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COMPLETE SPECIFICATION

Fountain Pen

We, THE PARKER PEN COMPANY, a Corporation duly organised under the laws of the State of Wisconsin, of Corner of Court and Division Streets, Janesville, State of Wisconsin, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to fountain pens and it has to do with new and novel means for filling the ink reservoir of the pen and for feeding the ink from the reservoir to a writing surface.

One of the objects of this invention is to provide an improved fountain pen which is simple in construction, inexpensive to manufacture, and which is adapted to perform its reservoir-filling and its writing functions with a high degree of efficiency.

Another object is to provide new and novel means for filling the ink reservoir of a fountain pen.

Another object is to provide new and novel means for feeding ink from the ink reservoir of a pen to a writing surface.

A further object is to provide a fountain pen having an ink reservoir of substantial capacity adapted to be filled solely by capillary action without the aid of mechanically manipulated filling devices.

A further object is to provide a fountain pen in which the possibility of leakage under varying temperature conditions or at high altitudes is eliminated.

Another object of the invention is the provision of a fountain pen having filling means devoid of moving parts, or parts which are subject to deterioration, and which filling means is not subject to wear or loss of operative adjustment, but is capable of operating almost indefinitely without replacement or adjustment of parts.

Another object of the invention is to provide a fountain pen in which the amount of ink which can be drawn into the reservoir by the filling operation is controlled automatically, ensuring that the pen will be filled to a predetermined capacity without overfilling, and which requires a minimum of attention on the part of the user during filling.

Still another object of the invention is the provision of a fountain pen in which the ink is drawn into the pen, retained in the reservoir and fed to the writing element solely by capillary action and which does not depend upon the maintenance of a sub-atmospheric pressure within the pen for retaining the ink or increase of such pressure for permitting the ink to feed to the writing element.

Another object of the invention is the provision of a capillary filling fountain pen having a filler element with capillary passages so formed that a relatively high percentage of the ink which is drawn into the pen during filling can be written-out, whereby, the pen can be filled, written-out, refilled and written-out indefinitely without substantial decrease in the effective ink capacity of the pen.

Other and more specific objects of the invention are to provide a capillary filler element having capillary cells and passages defined by rigid, fixed wall members whereby the size, shape and locations of the capillary cells and passages can be predetermined; to provide a filler element which can be readily manufactured and assembled in a fountain pen body; to provide a filler element which has a capillary feed extending substantially directly from the ink reservoir to the pen nib slit; to provide a feed which will ensure that substantially all of the ink is withdrawn from the ink reservoir in writing; to provide a filler element having air equalizer means incorporated therein for ensuring the maintenance of equal air pressures throughout the pen; to provide a filler element which supports a nib and feed bar within the pen body in proper feeding rela-

tion to the filler element; to provide a filler element which will last almost indefinitely and will not deteriorate; to provide a filler element which is self-cleaning and which will not clog; to provide a filler element which can be used with a pen body of substantially conventional overall size and shape and with a pen nib of known construction.

Further specific objects of the invention are to provide a capillary filling fountain pen which can be filled by inserting the end of the pen in a supply of ink with the pen held at any desired angle thereto, which will fill rapidly, which will not overfill, and which will, when filled, retain ink when placed or held in any position; to provide a fountain pen which will retain ink and will not leak when the pen is subjected to reduced external air pressures such as at high altitudes, or when the air in the pen is warmed as by the hand when grasped in writing, or when the pen is subjected to severe shocks such as occur when the pen is dropped; to provide a pen which maintains ink in the nib at all times by capillary action so that the pen is instantly ready for writing; and which feeds ink to the nib solely by capillary action so that a continuous, even flow of ink is insured and the feed does not flood or starve and thereby cause variations in the writing.

Other objects and advantages of the invention will appear from the following description and from the appended drawings, in which:—

Figure 1 is an enlarged fragmentary view of a vertical, longitudinal section through one illustrative embodiment of the invention, certain of the internal members being shown in elevation;

Fig. 2 is an enlarged fragmentary, vertical longitudinal sectional view of the pen of Fig. 1;

Fig. 3 is an enlarged fragmentary, horizontal, longitudinal sectional view of the pen of Fig. 1;

Fig. 4 is a bottom plan view of the capillary filler element of the pen of Fig. 1;

Fig. 5 is a fragmentary bottom plan view of the nib end of the pen of Fig. 1;

Fig. 6 is a transverse sectional view taken along the line 6—6 of Fig. 2;

Fig. 7 is a transverse sectional view taken along line 7—7 of Fig. 2;

Fig. 8 is a transverse sectional view taken along line 8—8 of Fig. 2;

Fig. 9 is a transverse sectional view taken along line 9—9 of Fig. 2;

Fig. 10 is a transverse sectional view taken along the line 10—10 of Fig. 2;

Fig. 11 is a transverse sectional view taken along the line 11—11 of Fig. 2;

Fig. 12 is an enlarged, fragmentary, vertical, longitudinal sectional view through a second embodiment of the invention;

Fig. 13 is a fragmentary bottom plan view of the nib end of the pen shown in Fig. 12;

Fig. 14 is a side elevational view of the central rod and feed bar of the pen shown in Fig. 12, these members being shown separated for better illustration;

Fig. 15 is a front elevational view of one of the cell discs of the pen shown in Fig. 12;

Fig. 16 is a side elevational view of the nib holder of the pen shown in Fig. 12;

Fig. 17 is a transverse sectional view taken along the line 17—17 of Fig. 12;

Fig. 18 is a transverse sectional view taken along line 18—18 of Fig. 12;

Fig. 19 is a transverse sectional view taken along the line 19—19 of Fig. 12;

Fig. 20 is a transverse sectional view taken along the line 20—20 of Fig. 12;

Fig. 21 is an enlarged, fragmentary, vertical, longitudinal section taken through another embodiment of the invention;

Fig. 22 is a fragmentary bottom plan view of the nib end of the pen of Fig. 21;

Fig. 23 is a transverse sectional view taken along line 23—23 of Fig. 21;

Fig. 24 is a transverse sectional view taken along the line 24—24 of Fig. 21;

Fig. 25 is a transverse sectional view taken along the line 25—25 of Fig. 21;

Fig. 26 is a transverse sectional view taken along the line 26—26 of Fig. 21;

Fig. 27 is an enlarged fragmentary, vertical, longitudinal sectional view through still a further embodiment of the invention;

Fig. 28 is a fragmentary bottom plan view of the nib end of the pen of Fig. 27;

Fig. 29 is a side elevational view of the unitary cell element and feed bar of the pen of Fig. 27;

Fig. 30 is a transverse sectional view taken along the line 30—30 of Fig. 27;

Fig. 31 is a transverse sectional view taken along line 31—31 of Fig. 27; and

Fig. 32 is a rear end elevational view of the structure shown in Fig. 29.

Referring now particularly to Figures 1 to 11, and especially to Fig. 1, the fountain pen comprises an elongated body 1 including a front section 2 having secured thereto, as by screw threads 3, a rear section 4. The inner end 5 of the rear section 4 preferably is reduced in diameter and fits into the front section 2 so that a substantially flush outer surface is provided at the joint between the two sections. The body sections 2 and 4 are formed of a suitable material, such as

hard rubber or a plastic which can be formed as by molding or machining or both, and which is not deteriorated by conventional inks.

The fountain pen can be made as a pocket pen having the usual cap (not shown), or it can be made as a desk pen for use with a desk stand and having the usual elongated tail piece (not shown), or it can be made as a convertible pen which can be used either as a pocket pen or a desk pen. A metallic clutch ring 7 may be secured adjacent the end of the barrel 2 for retaining a cap (not shown) in a manner similar to that described in Specification No. 547,825 or for seating the pen in a holder when the pen is used as a desk pen, as will be understood by those skilled in the art.

The body sections 2 and 4 are formed with bores 8 and 9, respectively, which together provide a chamber 10 defining an ink reservoir extending throughout a substantial portion of the length of the pen body 1 and adapted to contain sufficient ink for a relatively large amount of writing. Extending from the forward bore 9 and through the end of the front section 2 is a smaller bore 11 which accommodates a writing element as explained hereinafter.

The reservoir formed by the chamber 10 is adapted to be filled with ink by capillary action when the end of the pen is inserted in a supply of ink. An elongated capillary filler element 12 is disposed in the chamber 10 and extends substantially throughout the length and breadth thereof. The filler element is formed from a suitably rigid material which is wettable by the conventional inks and which will not deteriorate over a long period of use. We have found that hard rubber, plastics such as " Pyralin " (Reg. Trade Mark) (cellulose nitrate plastic), " Lucite " (methyl methacrylate resin), nylon, polymerized styrene, or polystyrene and metals, such as silver and gold are highly satisfactory, although other materials having the above properties may also be used.

The capillary filler element 12 takes the form of a capillary cell structure comprising a series of longitudinally spaced wall elements defining spaced capillary cells. In the form of the invention illustrated in Figs. 1 to 11, the filler element 12, is formed with a central, longitudinal core 13 and a series of circumferentially extending, axially spaced fins 14, which preferably are integral with the core 13, and extend to closely adjacent the side walls of the chamber 10. The fins 14 may be formed in any suitable manner which will provide wall members of the desired spacing as, for example, by slotting a generally cylindrical body with a gang saw. The spaces between adjacent fins 14 are of capillary width, as will be explained in more detail hereinafter, thus constituting a series of capillary chambers or cells 15 of generally annular form.

The fins 14 are made as thin as practicable, consistent with mechanical strength and rigidity, thus providing the maximum number of capillary cells for any predetermined length of cell structure and cell widths. The core 13 is made as small as practicable, consistent with mechanical strength and rigidity, to provide capillary cells of maximum depth, and consequently maximum capacity, for any predetermined diameter of chamber and cell widths. Provided at the ends respectively of the filler element 12 are end fins or heads 16 and 17, which preferably are relatively thicker than the intermediate fins 14, and are sufficiently sturdy to provide abutment means for firmly seating the filler element 12 in the chamber 10 when the body sections 2 and 4 are screwed together. The end fins also are resistant to the increased tendency to breakage during manufacture and assembly which might result from their more exposed positions.

The bore 9 in the front section 2 preferably tapered outwardly from front to rear to correspond to the taper of the external wall, and the fins 14 in that portion of the filler element (indicated by *a*, *b*, *c*, and *d* in Fig. 4) increase in diameter from the front toward the rear of the pen in a corresponding manner. Thus, the annular cells 15 in the forward portion of the reservoir have outer diameters, which are the maximum diameters practicable for the corresponding external diameters of the pen body. For convenience in manufacture and assembly the bore 8 in the rear section preferably is made uniform in diameter throughout its length and the fins in the rearward portion of the cell structure (indicated by *e* in Fig. 4) are correspondingly of uniform diameter. However, it will be understood that the bore 8 in the rear section also may taper in diameter correspondingly with the external taper of the body and the fins in that portion of the cell structure (indicated by *e* in Fig. 4) may vary in diameter accordingly, as in the embodiment of the invention illustrated in Fig. 27 and described more fully hereafter.

The core 13 is provided with an enlarged end or head 20 formed with a counterbore 21 and bore 22 which together comprise a nib and feed bar socket. A pen nib 23 is frictionally received and firmly seated in the counterbore 21 in such posi-

tion that only a small portiin of the slitted end of the nib projects out of the front section 2 of the pen body 1. The pen nib 23 may be of any suitable form, but preferably is of the type described in Specification No. 534,657. Such a nib includes a cylindrical body or shank 30 (Fig. 5), which is split throughout its length on its underside at as 31. The forward, lower end of the shank 30 is cut away or notched as at 32 and provides an air opening as will be explained more fully hereinafter. The forward end of the nib 23 is tapered to form a point and has a slit 33 which extends to a pierce 35 and divides the end of the nib into two nib sections 34.

The top wall of the bore 11 (Fig. 2) is relieved or recessed slightly adjacent its front end to provide a capillary feed space 38 above the nib 23, which space extends from rearwardly of the nib pierce 35 to close to the writing tip of the nib 23. The capillary space 38 preferably is generally triangular in shape and tapers laterally from a wide rear portion to a narrow forward end portion which registers with the nib slit 33, the end portion 18 of the top wall of the bore 11 being brought close to the nib at the forward end of the space 38.

A feed bar 24 is seated in the socket of the filler element 12 and extends into and along the nib 23. The feed bar 24 is formed with a cylindrical body portion 25 which projects rearwardly of the nib 23 and frictionally and firmly seats in the bore 22 in the head 20, and with a reduced semi-cylindrical portion 26 which extends along the underside of the nib 23. The feed bar 24 is of slightly less diameter than the nib 23, providing therewith a space 37 which is annular at its rear end and partially annular at its front end. The feed bar 24 preferably is slightly bowed from front to rear so that the forward tip 27 bears against the underside of the nib 23 forwardly of the pierce and provides with the end portion 18 of the front section 2 means for limiting movement of the nib sections 34 thereby preventing undue spreading of the nib sections and minimizing flexing of the nib. In order to augment the feeding action of the capillary feed space 37, a plurality of feed slots 36 may be provided in the upper wall of the feed bar 24, which slots extend longitudinally of the feed bar 24 from the rear end thereof to forwardly of the nib pierce 35, one of the slots 36 preferably being positioned to register with the nib slit 33 and pierce 35.

A capillary ink feed passage or duct 40 (Fig. 7) extends longitudinally throughout the capillary filler element 12 and intersects each of the cells 15 to provide means for feeding ink to the cells during filling and for feeding ink from the cells toward the nib during writing. The feed passage 40 is formed by a slot extending longitudinally throughout the entire series of cells 15, and is cut through the fins 14, as at 41, and cut into the core 13, as at 42. The feed passage 40 preferably is formed in the upper portion of the filler element, in alignment with the nib slit 33, and at its front end is cut through the core into the nib and feed bar socket to provide a slot 43 (Figs. 2 and 9) communicating with the space 37 between the nib 23 and feed bar 24.

In order to supplement the filling and feeding action of the feed passage 40, additional passages 40a (Fig. 9) may be provided by forming longitudinal slots in the filler element 12 generally similar to the feed passages 40. Preferably at least one of such additional feed passages 40a is provided in the lower portion of the filler element 12 and any additional feed passages 40a are spaced around the circumference of the filler element 12. Each additional feed passage 40a is cut through the core 13 at its forward end to communicate through slots 43a with the nib and feed bar socket in a manner similar to the feed passage 40.

A pressure equalizer or vent is provided which normally maintains the air in the pen at atmospheric pressure. It also equalizes the air pressure in all portions of the pen so that even if a pressure differential is developed between the interior of the pen and the atmosphere when the front end cap is in position closing the pen, atmospheric pressure will be re-established immediately within the pen when the end cap is removed. The pressure equalizer includes a passage extending longitudinally of the filler element and intersecting each of the cells 15 and vented to the atmosphere at the end of the pen. In the embodiment illustrated in Fig. 1 the air passage 45 (Fig. 7) is formed by a slot 46 cut in the lower portion of the filler element and extending throughout the length thereof. At its forward end the air passage is formed by a space 39 between the lower wall of the counterbore 11, the lower wall of the feed bar 24, and the notch 32 in the nib 23. If desired, the lower wall of the counterbore 11 may be cut back substantially to the juncture of the chamber 10 and the counterbore to place the forward end of the slot 46 substantially in direct communication with the atmosphere. The air passage 45 is sufficiently larger than the adjacent capillary cells 15 so that ink will not be drawn therein from adjacent

cells by capillary action. On the other hand if any ink does enter the air passage 45 from any cause, as might happen when the pen is dropped or shaken, the ink will normally be drawn back by capillary action into an empty or partially empty cell. Thus, the air passage will be maintained substantially free of ink at all times and will permit air to pass freely, but will not provide an outlet through which ink can leak from the pen.

When it is desired to fill the pen, it is merely necessary to remove the front end cap, if one is in position closing the front end of the pen, and insert the end of the pen in a supply of ink to place the capillary passages in the pen in capillary filling relation with the ink supply. Ink is drawn by capillary action in to the space 37 directly from the ink supply and passes therefrom through the slots 43 and 43a to the respective feed passages 40 and 40a. Ink also is drawn into the capillary space 38, thence through the nib slit 33, and pierce 35, and thence into the space 37, and through the slots 43 and 43a into the feed passages 40 and 40a.

Where the pen is inserted sufficiently in the ink supply, ink will enter the space between the feed bar 24 and the walls of the bore 21, from whence it is drawn into the space between the nib 23 and the feed bar 24 and thence through the slots 43 and 43a to the feed passages 40 and 40a. In order to provide the direct communication between the feed slots 40a and the ink supply, the former may be cut through the forward end fin 16 instead of terminating rearwardly thereof as does the feed passage 40 (Fig. 2).

Ink will rise by capillary action in the feed passages 40 and 40a, the bottom and side walls of the portion 41 of the slot in the core providing continuous wall surfaces which will insure that ink is drawn by capillary action rapidly up the feed passages 40 and 40a. Ink from the feed passages 40 and 40a will enter any empty or partially full cells 15 at the intersections of the feed passages 40 and 40a with respective cells to fill the latter. Normally the cells 15 will fill beginning at the front end of the pen but, if for any reason, a cell remains empty, or if the cells do not fill progressively, the filling of the pen will not be prevented since each cell is intersected by the feed passages and is individually in feeding relation therewith. Where a plurality of feed passages are provided in the manner indicated the filling of the cells is speeded.

During filling, the ink must displace air which was in the empty portions of the feed passages and capillary cells 15. As the ink enters such empty portions, it forces the air therefrom and into the adjacent portions of the air passage 45, from whence it is vented to the atmosphere at the front end of the pen through the vent passage 39 constituted as above described. Since the air is forced out through the air passage 45, which is free and unobstructed, substantially no back pressure is developed in the vent passage if the outlet at the front end of the pen is above the level of the ink supply.

However, the capillary action of the capillary system in the pen is sufficient to cause the ink which enters the pen to force out the air even if the pen is immersed in the supply of ink to such a depth that the air outlet at the front end of the pen is below the surface of the ink supply and is sealed by the ink. In this case, the air which is forced out of the pen will bubble up through the ink supply.

The vent system provides free, non-capillary air communication between all portions of the pen at all times and between the interior and the exterior of the pen when the cap is removed. Therefor, when the cap is removed, any differences between the air pressure in the pen and atmospheric pressure will be established equally on all portions of the body of ink in the pen. During use there will be no tendency for the ink to leak, or the feed of the ink to the nib be "starved" or "flooded" by reason of changes in atmospheric pressures. Likewise, when the temperature of the air in the pen is changed, as when the pen is taken suddenly from cold outside air into a warm room, or *vice versa*, or when the pen is heated by the hand when grasped as it is in writing, provided the cap is removed the pressure on the ink is equalized with that of the atmosphere, and no leaking or blocking of the ink will occur.

In order to insure that the ink will rise to the point in the filler element necessary to fill the reservoir to the desired extent, the capillarity of the feed slots must be sufficient to lift the ink to the required height above the surface of the ink supply and the capillarity of each cell must be sufficient to draw ink into that cell during filling and to retain ink therein against the action of gravity, but not so great as to prevent ink from being drawn out of the cell by capillary action of the feed passages when the pen is used in writing. Ink will rise in the pen and fill the capillary cells to a height above the surface of the ink supply as determined by the capillarity of the feed passages and capillary cells.

The height of rise of ink in the pen and the rate of filling of any particular pen

structure with any particular ink is influenced by the angle in which the pen is held relative to a horizontal plane, the greater the angle between the longitudinal axis of the pen with the horizontal, the slower will be the filling. The height of rise and the rate of filling for different designs and constructions of pens is influenced by such factors as, the sizes of the various capillary passages, the flow resistance through the passages, the wettability of the surfaces of the passages by the particular ink used and the surface tension of the particular ink. In general, the viscosity of the ink also would be a factor determining the rate of filling, but since most fountain pen inks used at present have viscosities substantially equal to that of pure water, the viscosity for such inks may be assumed to be the same in all cases.

As in many cases the pen will be filled by holding it in a substantially vertical position, the capillarity of the passages and cells must be sufficient to fill the pen to the desired extent when in this position. On the other hand the pen may be filled when in a position making relatively small angles with the surface of the supply of ink with the result that the feed slots and cells are capable of drawing up more ink than if the pen is held vertically. Accordingly, in order to prevent more ink being drawn into the pen 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 system 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.

Feeding of the ink to the nib so that ink will be available instantly at all times and so that the ink will flow smoothly and freely is accomplished by appropriate selection of the several capillarities of the various portions of the capillary system. The nib slit 33 is made with the highest capillarity to insure that ink will be drawn therein and maintained therein at all times in order to replace ink which evaporates or which is drawn off in writing. The passages in the feed section of the pen, that is, the portions adjacent the nib and feed bar and which provide capillary passages from the ink feed passages to the pen nib slot are made with the next highest capillarities in the system to cause ink to be drawn from the feed passages so long as any ink remains in the cells and feed passages. The feed passages in turn must be of a capillarity at least as great, and preferably slightly greater than, that of the cells of highest capillarity in order to draw ink from the cells and to insure that there will be no tendency for the cells to restrain the flow of ink from the cells to the feed passages. The ink, therefore, is maintained in a continuous body extending from the cells to the end of the pen nib slit. The capillarities of the several portions of the ink path being so selected as to maintain the continuity of the ink body and to insure the flow of ink to the nib during writing.

In writing, when the point of the pen nib is placed upon a writing surface, the ink which is held in the pen nib slot by capillarity is brought into contact with the writing surface and the capillarity established between the nib and the writing surface is sufficiently great to overbalance the capillarity of the capillary filler element of the pen. The pen nib slot, the longitudinal ink feed slots in the capillary filler element, and the capillary passages connecting the pen nib slot with the longitudinal ink feed slots are all of such capillarity that ink is drawn from the capillary cells by capillary action through the several ink feed passages, hereinbefore described, to the pen nib slot to replace the ink left on the writing surface as the pen moves over such surface. Because the flow of ink to the pen nib slot in writing is thus governed by the relation of the capillarity of the filler element to the capillarity established between the pen nib and the writing surface, a very uniform flow and even supply of ink to the writing surface is produced. The internal cohesion of the ink maintains the continuity of the column of ink from the capillary cells through the capillary ink feed passages to the pen nib slot so that continuity of supply of ink to the pen nib slot is maintained as the ink is removed from the pen nib slot.

Ink is fed automatically by capillary action to the nib to replace any ink which evaporates or is drawn off during writing. When the pen is held in writing position, capillary action is supplemented by gravity. Ink is drawn into the nib pierce 35 and nib slit 33 from the capillary space 37 between the nib 23 and feed bar 24 and, where such are provided, from the grooves 36. Ink is drawn into the capillary space 37 and the grooves 36 from the top ink feed duct 40 through the slot 43. Ink also is drawn from the capillary space 37 through the pierce 35 and into the capillary space 38 to maintain the space filled with ink. The space 38 above the nib slit feeds ink to the nib slit 33 during writing, to supplement the feed of ink from the space 37 below the nib. In addi-

tion, the space 38 serves to insure that ink is maintained closely adjacent the slit 33 throughout a substantial portion of its length so that ink which evaporates from the nib slit 33 or is drawn off during writing is immediately replaced and the nib slit 33 is always full so that the pen is instantly ready for writing.

Ink is drawn into the top feed passage 40 from the capillary cells 15, since the capillarity of the feed passage is at least as high as any of the cells 15. The topmost feed passage 40 serves to supply ink to the slot 43 from whence the ink passes, by the passages previously described, to the nib slit 33. The remaining feed passages 40a are primarily valuable in facilitating rapid filling of the pen but may also serve to draw ink from the portions of the cells 15 circumferentially removed from the top feed passage and feed it to the annular capillary space 37 through the slots 43a.

Normally, ink will be drawn into the feed duct 40 first from the capillary cells 15 at the rearward end of the pen and the cells will empty progressively from the rear toward the front of the pen. However, if for any reason a forward cell should empty before all of the cells rearwardly thereof are emptied, the feed would not be interrupted since each of the cells is individually intersected by the feed duct and in direct feeding relation therewith. The feed passage will be supplied with ink so long as any cell remains filled, and thus the reservoir will be substantially emptied.

In order to insure filling of the pen to capacity, retention of the ink during use, and smooth feeding during writing, the capillary cells at the portions more remote from the nib preferably are so made as to have a higher capillarity than at the portions nearer to the nib. The capillarity of each cell, theoretically, should be such as to hold a column of ink equal in height to the distance of that cell above the level of the supply of ink (when the pen is being filled) or to the distance of that cell above the writing surface (when the pen is used in writing). For convenience in manufacture, however, the cells are not dimensioned so that they increase in capillarity from cell to cell, but they are made so as to increase in capillarity by groups from the forward end of the pen toward the rear, all of the cells in each group being of the same capillarity, but the cells in each group being of suitably higher capillarity than those in the adjacent group nearer to the forward or nib end of the pen. This is illustrated somewhat diagrammatically in Fig. 4 of the drawings, in which the cells are grouped in five groups, the cells in each group being of the same capillarity (the capillarity theoretically at least as great as that required for the rearmost cell of the group and preferably somewhat greater) but the capillarity of the cells in each group being greater than the cells in the group next nearer the nib end of the pen. For example, referring to Fig. 4, all of the cells in the group indicated at "a" may have the same capillarity; all of the cells in the group indicated at "b" may have the same capillarity but higher than the capillarity of the cells in group "a". In a similar manner the groups "c", "d", and "e" each have cells of greater capillarities than any group nearer the nib end of the pen.

The capillarity of the capillary feed passages must not be so much greater than that of the cells that the edge effect will prevent ink from being drawn into the cells rapidly from the feed passages to fill the cells. In the event the capillarity of the feed passages necessary to lift ink to the rearmost cells during filling is substantially greater than that of the forward cells, preferably one of the feed passages is formed with the necessary capillarity to lift ink to the rearmost cells and at least one of the feed passages is formed with a lower capillarity, not greatly in excess of the capillarity of the forward cells. In such case, the feed passage having the lower capillarity may not be capable of lifting ink to the rearmost cells, but will serve primarily to fill the forward cells. In a similar manner, the capillarities of additional feed passages may be related to cells intermediate the rearmost and the forwardmost cells so that these pasages will feed ink to the intermediate cells.

A further consideration enters into the selection of the capillarity of the feed ducts and cells. Since, the pocket fountain pen is customarily inverted from writing (and filling) position when it is placed in the pocket, it must be made so as to be non-leaking in this position. In fact, it must be capable of retaining ink in any position (for example, upright vertical, horizontal or inverted vertical). Accordingly, in the pen of the present invention, the capillarity of all of the capillary passages and cells must be such that when the pen is inverted, ink will be retained in the cells by capillarity.

All of the ink which is in the fountain pen is contained in capillary passages and capillary cells forming the capillary system and the ink, therefore, is entirely maintained under the control of the system at all times. There is no free body of ink which is responsive to such factors

tending to cause leakage as, changes in atmospheric pressure, changes in the position of the pen, changes in temperature, or sudden shocks. Moreover, the fins serve as transverse baffles which tend to prevent ink from being thrown out of the pen even if it is dropped or shaken point foremost. The filling of the pen, retention of ink in the pen, and the feed of ink to the nib are controlled solely by capillary action. The operation of the pen does not depend upon the establishment or maintenance of a partial vacuum within the pen or any pressure differential between the interior and exterior of the pen or between various portions of the interior of the pen. In fact, as explained elsewhere herein, measures are taken to insure equalization of air pressure within the pen and between the interior and exterior of the pen.

The formation of air locks in the cells or passages during filling or feeding is prevented by the vent system provided by the present invention. In filling, ink will enter the cells from the feed passages and force the air from the cells into the air passage. If ink should fail to enter a particular cell, such failure will not prevent ink from proceeding up the feed passage or passages and entering a cell more remote from the nib end of the pen. Since the cells are independently fed with ink from the feed passages, and independently vented, even if air remains in one or more cells, the filling will not be stopped.

In feeding, ink is drawn from the cells by the feed passages which latter have at least as great capillarity as the cells. The feed passages are in communication with each cell, and the cells are in communication with each other, hence, even if a globule of ink surrounds a quantity of air in a cell, this will not prevent or restrict the feeding from the cells. In those embodiments of the invention where the cells are individually directly connected to the air vent this also aids in preventing air locks. The air passage provides constant communication between the atmosphere and the interior of the pen to constantly equalize the air pressure on the ink. Hence, ink will flow evenly and smoothly and there is no alternation of thin flow and free flow, as is often the case in pens of the type where air is admitted to the ink reservoir intermittently to replace ink withdrawn in writing, and the feed will not flood nor starve.

In pens of the type wherein ink is held in the reservoir by sub-atmospheric pressures it is customary in some instances to provide a governor or collector adjacent the nib for controlling the flow of ink to the nib and prevent flooding such as may occur owing to changes in temperature or pressure of the air in the pen or the atmosphere. In the pen of the present invention it is unnecessary to provide such a device inasmuch as the ink in the pen is entirely under control of capillary passages. Substantially all of the ink holding space in the pen may be utilized as useful, effective reservoir capacity.

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. Since all of the capillary spaces are so formed that their respective capillarities can be predetermined, they can be made with substantially no portions having such high capillarity as will retain ink permanently therein; thus, substantially all of the ink in the pen can be written out. This insures the maximum refill or effective ink capacity for a pen having a given initial ink capacity. The relatively smooth walls of the passages aid in preventing clogging.

Each capillary passage preferably is made with one transverse dimension substantially greater than the other. Since, in such cases, a variation in the greater dimensions will effect a relatively small change in the capillarity of the passage, the smaller dimension is primarily important in determining the capillarity of the passage. For example, in the case of a three-sided rectangular slot which is relatively deep as compared to its width, a variation in the depth of the slot will cause only a relatively small change in the capillarity of the slot. Accordingly, the capillarity can be closely predetermined and controlled by appropriate selection of the width of the slot. The flow capacity of such a slot can be increased by increasing the depth, without greatly decreasing the capillarity. A somewhat similar condition occurs where a capillary space is formed between two generally parallel or concentric, opposed surfaces spaced apart a distance which is relatively small as compared to the lateral extent of the opposing surfaces. In the latter case the capillarity of the passage defined by such surfaces is determined primarily by the width of the relatively narrow space between the surfaces and a variation in the lateral extent of the opposing surfaces

will effect only a relatively small change in capillarity.

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 having an overall length of approximately $2^3/_4$" with its forward end disposed approximately $^1/_2$" from the writing end of the nib. The cell forming fins (indicated at 14 in Fig. 1) were approximately 0.010" thick and of such diameter as to extend to within not less than 0.005" of the side walls of the reservoir. The end heads 16 and 17 (Fig. 1) were $^3/_{32}$" and $^1/_{16}$" in thickness respectively. The fins 14 were spaced apart to provide cell groups as follows (relative locations of the cell groups being indicated diagrammatically in Fig. 4): in the first group "a" nearest the forward end of the filler element there were 7 cells, each 0.012" wide; in the next group "b" there were 9 cells each 0.010" wide; in the next group "c" there were 9 cells each 0.008" wide; in the next group "d" there were 2 cells 0.006" wide; and in the rearmost group "e" the cells were 0.005" wide. The feed passages 40 in the filler element were 0.005" wide and around 0.012" to 0.015" deep. The feed slot 43 and feed passage 37 extending to the nib slit were less than 0.005" wide, but wider than the nib slit 33 which was from 0.001" to 0.0015" in width, and in general were approximately 0.003" in width.

The air passage 46 in the core was approximately $^3/_{64}$" in width and the air passage 39 at the front end of the pen was approximately the same width. When the end of the pen was inserted in a supply of Parker "Quink" (Reg. Trade Mark), an acid ink having a surface tension of around 55 dynes per centimeter, the ink reservoir filled to a height above the forward end of the filler element of about $2^3/_4$" in the feed passages, and the cells filled to a height of at least $2^1/_4$".

While the widths of the capillary spaces described above may not correspond to the widths which would be obtained as a result of mathematical computations giving the theoretically ideal widths of spaces for a pen of the type described, the values given have been found successful in one embodiment of the invention. In general, the capillary feed passages and the capillary cells are made with widths which are slightly less than the widths indicated by computations as necessary to lift ink to the desired heights.

The present invention is not limited to the dimensions above stated and it will be understood that variations may be made without departing from the invention. Demonstrations have shown that the dimensions of several parts may be varied to some extent so long as the relationships stated are substantially maintained. It will be understood that while the dimensions above have been given in connection with the embodiment of the invention illustrated in Figs 1 to 11 they may apply equally well to other modifications.

The capillarity of the several capillary feed passages and the capillary cells 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 to be used. The wettability of the surface of a solid by liquid is measured by the 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. We 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 cells and feed passages can be obtained by forming the walls of materials which are inherently suitably wettable by the inks. Materials such as hard rubber, "Lucite" (methyl methacrylate resin), "Pyralin" (Reg. Trade Mark) (cellulose nitrate plastic), nylon, polymerized styrene, or polystyrene as well as metals such as silver and gold have been found satisfactory. The wettability of the surfaces can be improved by insuring that all the surfaces of the capillary spaces are free of foreign matter which is not readily wettable, such as oils, greases or waxes. Preferably the filler element after it has been formed is washed thoroughly in water and, where necessary, in a solvent for the foreign matter which may adhere to the surface to insure a clean surface. We have found that washing in a solution of sodium hydroxide is effective in many cases to clean the surfaces and to improve the wettability.

In certain cases, the wettability can be increased by including in the material forming the filler element, a suitable wetting agent. For example, in the formation of methyl methacrylate resin from $2^1/_2$ to 10% and preferably about

10% by weight of " aerosol O.T. " (dioctyl sodium sulfosuccinate) is mixed with the methyl methacrylate while the latter is in monomer form and the latter is then polymerized. The " aerosol O.T. " is thus contained in the final product and is effective to provide a surface having a high degree of wettability. Excellent results also have been obtained by adding, in place of " aerosol O.T. ", such wetting agents as $7^1/_2$ to 12% benzoic acid, 5% glycerine, 7% methacrylic acid, or $2^1/_2$ to 10% di-ethylene glycol.

The wettability of the surfaces of the filler element also may be increased by appropriately treating the surface with suitable chemical reagents after formation of the filler element. Where the filler element is formed from " Lucite " (methyl methacrylate resin) excellent results have been obtained by immersing the formed filler element in 20% fuming sulphuric acid at room temperature for approximately 10 minutes. The filler element is then removed from the acid, and washed in distilled water. In another example, the filler element was immersed in concentrated sulphuric acid at room temperature for approximately 15 seconds and the filler element removed and washed with methanol immediately after removal from the sulphuric acid. In still another example, excellent results were obtained by immersing the filler element in a saturated solution of chromic acid at room temperature for approximately 10 minutes, then removing the filler element and washing it in distilled water and thereafter in methanol.

The entry of ink into the air vent passages from the adjacent capillary cells and feed passages is prevented to a substantial extent by the edge block at the junctions of the several air vent passages with the adjacent cells and the feed passages. Entry of ink into the air passages also can be prevented by so constituting the surfaces of the air vent passages that they are relatively non-wettable by the inks with which the pen is used.

Satisfactory results can be obtained by coating the walls of the air passages 45 and 39 and the lower wall of the bore 11 with a material such as methyl silicone chloride which will provide a relatively non-wettable surface. After such treatment the surfaces are of such nature that aqueous inks make liquid contact angles with these surfaces ranging from about 90 degrees and higher, and preferably at least 110 degrees. Thus if any ink tends to be forced out of any of the cells or feed passages at their junctions with the air vent passages the ink will not wet the surfaces of the latter and will not enter the vent passages readily. If any ink does enter the air vent passages it will be readily drawn back into the cells or feed passages owing to the wettability of the cells and the relative non-wettability of the surfaces of the air vent passages.

Several additional embodiments of the invention are illustrated in Figs. 12 to 32 of the drawings and described hereinafter. It will be understood where the construction and operation of the several forms described below are not described in detail they are similar to the construction and operation of the embodiments illustrated in Figs. 1 to 11 and above described.

A second embodiment of the invention is illustrated in Figs. 12 to 20. Referring to Fig. 12, the fountain pen shown includes an elongated body 50 comprising a front section 51 having a bore therein providing a chamber or reservoir 52 which extends substantially throughout the length of the front section and has a tapered forward end portion 61. A communicating smaller bore 53 extends from the chamber 52 and accomodates a writing element hereinafter described. The rear end of the front section 51 is closed by a rear section 55 secured to the former as by screw threads 56, and formed with a bore providing a non-capillary passage 57 which communicates through one or more passages 58 with the chamber 52. At the rear end, the passage 57 is closed by an end piece 54 threaded onto a bushing or coupling 59, which itself is threaded into the rear section 55. The bushing 59 is formed with an air vent opening 60 which registers with the joint between the rear section 55 and the end piece 54 to provide an air vent for the passage 57, such vent normally being provided by the hole 60 and the said joint, and, having an increased effect if the end piece 54 be unscrewed slightly.

Disposed in the chamber 52 is a capillary filler element 65 which comprises a series of cell discs 66 of annular shape which extend substantially to the wall of the reservoir and are spaced apart by generally annular split rings or spacers 67 of smaller diameter than the cell discs 66 to provide a series of capillary cells 68 of generally annular shape. The cell discs 66 and spacers 67 are positioned in alignment by a central rod 69 which abuts the end of the rear section 55 and extends through central openings 70 and 71 (Fig. 17) in the cell discs 66 and spacers 67 respectively. The central rod 69 fits snugly in the central openings 70 in the cell discs 66 in order to maintain the discs in proper alignment. The spacers 67 need not be maintained in alignment and con-

sequently the central openings 71 therein prefrably are of substantially greater diameter than the rod 69, thus providing a generally annular space 64 (Fig. 17) of capillary width defined by adjacent cell discs 66, the interposed spacer 67 and the central rod 69, for a purpose hereinafter explained. The discs 66 and spacers 67 are held in compact relation by a suitable means, as for example by providing a press fit between the rearmost disc or discs 66 and rod 69, or by providing a spacer (not shown) of small diameter at the rear end of the stack to bear against the adjacent end wall of the front section 51.

The rod 69 is flattened throughout the length of the series of discs 66 and thus two longitudinally extending spaces are provided, between the rod and the adjacent portions of the central openings 70 and 71 which spaces extend throughout the length of the stack of discs 66 and comprise capillary feed passages 72 and 72a. Communication between the feed passages 72 and 72a and each capillary cell 68 is provided a slot 73 formed in the corresponding spacer 67.

The cell discs 66 may be formed of a suitable material which has sufficient rigidity and which is suitably wettable by conventional inks. They may be formed of hard rubber, mica, metal such as silver, or a plastic such as " Pyralin " (Reg. Trade Mark) (cellulose nitrate plastic) or " Lucite " (methyl methacrylate resin). The cell discs may be formed in various ways depending upon the material from which they are constituted. However, owing to their flat discoidal shape they can be formed readily by punching them from a sheet or strip of the appropriate thickness.

Because of the convenient flat shape of the disc prior to assembly to form the filler element, they lend themselves to a method of increasing the wettability of the surfaces, in addition to those described above in connection with the unitary filler element embodied in the pen illustrated in Figs. 1 to 12 of the drawings. Where the cell discs are formed of hard rubber or a plastic, the wettability of the surface can be markedly increased by exposing the surface to a stream of very fine abrasive particles entrained in a fluid and projected against the surface with sufficient force to roughen or pit the surface. A suitable abrasive material is ground to a powder having about 1250 mesh and is thoroughly mixed with clean water. The mixture is forced under pressure through nozzles which atomize the water and project it and the entrained abrasive against the surface of the material to be surface treated under sufficient pressure to roughen the surface completely. Preferably the mixture is projected at pressures of from 50 to 100 lbs. per square inch, with the surfaces held at from 4 to 10 inches from the nozzle. While the increased wettability of surfaces treated in the foregoing manner is not fully understood, it is believed that the roughening of the surface provides very small capillary channels or depressions which act as pilot channels to draw the liquid along the surface and thus cause the liquid to advance along the surface more readily than where the surface is smooth.

The spacers may be formed of a material similar to the material of the cell discs and may be made wettable in a similar manner. However, since the spacers serve primarily as mechanical spacing means for the cell discs it is not essential in most cases that they have such a high degree of wettability as the cell discs.

Since the cell discs may be made very thin, a relatively large number of capillary cells may be provided in any predetermined length of reservoir. Also, since the spacers 67 serve primarily to space the cell discs 66 and do not have to serve as a mechanical support for the latter, the spacers can be made as relatively narrow annular rings, and consequently a relatively large percentage of the total space between adjacent cell discs is available as an ink holding space. Thus, this form of the invention provides a convenient means for forming a capillary filler element in which there is a relatively high ratio of total capillary ink space to the total volume in the reservoir.

Disposed at the forward end of the capillary filler element 65 (Fig. 12) is an end piece or nib holder 80 formed with a central core 81 from which extends a series of spaced circumferential fins 82 which define a series of capillary cells 83 of generally annular shape. The fins 82 extend to and fit snugly in the tapered end portion of the chamber 52 whereby the end piece 80 is firmly seated. The fins 84 and 85 at the ends of the nib holder may be thicker than the intermediate fins 82 for strength. The rear end fin 85 is spaced from the forwardmost cell disc 66 by a spacer disc 67 to provide a capillary cell 68 similar to the other cells 68 formed between adjacent cell disc 66.

The nib holder 80 (Fig. 12) is formed with a bore 86 which frictionally receives and firmly seats a pen nib 89, generally similar to the nib 23 described in connection with the embodiment illustrated in Fig. 1. The nib 89 extends through the bore 53 and projects slightly therefrom, the upper wall of the bore 53 being

relieved from rearwardly of the pierce 90 close to the writing tip of the nib to provide a capillary feed space 97.

A feed bar 88, co-operating with the nib 89, extends through the bore 86 and is frictionally received and firmly seated in a counterbore 87 formed in the nib holder 80. The central rod 69 which supports the cell discs 66 and spacers 67 extends through a second counterbore 99 in the nib holder 80 and firmly seats in the feed bar 88. However, if desired, the feed bar 88 and central rod 69 may be formed as a single, integral member.

The feed bar 88 is preferably smaller in diameter than the nib 89 so that a capillary space 96 is provided therebetween. The top of the feed bar 88 preferably is flattened or cut away as at 101 to provide an additional capillary space 98 between the nib 89 and feed bar 88 extending from the rear end of the nib 89 to forwardly of the pierce 90 and supplementing the space 96.

The nib holder 80 is provided with a longitudinally extending, radially arranged capillary feed slot 100 which, together with the counterbore 99 provides a capillary feed passage connecting the capillary feed passages 72 and 72a which extend through the discs 66 and spacers 67 with the capillary feed space 96. The slot 100 also provides a capillary connection between the feed space 96 and the cells 83 in the nib holder 80 and the cell formed between the rear end fin 85 of the nib holder 80 and the forwardmost cell disc 66. To facilitate the flow of ink between the capillary feed slot 100 and counterbore 87 and the feed space 96, the rear end of the feed bar may be cut away as at 102 providing an enlarged space 103 between the feed bar and wall of the counterbore 87.

In a manner equivalent to that explained in conection with the embodiment of the invention illustrated in Fig. 1, the various capillary passages and cells are so dimensioned that when the end of the pen is inserted in a supply of ink, the capillary action exerted by these passages will draw ink into the capillary system to fill all capillary passages and cells. At the same time, the capillarity of the system at the feed section adjacent the nib is such that ink will be drawn from the reservoir and will be supplied to the nib at all times and will feed freely and smoothly during writing.

To fill the pen, the end of the pen is inserted in a supply of ink. Ink is drawn by capillary action into the space 97 between the nib 89 and the end of the front section 51, and through the nib pierce 90 into the spaces 96 and 98 between the nib and the feed bar. Ink also is drawn into the space between the nib 89 and the tip 95 of the feed bar, and into the spaces 96 and 98 between the nib 89 and the feed bar. Where the pen is inserted deeply enough in the ink supply, ink also will be drawn directly into the space 96 between the nib and feed bar. Ink is drawn from the spaces 96 and 98 into the space 103, and thence into the feed slot 100 from whence it is drawn through the bore 99 and into the central feed passages 72 and 72a. Ink also is drawn from the feed slot 100 into the cells 83 and the first cell rearwardly of the nib holder 80.

The flattened top of the rod 69 and the adjacent edges of the openings 70 in the discs 66 provide walls along which the ink rises in the capillary feed passages 72 and 72a. Ink enters the capillary spaces 64 between the spacers 67, and the rod 69, and is drawn therefrom through the slots 73 in the spacers 67, and into the corresponding capillary cell 68 and fills the cell 68. Normally the cells 68 will fill progressively from front to rear but in the event a cell should fail to fill, filling of the pen will not be halted as the ink will continue to rise along the feed passages 72 and 72a beyond any cell which does not fill and will enter cells more remote from the forward end.

Air which is in any empty cell 68, is forced therefrom by the entering ink and escapes through the space between the peripheries of the capillary filler element and the wall of the chamber 52 from whence it flows through the passages 58 and 57 to the vent opening 60. Some air may escape through one or the other, or both, of the capillary feed passages 72 and 72a and thence through the vent passages.

It will be noted that the pen illustrated in Fig. 12 is vented at its rearward end through the joint between the rear section 55 and the end piece 54. While the joint may be made so as to provide adequate venting when in use, in some cases it may be desirable to provide a higher degree of venting to expedite filling. In the latter case, the end piece 54 is unscrewed slightly, before or at the beginning of the filling of the pen.

It will be noted that in this form of the invention the air passage is in communication with the rear end of the chamber 52 and does not extend along all of the capillary cells 68. However, air can pass freely into or out of the pen through the vent without having to pass through the body of ink. Since both the front and rear ends of the body of ink in the pen are under substantially atmospheric pressure, there will be no leaking or restriction in flow

such as might occur if there were unbalanced air pressures exerted on the ink.

Ink is maintained at the ends of the nib by the nib slit 91 (Fig. 13) which is fed from above by the capillary space 97 and from below by the capillary space 96. The space 97 is fed through the nib pierce from the space 96 and the latter receives ink from the space 103. Owing to the shape of the cut 102 in the feed bar 88, at least a portion of the space 103 between the upper rear end of the feed bar and the walls of the bore 86 is slightly larger than the adjacent capillary spaces and serves as a small reservoir to insure that ink will be available to feed freely to the nib through the capillary passages leading thereto. Ink is drawn into the space 103 form the capillary cells 83 by the feed slot 100 in the nib holder 80. Ink also is drawn into the space 103 from the capillary cells 68, by way of the feed passages 72 and 72a and the counterbore 99 through the end wall of the nib holder 80, and also through the slot 100.

A third embodiment of the invention is illustrated in Figs. 21 to 26. Referring particularly to Fig. 21, this pen includes a body 110 having an ink reservoir 111 extending throughout a substantial portion of its length and a nib and feed bar opening 112 at its front end. A capillary filler element 113 is disposed in and extends throughout the reservoir and includes a core 114 and fins 115 extending therefrom and defining capillary cells 116.

A nib 117 and a feed bar 118 extend through the opening 112 and seat in bores 119 and 120, respectively. The nib 117 and feed bar 118 are arranged in spaced relation to provide a capillary feed space 121 therebetween. The feed bar 118 is formed with a large downwardly opening groove 122 extending throughout its length and communicating with a central air passage 123 extending throughout the length of the core 114. The groove 122 and passage 123, together form an air vent passage extending from the rear end of the reservoir to the opening 112.

Extending longitudinally of the filler element 113 is one or more, and preferably, 3 feed passages 124 and 124a formed by slotting the filler element 113 and communicating with the space 121 through slots 125 in the core. At least one of the feed passages 124a preferably is cut through to the central air passage 123, thereby placing each of the cells in communication therewith.

This pen is filled by inserting the end in a supply of ink in the manner above described. Ink is drawn into the capillary space 121 and thence through the slots 125 and into the feed passages 124 and 124a; ink also enters the space between the nib and opening 112 and is drawn through the nib pierce into the space 121. Ink rises along the feed passages 124 and 124a and enters the cells 116. Air which is in the cells 116 is forced out through the feed passage 124a and into the air passage 123 and is vented through the outlet provided by the groove 122 in the feed bar 118 and the opening 112 in the pen body 110. In order to facilitate venting of the air from the cells, the feed passage 124a preferably is formed with a lesser capillarity than the other feed passages 124 so that ink will rise more slowly in the passage 124a than in the other feed passages 124. Air which is forced out of each cell thus can pass through the feed passage 124a and into the air passage 123.

In writing, ink is delivered to the nib slit in a manner generally similar to that described in connection with the pen illustrated in Fig. 1.

A further embodiment of the invention is illustrated in Figs. 27 to 32. Referring particularly to Fig. 27, the pen includes a body 130 having an ink reservoir 131 extending throughout a substantial portion of its length. A nib and feed bar opening 132 extends from the reservoir through the front end of the pen body 130.

A capillary filler element 133 is provided which is formed with a core 134 and with fins 135 defining capillary cells 136. The walls of the pen body 130 are made as thin as practicable having in mind the necessary mechanical strength, and the fins are tapered to correspond generally with the diameter of the reservoir, thus providing cells having the maximum diameters for the external size of the pen body. A feed bar 137 is formed integrally with the filler element 133 and frictionally mounts a nib 138 which snugly fits in the opening 132 and projects therefrom at its forward end. The core 134 is formed with an air passage 139 extending throughout its length and the feed bar 137 is formed with an air passage 140 extending throughout its length and providing communication between the air passage 139 and the exterior of the pen.

Extending along and intersecting the cells 116 is one or more, and preferably a plurality, of feed passages 141, 141a, 141b, and 141c formed by slotting the filler element 133 in a manner generally similar to that above described. One feed passage 141 extends along the top of the filler element 133 in alignment with the pen nib slit 142 and pierce 143 and is extended through the forward end fin 144 and throughout the length of the feed bar. This feed passage 141 thus provides a con-

tinuous capillary ink passage from all of the cells directly to the pen nib slit 142. At least one of the feed passages 141a, other than the top feed passage 141 is extended through the forward end fin 144 and partially along the feed bar 137 so that such passage can be brought into direct communication with a supply of ink in filling.

One or more and preferably several of the feed passages, for example, feed passage 141b, may be extended through to the air passage 139 to provide means for venting the cells during filling. Additional venting may be provided, where desired, by forming a non-capillary slot 145 in the capillary filler element preferably in the bottom portion thereof; this slot is in communication with the exterior of the pen through the space between the feed bar 137, the front opening 132 and the edges of the nib slot 146.

To fill the pen, the end is inserted in a supply of ink. Ink is drawn into the feed passage 141 and rises therein to the intersection of this passage with each cell and enters the cells progressively. Also, the other feed passages 141a, 141b and 141c may assist in filling the rearward cells by drawing ink from the forward cells and feeding it to the rearward cells. When the pen is inserted deeply enough in the ink supply, ink also enters the other feed passages 141a, 141b and 141c, and is drawn into and rises along these passages also.

Air which is in the cells is forced into the air passage 139 through the feed passages 141 and 141b and any others which may be in communication with the air passage and is vented through the front end of the feed bar. In addition, where an exterior air passage, such as the passage 145, is provided, air is forced into this passage and vented through the space between the feed bar 137 and front opening.

In writing, ink is fed directly to the nib slit 142 by the feed slot 141. The other feed passages 141a, 141b and 141c may serve to maintain the forward capillary cells filled by drawing ink from the rearward cells 116.

We 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 we have shown and described several forms of the invention, other details and arrangements of parts may be resorted to without departing from the spirit and scope of the invention as defined by the claims that follow.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A fountain pen including a pen body having a reservoir section and a feed section with a writing element carried at one end of the pen body, characterized in that there is disposed in the reservoir section a capillary ink filler and reservoir element having relatively fixed, rigid walls defining a capillary ink storage space of predetermined capillarity sufficient to draw ink into the storage space by capillary action when the filler and reservoir element is placed in communication with a supply of ink as when an end of the pen is inserted in a supply of ink and to retain the ink in the storage space by capillary action when the pen is not in use, and further characterized by a capillary ink feed element disposed in the feed section and providing a capillary ink feed duct connecting the storage space with the writing element and of predetermined capillarity sufficient to draw ink from the storage space by capillary action when the writing element is in contact with a writing surface.

2. A fountain pen as set forth in claim 1 wherein the pen is adapted to be filled merely by inserting the writing end in the supply of ink whereby ink is drawn into the filler and reservoir element through the feed section.

3. A fountain pen as set forth in claims 1 and 2 wherein the capillary filler and reservoir element is formed as a separate self-contained structure which may be removed from the body and replaced as a unit.

4. A fountain pen as set forth in claim 1, 2 or 3 wherein the portion of the storage space farthest from the writing element has a greater capillarity than the portions nearer to the writing element.

5. A fountain pen as set forth in any of the preceding claims wherein an air vent is provided for continuously venting the ink storage space to atmosphere.

6. A fountain pen as set forth in claim 5 wherein the air vent duct is of greater than capillary size and extends substantially throughout the length of the ink reservoir section and leads to the exterior of the pen body.

7. A fountain pen as set forth in claim 5 wherein the air vent duct leads out of the pen at the end adjacent the writing element.

8. A fountain pen as set forth in claim 5 wherein the air vent leads from the reservoir section at the end away from the feed section.

9. A fountain pen as set forth in any of the preceding claims wherein a capillary ink feed channel connected to

the ink feed duct in the feed section extends substantially throughout the length of the reservoir section and is connected substantially throughout its length to the ink storage space for feeding ink to the writing element.

10. A fountain pen as set forth in any of the preceding claims wherein the capillary ink feed duct has a capillarity at least as great as any portion of the ink storage space.

11. A fountain pen as set forth in any of the preceding claims wherein each portion of the capillary ink storage space has a capillarity at least as great as the minimum capillarity which will cause that portion of ink storage space to fill by capillary action when the pen is inserted in a supply of ink and not greater than the maximum capillarity which will permit ink to be withdrawn from that portion of the space by capillary action when the pen is used in writing.

12. A fountain pen as set forth in any of the preceding claims wherein the walls which define the capillary ink storage space are formed by a material with which the ink makes a contact angle of not more than approximately 60°.

13. A fountain pen as set forth in any of the preceding claims wherein a capillary ink channel is connected to the ink storage space and leads to the exterior of the pen body independently of the ink feed channel to aid in filling the pen.

14. A fountain pen as set forth in any of the preceding claims wherein the ink storage space includes a plurality of separate but interconnected capillary cells.

15. A fountain pen as set forth in claims 1 or 6 wherein the ink storage element consists of a plurality of longitudinally spaced, circumferential fins defining therebetween capillary cells which are intersected and interconnected by a capillary ink channel connected to the writing element by the ink feed duct.

16. A fountain pen as set forth in claim 1 or 6 wherein the ink storage element includes a structure disposed in and extending substantially throughout the reservoir section and having a plurality of spaced circumferential grooves providing capillar cells, a longitudinally extending groove of capillary size intersecting and interconnecting the circumferential grooves and providing an ink feed channel connecting the circumferential grooves with the ink feed channel leading to the writing element, and another longitudinal groove of greater than capillary size intersecting the circumferential grooves and providing an air vent channel leading to an opening in the pen body.

17. A fountain pen as set forth in claim 3 wherein the capillary cells are defined by a plurality of longitudinally spaced discs held together in a stack with the discs having openings therethrough for interconnecting adjacent cells.

18. A fountain pen as set forth in any of the preceding claims in which the writing element is carried by the capillary filler and reservoir element.

19. A fountain pen substantially as shown and described and for the purpose described.

Dated this 17th day of May, 1947.

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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig 1

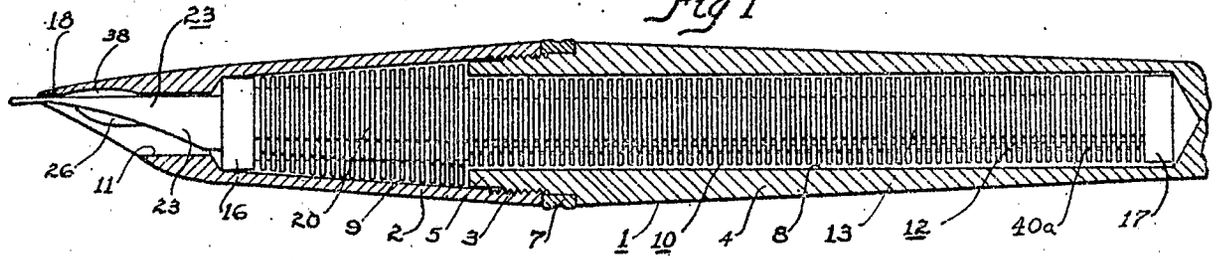


Fig 2

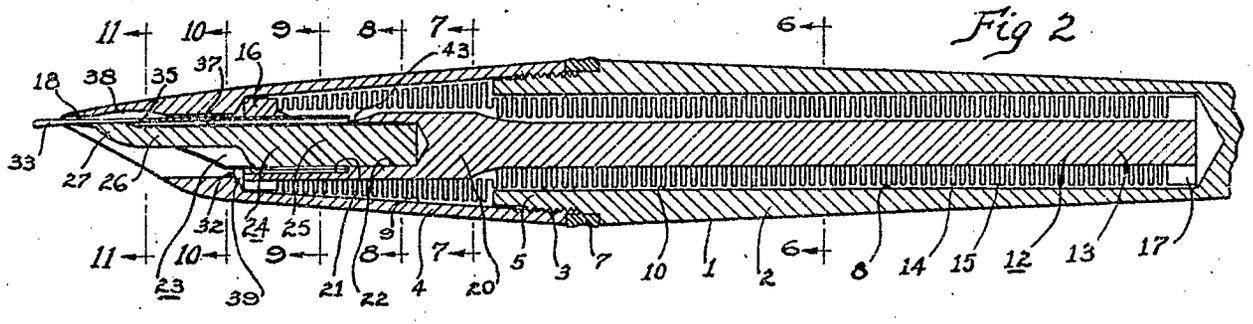


Fig 8

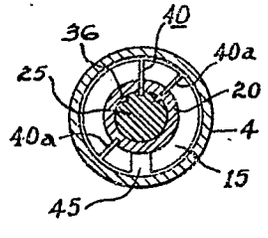
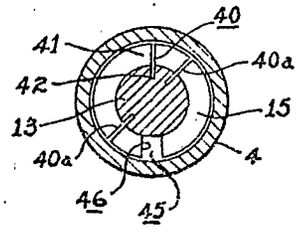
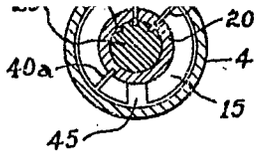
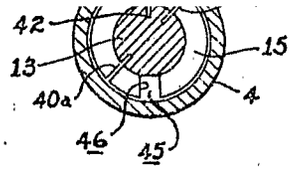


Fig 7

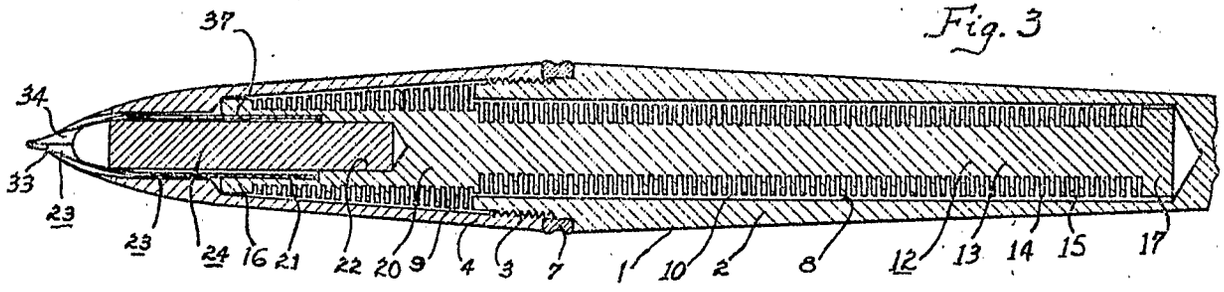






SHEET 1

Fig. 3



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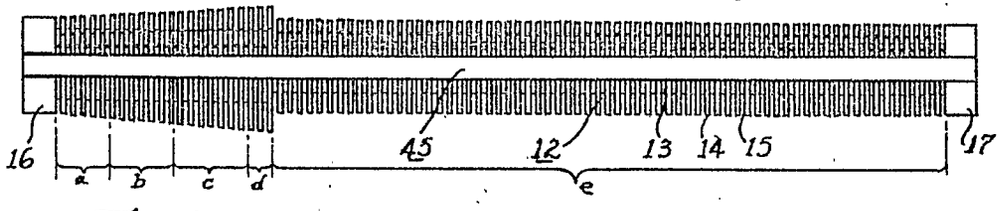

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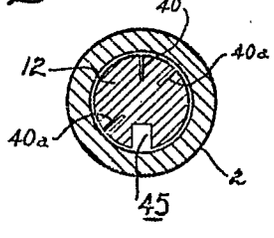

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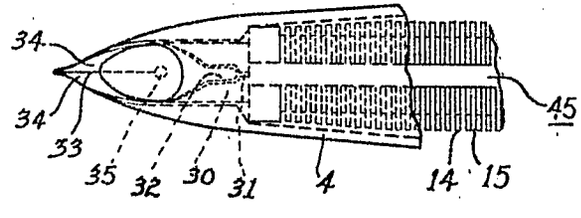

SHEET 2

6 SHEETS

H.M.S.O.(Ty.P.)

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634,735 COMPLETE SPECIFICATION

SHEET 1

Fig 1

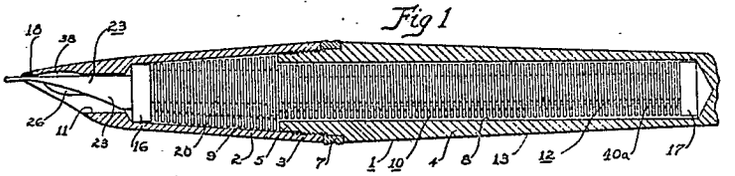


Fig 2

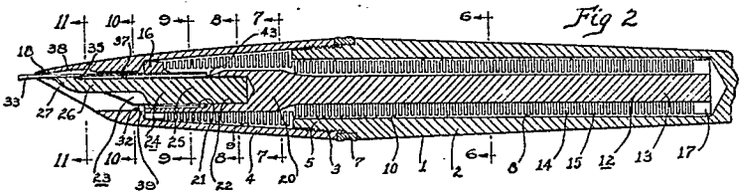


Fig 8

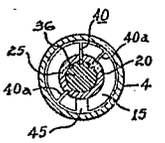


Fig 7

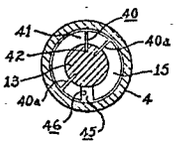


Fig. 3

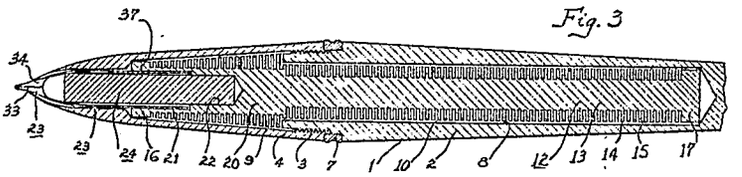


Fig. 4

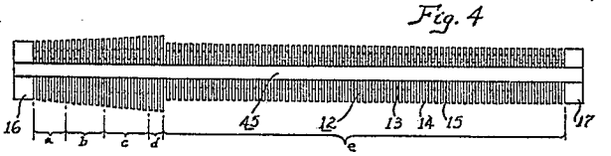
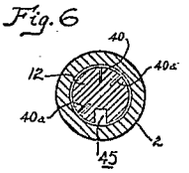


Fig. 6



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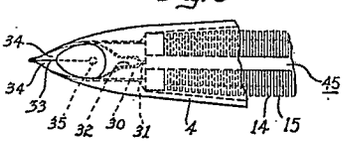

SHEET 2

6 SHEETS

H.M.S.O.(Typ.)

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Fig. 11

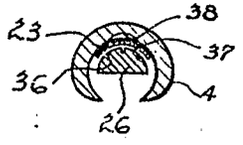
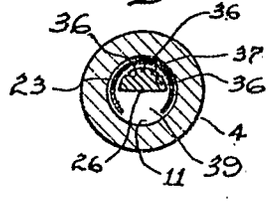


Fig. 10



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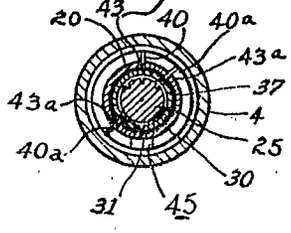

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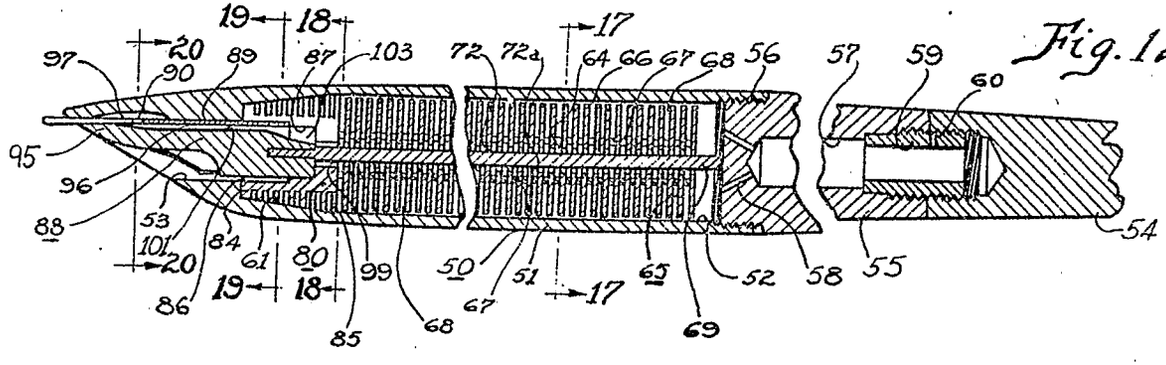
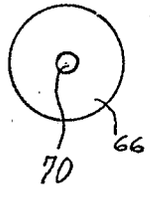


Fig. 15



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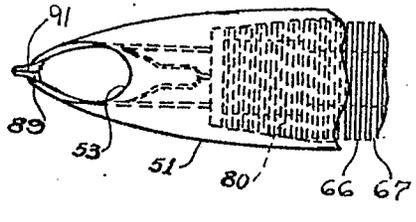

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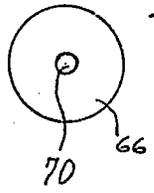

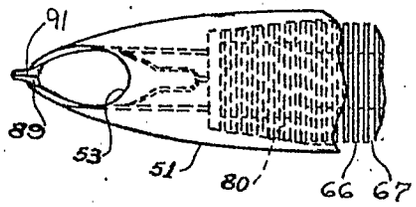

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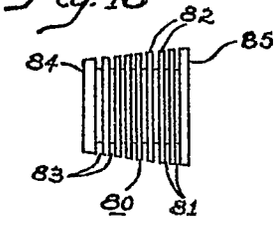

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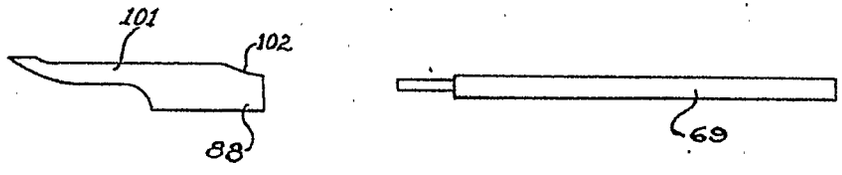
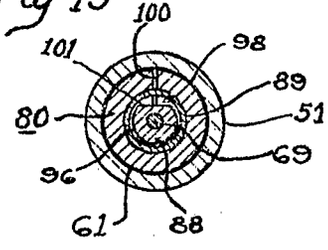


Fig 19



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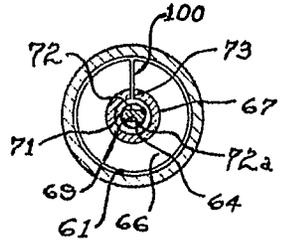

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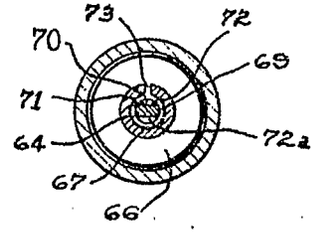

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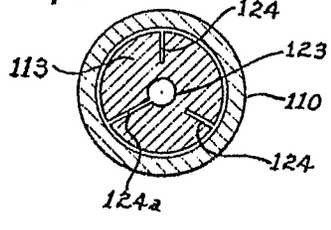
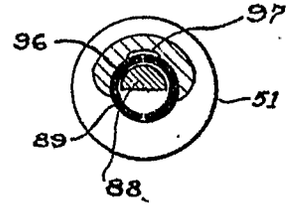


Fig 20



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634,735 COMPLETE SPECIFICATION

SHEET 3

Fig. 11

Fig. 10

Fig. 9

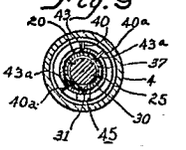


Fig. 12

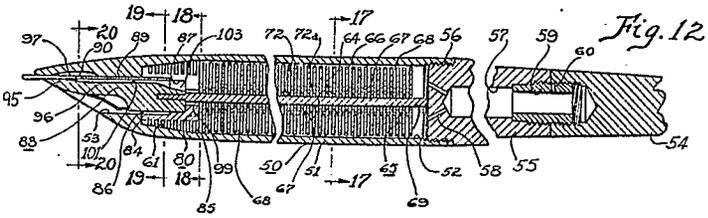


Fig. 15

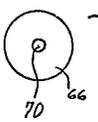


Fig. 13

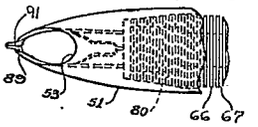


Fig. 16

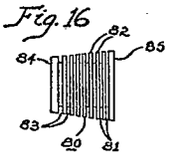


Fig. 14

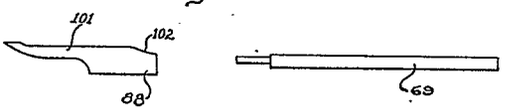
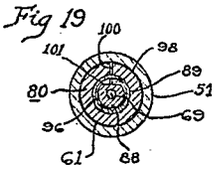


Fig 19



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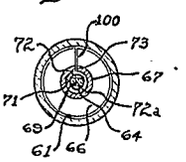

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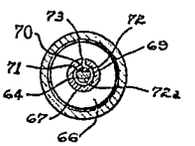


Fig. 23

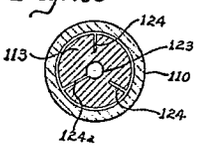
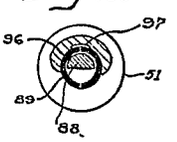


Fig 20



6 SHEETS
SHEET 4

H.M.S.O.(Pty.)(P)

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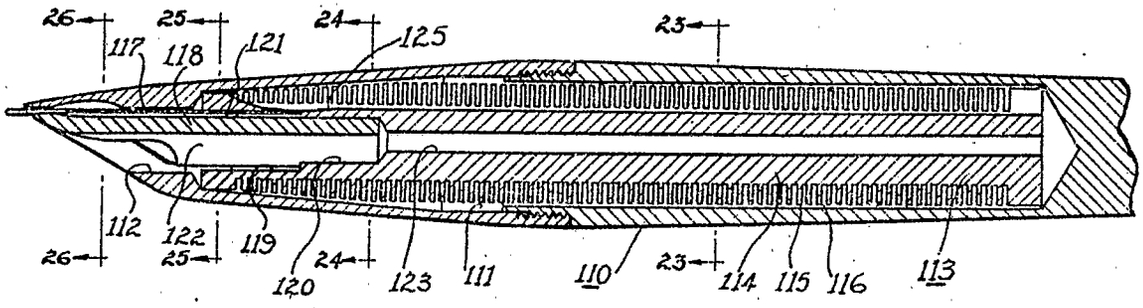


Fig 21

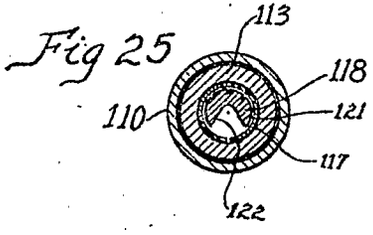


Fig 25

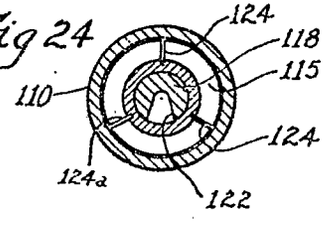


Fig 24

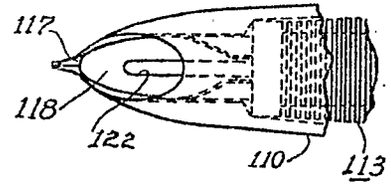


Fig 22

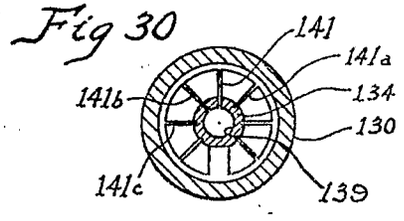


Fig 30

Fig 26

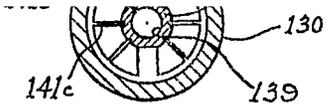


Fig. 27

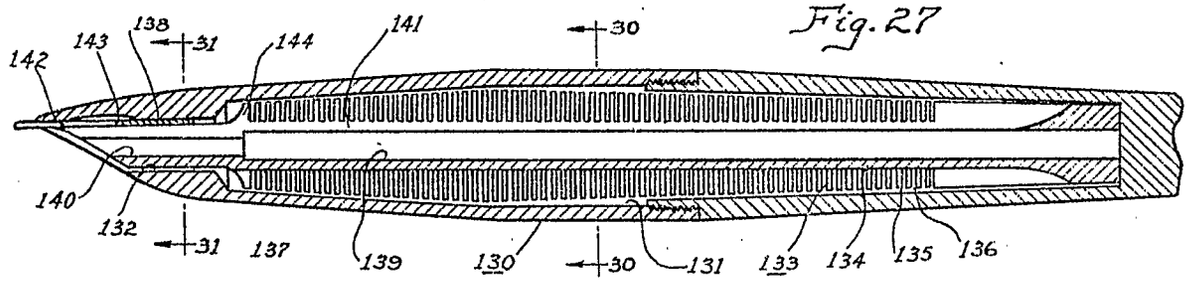


Fig. 29

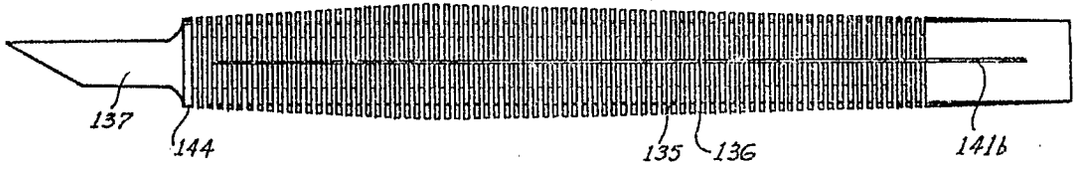


Fig. 32

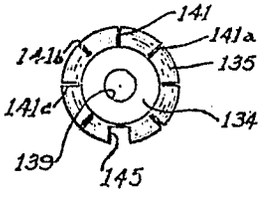


Fig. 31

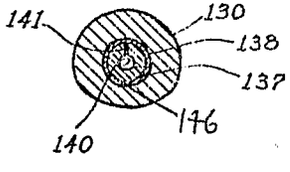
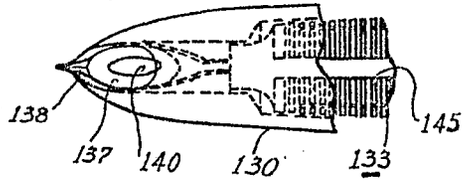


Fig. 28



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634,735 COMPLETE SPECIFICATION

SHEET 5

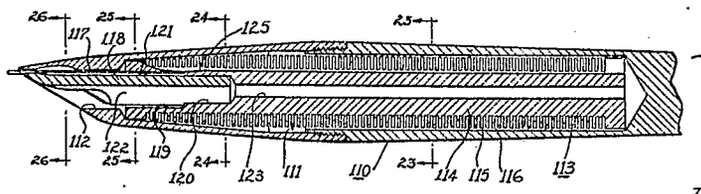

Fig 21

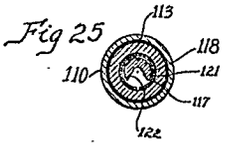

Fig 25

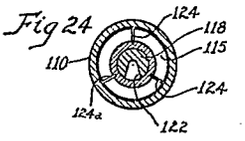

Fig 24

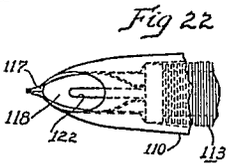

Fig 22

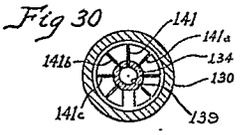

Fig 30

Fig 26

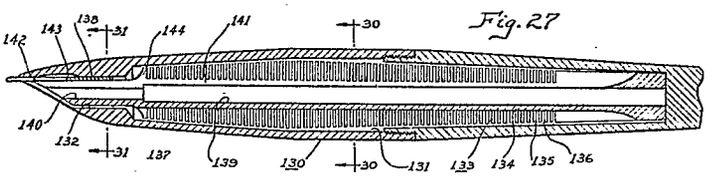

Fig. 27

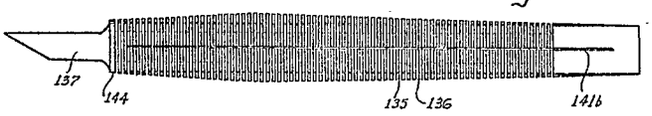

Fig. 29

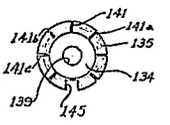

Fig. 32

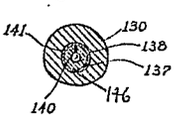

Fig. 31

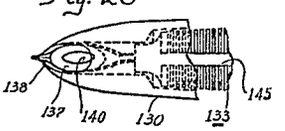

Fig. 28

SHEET 6

6 SHEETS

H.M.S.O.(Ty.P.)