 2 are inserted in a supply of ink. Ink is drawn by capillary action into the reservoir 7 through the capillary passages between the nib sections (the slit 17) and between the nib 15 and wall 8; ink also may be drawn into the space between the nib 15 and the edges 12 of the nib seat. Ink is then drawn into the feed element 13, where one is provided, and from thence into the capillary passages in the filler element 20. Ink rises by capillarity along the walls of the beads 10 and fills the capillary spaces therebetween; ink also may rise along the capillary spaces formed between the walls of the chamber and the adjacent beads.

Air which was in the empty or partially empty cells, in the filler element 20, is forced therefrom by the ink and passes out of the filler element at the rear end and is vented through the passages in the plug 21, the chamber 22 in the rear section 3 and the vent passages 25 and 26. Since each cell is in communication with a plurality of cells, the air can pass with relative freedom upwardly through the filler element and little if any pressure is required to eject the air. There is little likelihood that a complete layer of cells (transversely of the chamber 7) will fill with ink prior to the filling of all of the cells nearer to the nib end of the pen and thus cause an ink seal around a cell or series of cells having air therein. However, if this should happen, the air which is trapped will not form an air block and will not seriously impede the flow of ink upwardly in the cell structure. Owing to the large number of passages or channels along which the ink can rise, and the variable sizes of the cells throughout the cell structure ink may follow a number of paths of various capillarities and hence there will usually be certain paths of relatively high capillarity along which the ink will be drawn upwardly faster than along the other paths, and other paths of relatively low capillarity along which the air can pass to be vented.

The total height to which ink will rise in the capillary filler element and the rate of rise in any particular pen using any particular ink depends primarily upon the angle at which the pen is held to the surface of the ink supply. The least rise and the slowest rate of filling results when the pen is held perpendicularly to the surface of the body of ink. The greatest rise occurs when the pen is held at the lowest angle. Accordingly, the sizes of the capillary passages are so selected that the pen will fill to the desired height within a reasonable time when held vertically. However, in order to prevent more ink being drawn into the pen, if the pen is filled when held at a low angle, than can be retained by the capillary system when the pen is held vertically, the capacity and capillarity of the capillary passages are so chosen that the system will be capable of retaining in any position of the pen all of the ink drawn into the pen during filling, and no ink will drain out or leak.

The capillarity of the cells of each layer (considered transversely of the filler element) should be such that it is sufficient to lift against the action of gravity a column of ink equal in height to the vertical height of that layer of cells above the level of the supply of ink when the pen is being filled. This, theoretically, would call for a progressive variation in the sizes of the cells from front to rear in the pen. However, in order to provide for practical assembly of the beads to form the filler element, the latter preferably is made entirely of beads having the same size; the size being appropriately selected to provide satisfactory results. If desired, however, a closer approach to the theoretical requirements above mentioned can be obtained by arranging the beads in a series of layers, the layers increasing in capillarity from front to rear in the pen, but the beads in each layer being of the same size and providing cells of equal capillarity within the group.

It will be understood that, where heads are referred to herein as being of the same size, they may vary slightly in size owing to the manufacturing variations, it being desirable however, that they be as nearly of one size as practicable. It has been found that satisfactory results can be obtained with a variation of up to 10% in the diameters of the particles. However, the more nearly uniform the particle sizes the more accurately the operational characteristics of the pen can be predetermined.

Since a pocket pen is usually placed in the pocket in a position inverted from the filling and writing position, it must also be non-leaking when in such position; in fact it must be capable of retaining ink when in any position. Accordingly, in the pen of the present invention, the capillarity of all of the cells must be such that when the pen is in any position, ink will be retained in the pen by the capillarity of the capillary system.

Feeding of the ink to the nib so that ink is available at all times is accomplished by appropriate selection of the capillarities of the several portions of the capillary system within the pen, which system includes the several capillary cells and passages. The passages in the feed section of the pen, that is, the portions adjacent the nib, preferably are made with the highest capillarity to insure that ink is drawn to the nib.

In writing, when the point of the pen nib is placed upon a writing surface, the ink which is held in the nib slit by capillarity is brought into contact with the writing surface and the capillarity established within the nib and the writing surface is sufficient to overbalance the capillarity of the capillary filler element of the pen and ink is drawn from the nib slit and deposited on the writing surface as the ink is drawn thereacross.

Ink drawn from the nib slit 17 is replaced by ink drawn into the nib slit along the capillary passages provided by the feed element 13 (where such is used) and by the capillary filler element 20. Ink flows along the passages in the filler element provided by adjacent inter-connecting cells. As ink is drawn out of a cell, it is replaced by ink from an adjacent cell, the cells more remote from the nib generally being emptied prior to the cells nearer to the nib.

Air to replace the ink withdrawn from the cells is drawn into the cell structure through the vent passages above described. However, owing to the large number of passages in the filler element and to the fact that there is always one passage of greatest capillarity and one passage of least capillarity, it is not necessary, in many cases, to provide any venting at the rear of the pen during writing. As ink is drawn along the passage of highest capillarity in the filler element, air will enter the pen through the front end and pass upwardly along the passage of least capillarity to replace ink which is drawn off during writing. Owing to this action, the pen is not subject to the detrimental affects of "air locks" such as are possible in pens where air locks form due to a quantity of air being surrounded by an ink globule and blocking a feed passage. Owing to the rear end venting and to the provision of a number of feed passages, ink is fed smoothly and evenly to the nib and there is no alternate of starving or flooding of the feed with a corresponding variation in the character of the writing.

The several portions of the capillary system are defined by relatively fixed, rigid members having definite and controllable, fixed shapes and dimensions, consequently, the capillarities of the several portions of the system can be readily predetermined. Such capillarities will remain substantially fixed during the life of the pen, since the members defining the capillary passages are not subject to substantial change in shape, dimension or relative position during operation.

When spheres, such as the beads 10, of approximately equal size are disposed in intimate contact in a random manner and without prearranged stacking, they will arrange themselves in not more than three different types of stacking as illustrated diagrammatically in Fig. 30. That is, the arrangement between adjacent beads will be pyramidal, cubical or rhombohedral providing corresponding voids (indicated at *a*, *b* and *c*, respectively, in Fig. 30). The pyramidal stacking represents the closest stacking, the cubical the most open, and the rhombohedral an intermediate type of stacking which may vary throughout the range between the closest to the most open. Where the beads are stacked without predetermined arrangement, the maximum variation in arrangement, and consequently the maximum variation in the sizes of the voids, will range from that resulting from the pyramidal stacking to that represented by the cubical stacking. Where a relatively large number of beads of similar size are involved, and the diameter of the stack is at least eight times the bead diameter, the percentage of each type of stacking will remain approximately constant and the percentage of total void space to total volume of the compact mass of beads will remain constant. Accordingly, the total capillarity of the mass and the range of capillarities of the several spaces between adjacent beads can be predetermined to a relatively high degree of accuracy by appropriately selecting the size or sizes of the beads. With the most open stacking of the beads, the volume of the voids equals 47.64% of the total volume of the stack. With the closest stacking the volume of voids equals 25.95% of the total. When the large number of beads are stacked without predetermined arrangement, the three forms of stacking will occur in about the following ratios: rhombohedral, 37.5%; cubical, 37.5%; pyramidal, 25%. Thus, the overall volume of voids, or the "porosity" of the entire stack is approximately 38% of the total volume of the stack. In several practical applications the porosity was found to be approximately 36% to 38% of the total volume of the stack.

It will be understood that regardless of which type of stacking is considered, each space or cell in the mass has wall-to-wall distances (the distance from any point on a wall of one bead to the nearest wall of another bead) which vary from zero (at the point of contact between abutting spheres) to a maximum (indicated at *d* in Fig. 30). The smallest maximum wall-to-wall distance results from the pyramidal stacking and the greatest maximum wall-to-wall spacing results from the cubical stacking. By appropriately selecting the diameters of the beads, the maximum wall-to-wall distances may be predetermined at values which are such that all portions of each cell are of capillary dimensions. The diameters of the beads used in forming the filler element are so selected as to provide the desired height of rise and also, to the fullest extent practicable, consistent with the foregoing, to provide the maximum volume of what I term the "effective usable void space." The effective usable void space is that space which is of sufficiently high capillarity to insure that ink will be drawn therein by capillary action during filling but of sufficiently low capillarity to permit ink to be drawn therefrom in writing by the capillarity between the nib and the writing surface. Any spaces which are of too low capillarity to draw in ink during filling or too great capillarity to give up ink during writing are not effective to contain ink used in writing and consequently reduce the effective capacity of the reservoir.

Owing to the forms of the cells provided by the spherical beads, each cell has a central portion of relatively great wall-to-wall distance and side portions of relatively small wall-to-wall distance adjacent the points of contact between the abutting beads. The shape of the cell is predetermined by the shape of the bead, and consequently the ratio of space having relatively great wall-to-wall distance to space having relatively small wall-to-wall distance is predetermined. However, by appropriately selecting the size of the beads, the sizes of the cells can be predetermined so that the maximum wall-to-wall distance is such that the capillarity of each cell is sufficient to raise the ink to the desired height. On the other hand, such size of cell can be selected that a substantial portion of the space is of such wall-to-wall distance that the capillarity is less than that which will retain ink against the capillary action exerted in the ink when the pen is used in writing and tending to withdraw ink from the pen. Thus, the cells can be made of such size that the pen is inherently capable of writing out to a relatively complete extent. It will be understood, of course, that due to the extremely small wall-to-

wall distances immediately adjacent the points of contact between abutting particles, the capillarities of these portions of the cells may be so high as to prevent ink from being completely withdrawn therefrom.

While the bead size suitable for providing the desired capillarity may vary somewhat, depending upon the size and construction of the pen with which the filler element is to be used, very satisfactory results have been obtained by using beads of approximately 0.040'' in diameter, which are commonly designated as "No. 4" beads, and satisfactory results have been obtained with beads as ranging in size from 0.030'' to 0.045''.

The rate of filling and height of rise of ink when the pen is held at any predetermined angle will be influenced by a number of factors, such as the wettability of the surface of the beads, and the surface tension of the ink. Viscosity of the ink also would be a factor except all commonly used fountain pen inks have viscosities which do not very greatly from each other or from the viscosity of water and hence variations in viscosity may be disregarded for all practical purposes.

The capillarity of the several capillary spaces in the filler element can be increased by providing wall surfaces defining these passages which have a relatively high degree of wettability by the inks with which the pen is used. Thus, the height of rise and consequently capacity of the reservoir as well as the rate of filling can be improved by increasing the wettability of the surfaces of the beads forming the capillary filler element. The wettability of the surface of a solid by liquid is measured by effective angle of contact between the liquid and the surface of the solid, a low contact angle indicating relative wettability and a high contact angle indicating relative non-wettability. I have found that a surface is satisfactorily wettable for the purposes of the present invention where the contact angle between the surface and the ink with which the pen is used is not substantially greater than 60 degrees. However, it will be understood that in certain instances surfaces having greater contact angles may be used but the height of rise in the pen will be less; other factors being equal.

Satisfactory wettability of the wall surfaces of the capillary spaces can be obtained by forming the beads of materials which are inherently suitably wettable by the inks with which the pen is used, as for example the materials above specified. I have found that beads formed from glass have very desirable surface characteristics although beads formed of other materials such as Lucite, hard rubber, Saran and metal have been found satisfactory. The wettability of such surfaces may be increased in many cases by appropriate treatment depending upon the nature of the surface.

Where the beads are formed from glass very satisfactory increase in the wettability of the surface can be obtained by suitably etching the surfaces of the beads. In one specific example the beads which were formed of soft lime glass and had a diameter of approximately 0.040'' were placed in a lead receptacle and a 60% solution of hydrofluoric acid was poured over the beads to fully immerse them. The beads were allowed to remain immersed for approximately 60 seconds and were then removed from the acid and washed thoroughly in water to remove all free acid. The etching reaction was allowed to proceed with the receptacle being unheated except for the heat of reaction between the hydrofluoric acid and the glass forming the beads. Similar etching processes have been successfully carried out on other sizes of beads of soda glass in a manner similar to that above described. However, where the beads are of smaller size than above stated the immersion time preferably is somewhat shorter. For example, where beads having a diameter of approximately 0.030'' were thus treated, they were immersed approximately 50 seconds and where beads having a diameter of 0.020'' were treated they were immersed for approximately 30 seconds.

Further increase in wettability of glass beads can be obtained by additionally treating beads etched in the manner above described. In one specific example beads etched as above described were immersed in a molten bath consisting of 95% chemically pure cuprous chloride and 5% reagent grade of cupric sulphide maintained at a temperature of 1050° F. The beads were immersed for approximately 30 minutes and then were removed and allowed to cool in air, after which they were ready for assembly in a pen. In another specific example, etched beads were immersed for 30 minutes in a molten bath consisting of 90% silver nitrate and 10% sodium nitrate maintained at a temperature of around 1050° F. Excellent results also have been obtained by subjecting unetched beads to one of the foregoing treatments in the manner described.

Wettability of the surface of the beads can also be increased by a somewhat different process. In one example of this process 2 drops of formaldehyde solution were added to 20 ml. of silver nitrate solution and immediately thereafter the etched beads were inserted in the mixture and the mixture was swirled to thoroughly wet all surfaces of the beads. The contents of the dish were allowed to stand for 5 minutes and then 10 ml. of formaldehyde was added to the dish and contents thoroughly mixed. The beads were allowed to stand for 10 minutes with occasional stirring of the mixture and the beads were then removed and thoroughly washed with distilled water. Thereafter the beads were dried in air at 250° F. and after cooling in air were ready for use. This process left a silvery deposit permanently adhering to the beads.

Another method of improving the wettability of etched glass beads consisted of immersing the beads in a solution consisting of 10% by weight of sulphuric acid and inserting the solution containing the beads in an autoclave. The solution containing the beads was maintained at a temperature of at least 250° F. under a pressure of 100# per square inch for 6 hours. The beads and the solution were thereafter removed from the autoclave and the beads removed from the solution and allowed to cool and dry in air. Variations of this process consisted in employing in lieu of sulphuric acid such materials as sodium carbonate or lithium chloride.

A somewhat different method of treating the beads has been found successful which method is suitable for treating not only glass beads but beads formed from hard rubber, metal such as silver, or a plastic such as methyl methacrylate resin. In one specific embodiment of this method a granular abrasive material is ground to a powder which will pass a 1250 mesh screen and is thoroughly mixed with water. The water is then

forced under pressures of from 50 to 100 pounds per square inch through nozzles which atomize the water. The beads are placed at a distance of from 4 to 10 inches from the nozzles and the vapor containing the entrained abrasive is projected against the surfaces of the beads with sufficient force to roughen or pit the surfaces. The beads thus treated have surfaces formed with very minute depressions and valleys along which ink will rise rapidly to thoroughly wet the surfaces.

Instead of forming the beads from glass as above described, they may be formed from Lucite (methyl methacrylate resin) having incorporated therein, or treated after formation with a material which increases the wettability of the surface of the beads. Excellent results have been obtained by mixing with the methyl methacrylate while the latter is in monomer form from 2½ to 10% by weight, and preferably about 10% of Aerosol "O.T." (di-octyl sodium sulphosuccinate) and thereafter polymerizing the methyl methacrylate.

The wettability of the surfaces of beads formed from "Lucite" (methyl methacrylate resin) may be increased by suitably treating the beads after formation. In one specific form of such treatment the beads were moistened with water and allowed to absorb water. Thereafter, silicon tetrachloride in the vapor phase was allowed to react, at room temperature and atmospheric pressure, with the absorbed water. The beads then were ready for use and were found to have more readily wettable surfaces than beads formed from untreated "Lucite."

A fountain pen of the capillary type in order to operate satisfactorily must be capable of being filled, written out, and refilled and written out repeatedly. In order to achieve this result, the capillary system of the pen must have such capillary characteristics that it will draw in ink during filling to fill the reservoir to the desired extent, retain the ink in the pen during periods of non-writing, and, when the pen is used in writing, will permit ink to be drawn from the pen by the capillarity established between the nib and the writing surface and the capillary action of the feed between the reservoir and the nib. It has been found that, in order for a pen to have these characteristics, it is necessary that the total ink retentive force of the pen per unit of mean transverse cross-sectional area of the capillary system (or what may be termed the "capillary intensity" of the pen) be within a definite range of values.

The optimum capillary intensity will vary in pens having capillary systems of different characteristics. However, it has been found that for satisfactory operation, capillary systems in pens of normal sizes and shapes must have capillary intensities within the range of from zero to 16 grams per square centimeter. Where the capillary intensity of a capillary system in a pen of normal size and shape exceeds 16 grams per square centimeter, the ink is retained in the pen when it is attempted to use the pen in writing and the pen will not write out satisfactorily. Excellent results have been obtained in practical demonstrations with capillary pens having capillary intensities ranging from 4 to 10 grams per square centimeter. By way of specific example, the pen for which specific dimensions and performance data is given elsewhere herein and described as one specific practical embodiment of my invention has a capillary intensity of approximately 7 grams per square centimeter.

Capillary intensity may be expressed mathematically approximately as follows:

$$f=\frac{K_1[K_2\sum lT\cos(\theta-\alpha)+\Delta N]}{A_m}$$

f represents capillary intensity,

K_1 and K_2 represent constants which depend upon the character of the particular capillary system,

l represents the mean perimeter of the individual capillary passages,

T represents the surface tension of the ink,

Θ represents the wetting angle of the ink relative to the type of capillary surface by which it is confined,

α represents the angle of inclination of the walls of the capillary passages to the axis of the pen where such inclination exists,

ΔN represents the total change in capillary force exerted by the nib (and adjacent portion of the capillary system) from the time the pen is filled and suspended vertically with the nib down until the instant after write-out when write-out ceases, and

A_m represents the mean transverse cross-sectional area of the capillary system.

In one practical embodiment of a fountain pen embodying the invention and having overall exterior dimensions approximately equal to those of a conventional fountain pen, excellent results were obtained by employing a capillary filler element formed of "No. 6" beads having an average diameter of 0.6 mm. The pen was filled by inserting the end in alkaline ink, such as Parker Tunis Blue "51" ink, having a surface tension of around 42 dynes per square centimeter. The ink rose to a height of approximately 2½" from the bottom of the capillary filler element, approximately 1.0 gram of ink was drawn into the pen and approximately 0.69 gram wrote out freely. When the pen was refilled, approximately 1.0 gram was drawn into the pen. In a similar pen employing a capillary filler element formed of beads having an average diameter of approximately 0.9 mm. in diameter, approximately 0.66 gram of ink was drawn into the pen and approximately 0.53 gram was written out freely; when the pen was refilled approximately 0.66 gram was drawn into the pen.

Referring now to Fig. 4 there is illustrated an alternative feed construction for a pen having a body and filler element construction generally similar to that illustrated in Fig. 1. In this form of the invention the pen body **27** is formed with a nib opening **28** generally similar to that above described and a nib **29** is secured in the body in a generally similar manner as by a ring **30**. The nib **29** is so secured in the body **27** as to provide a narrow capillary space **31** between the nib **29** and the end wall **32** of the body. The nib **29**, however, is formed with a slit **33** which terminates rearwardly at a point intermediate the front and rear surfaces of the end wall **32** and a feed slot **34** is formed in the end wall **32** in alignment with the nib slit **33**. The feed slot **34** extends from the forward end of the chamber **35** and provides communication between the capillary passages in the capillary filler element **36** and the nib slit **33**. Additional feed passages **37** preferably are formed in the end wall **32** on either side of and generally parallel to the feed slot **34** to draw ink from the capillary filler element **36** and maintain it in the capillary space between the top surface of the end wall **32** and the nib **29** from whence the ink can be drawn into the nib slit **33**. A shallow de-

pression 38 may be formed in the top portion of the end wall 32 which may be of capillary depth and provide a small ink reservoir. Alternately this depression 38 may contain a feed element (not shown) such as beads preferably of smaller diameter than the beads forming the filler element 36 or a pad. In some cases it has been found desirable to interpose a pad 39 between the end of the filler element 36 and the nib 29 and end wall 32 of the body 27.

Referring now to Fig. 7 there is illustrated another embodiment of the invention in which embodiment the feed from the capillary filler element to the nib includes a feed bar associated with the nib. This pen comprises a body 40 including a front section 41 and a rear section 42 secured together as by a threaded joint 43. The front section 41 is formed with a chamber 44 which defines an ink reservoir, a threaded counterbore 45 extending from the chamber 44 and a bore 46 extending from the counterbore 45 and through the end wall of the body member 41. A nib and feed bar holder 50 which takes the form of an externally threaded bushing is secured in the counterbore 45 and is formed with a bore 51 and counterbore 52. A plurality of circumferentially spaced longitudinally extending slots 53 are formed as by broaching in the bushing 50 and provide passages between the bore 46 and the chamber 44 for a purpose which will hereinafter be explained.

Seated frictionally in the bore 52 in the bushing 50 is a pen nib 54 which is positioned longitudinally by the shoulder formed at the junction of the bore 51 and the counterbore 52. The nib 54 may be of any suitable construction but preferably has a generally cylindrical body or shank 55 formed with a slot 56 in its underside, a pierce 57, and a slit 58 extending from the pierce to the end of the point and dividing the pen end into two nib sections 59. The top slot 53 in the bushing 50 preferably is in alignment with the pierce 57 and slit 58. The upper wall of the bore 46 is cut away to provide a capillary ink space 49, over the nib 54 extending from rearwardly of the pierce 57 to close to the wiring tip; preferably this space is generally triangular in horizontal cross section and has its apex toward the front end of the pen and registering with the nib slit 58.

Extending through and frictionally mounted in the bore 51 of the collar 50 is a feed bar 60 which has a generally cylindrical body portion projecting at its rear end into the chamber 44 and a generally semi-cylindrical forward end portion 61 extending approximately to the end of the bore 46 in the pen body. The body of the feed bar 60 is slightly smaller in diameter than the pen nib thereby providing a capillary ink space 48 (Fig. 10) between the nib 54 and feed bar 60. The outer or forward end of the feed bar 60 is positioned to bear against the underside of the nib sections 59 and cooperates with the adjacent upper wall of the bore 46 in providing restraining means limiting the spreading of the nib sections 59 and preventing undue vibration of the nib 54. The reduced end 61 of the feed bar 60 is so positioned that a space 47 of substantial size is provided between the feed bar 60 and the counterbore 46 in the pen body.

A feed slot 62 is formed in the upper portion of the feed bar 60 and extends therealong from the rear end to forwardly of the pierce 57 of the nib 54, and registers with the pierce 57 and slit 58. One or more additional feed slots 64 may be formed in the side and bottom portions of the feed bar 60 which slots extend from the rear end of the feed bar 60 to the space 48 between the feed bar 60 and the nib 54, thus providing communication between the chamber 44 and the space 48.

A capillary filler element 65 is disposed in the chamber 44 and may be similar to that illustrated in Fig. 1 and described above. The beads, whether separate or joined in a unitary mass, surround and abut the rear end of the feed bar 60 which projects into the chamber 44, and the capillary cells of the capillary cell structure are thus placed in communication with the feed slots 62 and 64 in the feed bar 60. The beads of the capillary filler element also abut the end wall of the collar 50 and the capillary cells are placed in communication also with the slots 53 in the collar 50.

The feed element (not shown) may be provided which may consist of beads of smaller sizes than the remainder of the beads or which may take the form of a pad or wick, as above explained. Such feed element has a capillarity higher than that of the adjacent cells of the filler element in order to draw ink therefrom but not higher than the capillarity of the feed passages formed by the feed slots 62 and 64 in the feed bar 60, or the slots 53 in the collar 50.

The capillary filler element 65 is held in position in a suitable manner as by disposing a plug 66 at the rear end of the filler element 65 which plug may be formed in a manner generally similar to the plug 21 above described and which is itself positioned by the forward end 67 of the rear section 42. In order to vent the chamber 44 to the atmosphere, an air passage 68 is provided in the rear section 42. Secured to the end of the body member 42, as by screw threads 69 is an end piece 70 which normally closes the passage 68 but which has a vent 71 providing communication between the passage 68 and the atmosphere when the end piece 70 is slightly unscrewed.

The fountain pen is filled by inserting the end in a supply of ink in order to allow capillary action of the capillary passages within the pen to cause the ink to be drawn into the reservoir. To expedite filling, the end piece 70 may be unscrewed slightly to open the vent 71 fully to the atmosphere.

Ink is drawn into the space 48 between the nib and feed bar and passes therefrom along the feed slots 62 and 64 in the feed bar and into the filler element 65; ink also passes from the space 48 through the broached slots 53 in the bushing 50. Ink also may be drawn into the pen through the space 49 above the nib from whence it is drawn into the top broach 53 and also is drawn from the space 49 through the pierce 57 and into the space 48. Where the pen is inserted to a sufficient depth in the supply of ink the broached passages 53 are brought into direct communication with the ink supply and ink is drawn directly into these passages and from thence into the filler element 65. Where a feed element (not shown) is provided adjacent the end of the filler element ink will be drawn into the feed element from the passages 53 and thence into the capillary filler element.

Ink rises in the capillary filler element in a manner similar to that described above, and fills the cells formed by the voids between the beads constituting the filler element. Air which was in the voids is forced out through the venting passages formed by the passage 68 and the vent opening 71 in the end piece 70.

Ink is maintained at the nib at all times so

the pen is instantly ready for writing and so that ink which is withdrawn during writing is immediately replaced. In order to insure this supply, ink is fed to the nib from both above and below. The feed slot 62 in the feed bar 60 leads directly from the capillary filler element 65 to the pierce 57 and slit 58 of the nib 54 to supply ink thereto by capillary action. Ink also is drawn through the pierce 57 and through the top slot 53 and fills the space 49 above the nib 54. The space 49 extends above a substantial portion of the nib slit 58 and thus maintains adjacent the nib slit a supply of ink which replaces ink which evaporates from the slit or is drawn off in writing. Ink also may be drawn into the feed slots 64 and the space 48 between the nib 54 and feed bar 60 and thence into the feed slot 62 by which it is fed to the nib pierce 57.

While a single ink feed passage is usually adequate to feed ink from the storage spaces to the nib in writing, the provision of a plurality of feed passages has the advantage that ink flow to the nib will be insured in the event that one of the passages should become clogged. With respect to the embodiment illustrated in Fig. 7, the feed slot 62 formed in the feed bar and which communicates directly with the nib pierce and nib slot, may be considered as the principal feed passage. The other passages described, while also useful in feeding ink to the nib in writing and which provide additional passages to insure that ink is fed freely to the nib, are of primary importance in providing a plurality of passages of substantial total capacity for permitting the pen to fill rapidly. Moreover, the passages such as the broached slots 53, which are provided in addition to the principal feed passage, provide means whereby ink may be drawn into the pen into the reservoir independently of the principal feed passage. It is desirable that the principal feed passage leading to the pen nib slit have a relatively high capillarity in order to insure that ink is maintained at all times at the pen nib slit and to insure that a high percentage of the ink in the reservoir is written out. The other passages need not have such a high capillarity and, therefore, may have larger transverse dimensions and a greater flow capacity.

When ink is drawn from the cells in the capillary filler element, air enters the pen to replace such ink. It is not necessary, however, that the air be admitted through the vent system provided at the rear of the pen body. Air will enter the pen at the nib end through those passages which are of lesser capillarity and will pass into the capillary filler element. This is due to the fact that the passages of higher capillarity will draw ink from the passages of lower capillarity, leaving the latter in a condition to permit the entrance of air. Any changes in atmospheric pressure are transmitted to the air within the pen body in a generally similar manner. However, when the pen is being filled, it is desirable to vent the air rapidly in order that the filling may be accomplished promptly and, therefore, a venting system such as described above is provided.

Another embodiment of the invention is illustrated in Figs. 15 to 19. Referring to Fig. 15, the fountain pen includes a body 80 having a front section 81 formed with a chamber 82 defining an ink reservoir space. Secured in the front section 81 as by screw threads 83 is a metal connector sleeve 84 having an enlarged head 85 and a reduced body 86. A rear section 87 is slidably supported on the connector sleeve 84 and

abuts at its end the enlarged head 85 and the adjacent end of the front section 81. The rear section 87 may be secured in place by a thermoplastic adhesive.

The front section 81 is formed with a bore 91 and a communicating counterbore 90, which together extend from the chamber 82 through the end wall of the front section 81 and provide means for accommodating a nib 95 and a feed bar 92. Frictionally fitted in the counterbore 90 is a nib 95 generally similar to the nib 54 above described.

A feed bar 92 having a generally cylindrical body is frictionally seated in the bore 91 and projects at its rear end into the chamber 82 and at its forward end extends within the nib 95. The feed bar 92 is of slightly smaller diameter than the nib 95 and a capillary space 97 is provided therebetween.

The feed bar 92 is provided with a capillary feed slot 98 in its upper portion which extends from the rear end of the feed bar 92 to a point under the pierce 96 of the nib 95. One or more additional capillary feed slots 99 may be provided which extend longitudinally of the feed bar 92 from its rear end to at least as far as the portion which extends in the counterbore 90. The longitudinal feed slots 98 and 99 are connected by a circumferential capillary feed slot 100 formed in that portion of the feed bar 92 which seats in the bore 91.

Disposed in the chamber 82 is a capillary filler element 101 similar to that described in connection with the embodiment of the invention illustrated in Fig. 1, and which may be formed either of separate beads held in abutting relation, or beads joined in a unitary structure. The filler element 101 is disposed in closely abutting relation with the portion of the feed bar 92 which projects into the chamber 82 so that the capillary cells of the former are in feeding relation with the feed slots 98 and 99. As previously explained, a feed element (not shown) of higher capillarity than the filler element proper may be disposed between the feed bar and the principal portion of the filler element.

Abutting the end of the filler element 101 and firmly secured in the connector 84 is a plug 102 which serves to retain the beads in firm abutting relation where the cell structure is constituted by separate beads. The plug 102 preferably is formed in a manner similar to the plug 21 described above and permits air to pass therethrough but will not draw ink from the capillary filler element 101. The body member 87 has a passage 104 which may be closed at its rear end by an end piece 105 which may be attached to the body member 87 as by a threaded collar 106. When the end piece 105 is unscrewed slightly the vent opening 107 provides communication between the passage 104 and the atmosphere.

This embodiment of the pen operates in substantially the same general manner as the pen illustrated in Figs. 5 to 11, inclusive. To fill the pen, the ends of the nib 95 and feed bar 92 are inserted in a supply of ink. To facilitate filling the end piece 105 is unscrewed slightly to open the vent 107 to atmosphere.

Ink is drawn into the space 97 between the nib 95 and feed bar 92 and thence into the feed passages 98 and 99 by which it is drawn into the capillary filler element 101. Ink also enters the space above the nib 95 and is drawn through the pierce 96 and into the space 97. Where the pen is inserted sufficiently in the ink supply, ink also

may be drawn into the space between the feed bar 92 and walls of the counterbore 90 and from thence into the feed passages 98 and 99 by which it finds its way into the capillary filler element 101.

In writing, ink is drawn from the capillary filler element 101 by the capillary action of the feed passages 98 into the space 97 and is supplied to the pierce 96 and slit 89. Ink also is drawn from the cell structure 101 into the feed slots 99 which are in communication with the top feed slot 98 through the circumferential slot 100 and serve also to feed ink to the top feed slot 98.

For a reservoir of any given diameter, the amount of ink which will be drawn into the reservoir will depend upon the height to which ink will be lifted above the surface of the ink supply by the capillary action of the capillary system in the pen. The height to which ink will be lifted, depends upon a number of factors, as indicated above, but is independent of the diameter of the reservoir. Accordingly, in a fountain pen having predetermined capillary characteristics which will cause ink to be raised to a predetermined height, the amount of ink which can be drawn into the pen can be increased by increasing the diameter of the reservoir below the point of maximum rise of ink. In the embodiment illustrated in Fig. 15, increased capacity of the pen is obtained by providing a reservoir of substantial girth. In order to prevent the pen from presenting to the sight and grip a too great overall bulk, the rear portion is sharply reduced in diameter. Various other body shapes may be employed to accomplish the results indicated, however.

A further embodiment of the invention is illustrated in Figs. 20 to 25. Referring to Fig. 20, the fountain pen includes a body 110 having a front section 111, and a rear section 112 secured thereto as by a frictional telescopic fit. Preferably the body sections 111 and 112 may be further secured together by a thermoplastic adhesive (not shown). The body sections 111 and 112 are formed with hollow interior portions which together provide a chamber 113 defining an ink reservoir space. In order to provide increased ink capacity for a predetermined length of reservoir, the body 110 is enlarged at the central and forward portions thereof. Preferably this is accomplished by flaring or "bellying" the underside which provides the increased capacity but at the same time maintains a suitable balance of the pen so that it has a comfortable shape and distribution of weight.

At its forward end the front section 111 is formed with a bore 115 and a counterbore 114 which together extend from the chamber 113 through the end wall of the body member 111. Frictionally seated in the counterbore 114 is a pen nib 120 generally similar to the nibs above described. A feed bar 116 is frictionally seated in the bore 115 and projects at its rear end into the chamber 113 and at its forward end extends within the pen nib 120. The feed bar 116 is of a smaller diameter than the nib 120 and the capillary space 117 is provided therebetween.

The feed bar 116 is provided with a capillary feed slot 125 in its upper portion and extending from its rear end to a point under the pierce 122 of the nib 120 and thus is positioned to feed ink to the nib pierce 122 and slit 123 from below the nib. One or more additional capillary feed slots 126 preferably are provided in the feed bar 116 which extend from the rear end thereof to the portion of the feed bar 116 forwardly of the bore 115.

Formed in the body member 111 at the bore 115 and extending between the bore 114 and the chamber 113 are a plurality of capillary slots 127 and 128 which provide passages of somewhat lesser capillarity than the feed slots 125 and 126. The uppermost slot 127 preferably extends to and is in alignment with the nib slit 123, thus providing a substantially direct passage for feeding ink to the nib pierce and slit from above the nib.

Disposed in the chamber 113 is a capillary filler element 130 generally similar to those described above and which may consist of separate beads or a unitary cellular mass. Feed means (not shown) of higher capillarity than the cell structure generally may be interposed between the cell structure and the feed bar and may consist of a pad or small beads, or incorporated in the cell structure as described above.

The filler element 130 may be suitably secured in place by a plug 131 which bears against the filler element 130 and seats against a shoulder 134 at the rear end of the chamber 113. The plug 131 is formed in a manner similar to the retaining plugs above described so as to permit air to flow therethrough but to prevent the passage of ink from the chamber 113.

The body rearwardly of the chamber 113 is formed with an air passage 133, the rear end of which is closed by an end piece 135 which carries a vent valve member 136 slidable in a guide 137 fixedly secured in the body member 112, as by an adhesive. The valve member 136 has a vent opening 138 in its side wall communicating through a central passage 139 with the passage 133. When the end piece 135 is in closed position (shown in Fig. 20) the vent is closed. However, if the end piece 135 is drawn away from the body member 112, the vent opening is open to the atmosphere. In order to limit outward movement of the end piece 135 and guide the valve 136 in its movement, the valve 136 is provided with ears 140 which slide in slots 141 in the guide 137.

In this fountain pen, filling is accomplished in a manner generally similar to the filling of the other fountain pens above described. The end piece 135 is drawn outwardly to open the vent, and the nib end of the pen is inserted in a supply of ink.

Ink is drawn into the space 117 between the nib 120 and the feed bar 116 and from thence along the feed passages 125 and 126 in the feed bar 116 and also along the passages 127 and 128 in the pen body and thence to the capillary filler element 130. Ink also may be drawn into the space between the nib 120 and top wall of the counterbore 114 from whence it is drawn by the feed passage 127 to the filler element 130. Where the pen is inserted sufficiently in the supply of ink, ink will enter the space between the feed bar 116 and the bore 114 at the rear portion of the latter and will be drawn from thence along the feed passages 128 and the feed passages 126 and thence into the capillary filler element 130.

During filling, air is vented through the plug 131, the passage 133, the passage 139 in the valve member 136 and the vent opening 138.

In writing, ink is drawn from the capillary filler element 130 along the feed passages 125 and 126 in the feed bar and is supplied to the space 117 between the nib and feed bar from whence it is drawn into the nib pierce 122 and nib slit 123.

A further embodiment of the invention is shown

in Figs. 26 to 29 inclusive. The pen comprises a body 150 formed by front and rear sections 151 and 152 joined by a connection somewhat similar to the connection illustrated in Fig. 15. However, the connection illustrated in Fig. 26 includes a metal thimble 153 secured as by threads 154 in the body member 151 and having an inturned flange 155, and a metal connector sleeve 156 extending into the thimble 153 and having an outturned flange 157 engaging the flange 155; the body member 152 is fitted into the sleeve 156 and may be secured thereon as by an adhesive.

The front section 151 is essentially hollow, the interior providing a chamber 160 which defines an ink reservoir space. Extending through the end of the front section 151 is a counterbore 161, communicating by a bore 162 with the chamber 160.

A pen nib 164 is frictionally seated in the counterbore 161 and a feed bar 163 is frictionally seated in the bore 162 and projects into the chamber 160 at its rear end and extends within the nib 164 at its forward end. The feed bar 163 is of smaller diameter than the nib and provides a capillary space 165 between the nib and feed bar.

The feed bar 163 is formed with one or more, and preferably a plurality of capillary feed slots extending from the rear end of the feed bar. The uppermost feed slots 170 extend to and register with the nib pierce 166. The remaining feed slots 171 extend to and are in communication with the bore 161.

The upper wall of the bore 161 is provided with one or more and preferably a plurality of feed grooves 172 extending forwardly from the chamber 160; preferably the topmost groove 172 is in alignment with and extends substantially to the nib pierce 166. Each groove is of tapered or V-shaped cross-section with the inner or closed portion of small dimensions and of relatively high capillarity; the outer or open portions of the grooves are of relatively low capillarity. The grooves 172 also taper from front to rear.

Disposed in the chamber 160 is a capillary filler element 175 which may be similar to those above described and arranged with its cells in communication with the feed slots 170 and feed grooves 172.

The filler element may be retained by a plug 176 similar to the retaining plugs above described. The body member 152 may be closed by an end piece 179 attached thereto as by threading it on a thimble 180 threaded into the body member 152. The thimble 180 is provided with a vent opening 181 which provides communication from the passage 178 to the atmosphere when the end piece is unscrewed slightly.

The pen is filled in a manner generally similar to the pen illustrated in Fig. 20 and above described and ink is fed to the nib in writing in a generally similar manner, the tapered feed passages 172 serving to feed ink to the pen nib in a manner generally analogous to the feed passages 127 and 128.

In writing, the ink feeds in a manner generally similar to that described in connection with the pen of Fig. 20. Owing to the high capillarity of the inner portions of passages 172 there is a strong force acting to draw ink forward to the nib. The outer or open portions of the grooves 172, however, is relatively large and therefore a substantial body of ink is maintained in position to be drawn toward the nib so that free even flow of ink is assured.

I believe that the operation and advantages of the invention will be well appreciated from the foregoing description, and it is to be understood that, while I have shown and described several forms of my invention, other details and arrangements of parts may be resorted to without departing from the spirit and scope of my invention as defined by the claims that follow.

I claim:

1. A fountain pen comprising a hollow body having an ink-reservoir-receiving space therein, a capillary filler-and-reservoir element disposed within and throughout said space and comprising a porous mass of material defining throughout a plurality of interconnected capillary ink storage spaces, a nib at the forward end of said body and having a capillary feed passage therein for delivering ink directly to the surface being written upon, capillary feed means between and interconnecting said porous mass and said nib feed passage, and means for venting said reservoir space to atmosphere independently of said capillary feed passage so that ink in said filler-and-reservoir element is constantly exposed to atmospheric pressure.

2. A fountain pen comprising a body having a reservoir section and a feed section, a capillary filler-and-reservoir element disposed within and substantially throughout said reservoir section and comprising a porous mass of non-ink-absorbent material defining a plurality of interconnected capillary spaces throughout the mass, a writing element carried by said feed section and having a slitted writing point forming a capillary ink feed passage adapted to communicate with the writing surface, and means disposed in said feed section between said writing element and said filler-and-reservoir section, and having a capillary flow path interconnecting the capillary spaces of said filler-and-reservoir element and the capillary feed passages in said writing element.

3. A fountain pen comprising a hollow body having an ink reservoir therein, a capillary reservoir element disposed within said reservoir comprising a porous mass of material defining throughout a plurality of interconnected capillary spaces, said mass being rigidly confined in said reservoir to provide a substantially rigid mass wherein the size, shape and arrangement of the capillary spaces are maintained, a nib carried by said body and having a capillary feed passage therein for delivering ink directly to the surface being written upon, and capillary feed means between and interconnecting said porous mass and said nib feed passage.

4. A capillary filler-and-reservoir element for a capillary filler fountain pen comprising a porous mass formed of beads defining therein a plurality of interconnected capillary spaces of sufficient capillarity to draw ink therein by capillary action to fill said spaces when said spaces are placed in filling communication with a supply of ink and to retain the ink therein except when a capillary force at least as great as that established between a writing point of a pen and a writing surface is exerted on the ink in said capillary spaces tending to withdraw it therefrom, said beads being maintained in fixed abutting relation to maintain the size, shape and arrangement of said capillary spaces.

5. A capillary filler-and-reservoir element for a capillary filler fountain pen comprising a mass of individual, rigid particles defining a plurality of interconnected capillary spaces of sufficient capillarity to draw ink therein by capillary action

to fill said spaces when said spaces are placed in filling communication with a supply of ink and to retain the ink therein except when a capillary force at least as great as that established between a writing point of a pen and a writing surface is exerted on the ink in said spaces tending to withdraw it therefrom, said particles being retained in firm abutting relationship to maintain the size, shape and arrangement of said capillary spaces.

6. A fountain pen comprising a pen body having an open forward end and a reservoir space rearwardly therein, spherical particles packed in and throughout said space in close abutting relation, said particles being of a diameter sufficient to form therebetween and throughout said space a multitude of interconnected and uniformly sized capillary voids providing a self-filling reservoir, a writing element in the forward end of said pen body having its writing end or tip exposed for engagement with the writing surface, and feed means within said body and having a capillary feed connection with the foremost of said voids, the capillarity of said feed means and voids being sufficient to draw ink into and fill said voids and to retain the ink in said voids except when said writing element is engaged with a writing surface to establish a condition of greater capillarity at the writing surface than that which exists in said feed means and voids.

7. A fountain pen comprising a pen body having an open forward end and a reservoir space rearwardly therein, rigid granular particles packed in and throughout said space in close abutting relation, said particles being of a diameter sufficient to form therebetween and throughout said space a multitude of interconnected voids providing an ink reservoir of sufficient capillarity to retain the ink therein and substantially throughout the length of said space when said pen body is disposed in a substantially vertical position, a writing element mounted in the forward end of said body with its writing end portion exposed for engagement with a writing surface, and feed means within said body and having capillary feed channels of greater capillarity than said voids and connecting the foremost of said voids with said writing element, the capillarity of said feed means and voids being sufficient to draw ink into and fill said voids, to normally retain the ink in said voids when they are filled, and to feed the ink from said voids through said feed means to the writing element and the writing surface when the writing end portion of said writing element is engaged with a writing surface.

8. A fountain pen comprising a pen body having an open forward end and a reservoir space therein, bead elements of substantially uniform size packed into said space throughout the length and width thereof to provide therein a multitude of interconnected capillary voids constituting an ink reservoir, a writing element mounted in the forward end of said pen and having a writing end portion with a capillary feed fissure therein, and feed means mounted in said pen body interconnecting the feed fissure of said writing element and the voids in the forward portion of said space, said feed means having a capillary feed channel of greater capillarity than the voids in the forward portion of said space and of less capillarity than said feed fissure.

9. A capillary fountain pen comprising a body, a writing element supported by said body, and a capillary filler-and-reservoir element for filling said pen by capillary action, said element including a porous mass of rigid material, the pores of which are interconnected and are connected in ink-feeding relation to said writing element, said pores being of capillary dimensions to provide ink storage spaces of sufficient capillarity to draw ink therein to fill said spaces when placed in filling relation to a supply of ink and to retain the ink therein in all positions of said pen when the pen is not used in writing, but insufficient to retain the ink against the capillarity established when the writing element is engaged with a writing surface in writing.

10. A fountain pen comprising a pen body having an ink reservoir space therein, a writing element, means mounting said writing element on said body, and capillary filler-and-reservoir means in said reservoir space including a plurality of solid particles of substantially uniform sizes and shapes disposed in intimate contact in said reservoir space and defining voids providing capillary ink storage spaces extending throughout said reservoir space of sufficient capillarity to draw ink into said capillary spaces and to retain the ink therein except when the writing element is engaged with a writing surface, and means connecting said capillary spaces in ink feeding relation with said writing element.

11. A fountain pen comprising a pen body having an ink reservoir space therein, a writing element, means mounting said writing element on said body, capillary filler-and-reservoir means in said reservoir space including a plurality of solid, spherical particles disposed in intimate contact, the voids between said particles providing capillary ink storage spaces in said reservoir space of sufficient capillarity to draw ink therein and to retain the ink therein except when the writing element is engaged with a writing surface, and means connecting said capillary spaces in ink feeding relation with said writing element.

12. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, capillary filler-and-reservoir means in said reservoir space by including a plurality of solid particles disposed in intimate contact and having surface portions of predetermined, fixed sizes defining capillary ink storage cells in said reservoir space of sufficient capillarity to draw ink therein and to retain the ink therein except when the writing element is engaged with a writing surface, and capillary feed means extending from said cells into feeding relation with said writing element.

13. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, a capillary filler-and-reservoir element disposed in said reservoir space and including a plurality of initially individual, solid particles of such sizes and shapes that when disposed in intimate contact define a plurality of capillary ink storage spaces therebetween of sufficient capillarity to fill by capillary action and to retain the ink therein except when the writing element is engaged with a writing surface, said particles being disposed in a compact mass in said reservoir, said particles being joined at abutting surface portions to form a unitary structure, and means connecting said spaces in ink feeding relation with said writing element.

14. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, and a capillary filler-and-reservoir element

disposed in said reservoir and including a plurality of solid particles disposed in intimate contact and defining therebetween a plurality of capillary ink storage spaces in said reservoir space of sufficient capillarity to fill by capillary action and to retain the ink therein except when the writing element is engaged with a writing surface, the particles in that portion of the filler element more remote from said writing element defining spaces of greater capillarity than the particles closer to said writing element, and means connecting said storage spaces in feeding relation with said writing element.

15. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, a capillary filler-and-ink-storage element disposed in said reservoir space and including a plurality of solid particles defining capillary spaces therein of sufficient capillarity to draw ink therein and to retain the ink therein except when the writing element is engaged with a writing surface, the particles more remote from said writing element providing spaces of greater capillarity than the particles closer to said writing element, and capillary feed means of greater capillarity than said capillary spaces interposed between said capillary spaces and said writing element.

16. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, a capillary filler-and-ink-storage element disposed in said reservoir space and including a plurality of solid generally spherical particles of predetermined sizes and shapes disposed in intimate contact and defining a plurality of capillary spaces of sufficient capillarity to draw ink therein and to retain the ink therein except when the writing element is engaged with a writing surface, means connecting said capillary spaces in feeding relation with said writing element, and means continuously venting said reservoir to atmosphere.

17. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, a capillary filler-and-ink-storage element disposed in said reservoir space and including a plurality of solid generally spherical particles of predetermined sizes and shapes disposed in intimate contact in said reservoir space, and means for retaining said particles substantially in fixed abutting position to define a plurality of capillary spaces of fixed sizes and locations and of sufficient capillarity to draw ink therein and to retain the ink therein except when the writing element is engaged with a writing surface, and means connecting said capillary spaces in feeding relation with said writing element.

18. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, capillary filler-and-reservoir means in said reservoir space including a plurality of solid particles disposed in abutting relation in said reservoir space and defining capillary spaces therebetween of sufficient capillarity to draw ink therein and to retain the ink therein except when the writing element is engaged with a writing surface, means for retaining said particles in abutting relation in said reservoir space and providing an air passage communicating with said spaces and the atmosphere, and feed means connecting said capillary spaces in feeding relation to said nib.

19. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, a capillary filler-and-ink-storage element disposed in said reservoir space including a plurality of solid particles defining a plurality of capillary cells in said reservoir space, a substantial proportion of which are of such dimensions that the capillarity of each cell is at least as great as the minimum capillarity at which the cell will fill by capillary action when the filler and ink storage element is placed in filling relation to a supply of ink for filling of the pen and not greater than the maximum capillarity at which ink will be drawn therefrom by capillary action in writing, and means connecting said capillary passages in feeding relation with said writing element.

20. A fountain pen comprising a pen body having an ink reservoir space, a writing element, means mounting said writing element on said body, a capillary filler element disposed in said reservoir space and including a plurality of generally spherical solid particles having diameters ranging from about 0.020'' to about 0.060'', disposed in intimate contact and defining therebetween capillary ink storage spaces, said storage spaces being connected in feeding relation to said writing element.

21. A fountain pen comprising a pen body having an ink reservoir space, a pen nib supported on said body, and capillary filler-and-reservoir means in said reservoir space including a porous mass defining a plurality of capillary spaces in said reservoir space in ink feeding relation with said nib, said capillary spaces being of sufficient capillarity to draw ink therein during filling and to retain the ink therein except when the nib is engaged with a writing surface, said mass having surfaces which, when aqueous inks are used therewith, such inks make liquid contact angles therewith not substantially in excess of 60 degrees.

22. A fountain pen comprising a pen body having an ink reservoir space, a pen nib supported on said body and providing a capillary ink feed passage, and capillary filler-and-reservoir means in said reservoir space including a porous mass of rigid material defining a plurality of capillary spaces in said reservoir space of sufficient capillarity to fill by capillary action and to retain the ink therein except when the nib is engaged with a writing surface, at least a portion of said mass abutting said nib and defining capillary passages in ink feeding relation with the ink feed passage provided by said nib.

23. A fountain pen comprising a pen body having an ink reservoir space and an air vent passage extending from said reservoir, a pen nib supported on said body, capillary filler-and-reservoir means in said reservoir space including a plurality of solid particles defining a plurality of capillary spaces in said reservoir space, of sufficient capillarity to draw ink therein and to retain the ink therein except when the nib is engaged with a writing surface, in ink feeding relation with said nib and in communication with said air vent, and means in said air vent passage for preventing the entry of ink therein from said spaces.

24. A fountain pen comprising a pen body having an ink reservoir space and an air vent passage extending from said reservoir space, a pen nib supported on said body, capillary filler-and-reservoir means in said reservoir space including

a porous mass defining a plurality of capillary spaces in said reservoir in ink feeding relation with said nib and in communication with said air vent, said capillary spaces being of sufficient capillarity to draw ink therein and retain the ink therein except when the nib is engaged with a writing surface, and a porous mass in said air vent passage defining a plurality of air vent outlets, said second named mass having surfaces which, when used with aqueous inks, are relatively non-wettable thereby.

25. A fountain pen comprising a pen body having an ink reservoir space and an air vent passage extending from said reservoir, a pen nib supported on said body, capillary filler-and-reservoir means in said reservoir space including a plurality of solid particles defining a plurality of capillary spaces in said reservoir space in ink feeding relation with said nib and in communication with said air vent, and a plurality of solid particles disposed in said air vent passage defining a plurality of air vent outlets, said second named particles having surfaces which, when aqueous inks are used therewith, such inks make liquid contact angles therewith not substantially less than 90 degrees.

26. A fountain pen comprising a pen body having a chamber therein, a pen nib supported on said body, and capillary filler, ink storage, and air vent means in said chamber defining a plurality of capillary ink storage spaces and a plurality of air vent outlets communicating therewith, said means including a plurality of solid particles disposed in contact and having capillary voids therebetween connected in ink feeding relation with said nib, said particles being provided in one portion of said chamber with surfaces which, when used with aqueous inks, are relatively wettable thereby, to provide a plurality of interconnected storage spaces, and in another portion of said chamber with surfaces which when used with aqueous inks are relatively non-wettable thereby to provide air vent passages communicating with said ink storage spaces and through which air, but not ink, will pass.

27. A capillary filler element for a capillary filling fountain pen comprising a plurality of initially individual solid particles disposed in abutting relation, adjacent particles being secured together at their respective points of contact to form a unitary structure and defining a plurality of capillary spaces extending throughout said filler element of sufficient capillarity to draw ink therein to fill said spaces when the filler element is placed in filling relation to a supply of ink and to retain the ink therein but insufficient to retain the ink against a capillarity of the order of that established between the writing element of a pen and a writing surface.

28. A combined capillary filler and feed element for a capillary filling fountain pen comprising a plurality of initially solid particles disposed in abutting relation, adjacent particles being secured together at their respective points of contact to form a unitary structure and defining a plurality of capillary ink spaces extending through said structure of sufficient capillarity to draw ink therein to fill said spaces when said element is placed in filling relation to a supply of ink and to retain the ink therein but insufficient to retain the ink against a capillarity of the order of that established between the writing element of a pen and a writing surface, the unitary structure at the end thereof which is adapted to be located nearest the writing element when the filler and feed element is incorporated in a fountain pen defining spaces of lesser width than in the remainder of said structure to provide a feed element having feed passages of greater capillarity than the spaces in the remainder of said element.

29. A fountain pen comprising a pen body having an ink reservoir space, a pen nib supported on said body, and capillary filler-and-reservoir means in said reservoir space having walls defining a plurality of capillary spaces in said reservoir space in ink feeding relation with said nib end of sufficient capillarity to fill by capillary action and to retain the ink therein except when the nib is engaged with a writing surface, said walls being formed of glass and having etched surfaces providing a relatively high degree of wettability when used with aqueous inks.

30. A fountain pen comprising a pen body having an ink reservoir space, a pen nib supported on said body and having a capillary ink feed passage, and capillary filler-and-reservoir means in said reservoir space including a plurality of generally spherical particles packed in said reservoir space and of such size as to form therebetween and throughout said reservoir space a plurality of interconnected capillary spaces of sufficient capillarity to fill by capillary action and to retain the ink therein except when said nib is engaged with a writing surface, a portion of said plurality of particles abutting said nib with said capillary spaces in feeding relation with the capillary passage of said nib.

31. A fountain pen comprising a pen body having an ink reservoir space, a pen nib supported on said body, and capillary filler-and-reservoir means in said reservoir space having walls defining a plurality of capillary spaces in said reservoir space in ink feeding relation with said nib and of sufficient capillarity to fill by capillary action and to retain ink therein except when said nib is engaged with a writing surface, said walls having at least their surfaces formed of a metal having a relatively high degree of wettability when used with aqueous inks.

32. A fountain pen comprising a pen body having an ink reservoir space, a pen nib supported on said body, and capillary filler-and-reservoir means in said reservoir space having walls defining a plurality of capillary spaces in said reservoir space in ink feeding relation with said nib of sufficient capillarity to fill by capillary action and to retain the ink therein except when said nib is engaged with a writing surface, said walls having their surfaces formed with minute depressions providing a surface substantially more readily wetted when used with aqueous inks than the normal smooth surface of the material forming said walls.

33. A fountain pen comprising a body having an ink reservoir space, a pen nib having a capillary ink feed passage, means supporting said pen nib on said body, capillary filler-and-reservoir means in said reservoir space including a plurality of solid particles of generally uniform shape disposed in said reservoir and defining therebetween and throughout said reservoir a plurality of interconnected capillary spaces of sufficient capillary to fill by capillary action and to retain the ink therein except when the nib is engaged with a writing surface, and feed means including a capillary feed passage formed in said body and connected in feeding relation to said capillary spaces and to the feed passage of said nib.

34. A fountain pen comprising a body having

an ink reservoir space, a nib opening extending into said body, and communicating with said reservoir space, a capillary filler element disposed in said reservoir space and including a plurality of solid particles disposed in intimate contact and defining a plurality of capillary cells of sufficient capillarity to fill by capillary action and to retain the ink therein except when said nib is engaged with a writing surface, a nib in said opening and projecting therefrom and formed with a capillary ink feed passage, and a feed bar in said opening and defining a plurality of capillary feed passages connected in feeding relation with said capillary cells and extending to the feed passage of said nib.

35. A fountain pen comprising a pen body having an ink reservoir space, a pen nib having a capillary ink feed passage, means supporting said pen nib on said body, a capillary filler element in said reservoir space and including a porous, substantially rigid mass defining a plurality of capillary cells of sufficient capillarity to fill by capillary action and to retain the ink therein except when the nib is engaged with a writing surface,

and ink feed means including a flexible feed element interposed between said mass and said nib and providing a plurality of capillary ink feed passages connecting said cells in feeding relation to said nib passage.

HARLAN H. ZODTNER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
715,359	Dickie	Dec. 9, 1902
1,001,225	Sinnot	Aug. 22, 1911
2,151,682	Burkey	Mar. 28, 1939
2,187,528	Wing	Jan. 16, 1940
2,225,990	Henry	Dec. 24, 1940
2,311,488	Stow	Feb. 16, 1943
2,319,244	Lo Cascio	May 18, 1943
2,342,904	Sledge	Feb. 29, 1944
2,360,297	Wing	Oct. 10, 1944
2,410,423	Brinson	Nov. 5, 1946
2,421,079	Narcus	May 27, 1947