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COMPLETE SPECIFICATION

Improvements in or relating to Fountain Pens.

I, STANLEY GUSTAV DEHN, M.A., a British subject of Kingsway House, 103, Kingsway, London, W.C.2, Chartered Patent Agent do hereby declare the nature of this invention (a communication to me from THE PARKER PEN COMPANY, a corporation duly organised under the laws of the State of Wisconsin, United States of America, of Corner of Court and Division Streets, Janesville, State of Wisconsin, United States of America), 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 more particularly to fountain pens in which capillary action alone is utilized for filling the ink reservoir, for retaining ink therein and for feeding ink therefrom to a writing surface when the pen is in use.

Fountain pens operating generally in this manner are disclosed in the communicator's Specification No. 634,735, which describes and claims 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.

In the said Specification No. 634,735 are shown various forms of pen each having an ink reservoir comprising a plurality of annular spaces of capillary dimensions, with longitudinal passages interconnecting the said spaces and serving to feed ink therefrom to a writing element such as a nib when the pen is in use. The annular spaces may also be formed so that those farthest from the writing element are of greater capillarity than those nearer to said writing element, and/or an air vent may be provided for continuously venting the ink storage to the atmosphere.

It is an object of the present invention to provide an improved fountain pen which operates on the same principles as described in the said specification. To this end is employed an ink storage and filler element having elongated capillary passages or cells extending longitudinally substantially throughout said element, each of said passages or cells embodying means extending longitudinally therealong which is of greater capillarity than the remainder of the passage or cell.

It will be appreciated that such a construction is relatively simple to manufacture and may have considerable mechanical strength. There may for example be constructed a filler element in substantially cylindrical form with radial vanes within such cylinder defining said capillary passages, as will be later described.

A particular advantage of such a construction is that, owing to the fact that the capillary passages extend longitudinally of the pen, substantially all said passages may be simultaneously placed in substantially direct contact with a supply of ink, which facilitates rapid filling.

It will also be noted that a plurality of feed paths are provided, each extending substantially throughout the length of the ink reservoir, and the members forming

these paths need occupy only a relatively small portion of the space available for ink storage, thus providing increased ink capacity.

Pens according to the invention are also less liable to develop air locks, as when any of said passages or cells is incompletely filled with ink, the said means of greater capillarity than the remainder of the passage or cell tends to attract the ink, leaving a continuous space, and the ink may feed out of the pen via said means of greater capillarity. It is thus possible for the pen, whether completely or partially filled, to be "written out"—i.e. emptied by writing—completely before refilling is necessary.

The advantages common to fountain pens using capillary action for filling and ink feed are also obtained. Among these may be mentioned the absence of plunger, levers or the like for filling, and the fact that air vents and pressure equalizing passages may be provided so that changes in atmospheric pressure do not cause leaks or otherwise affect ink feed.

The various features of the invention will appear from the following description, taken in connection with the accompanying drawings, in which:—

Figure 1 is a view of a longitudinal, vertical cross-section taken through a fountain pen embodying the present invention;

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

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

Fig. 4 is an enlarged, fragmentary transverse cross-sectional view taken along the line 4—4 of Fig. 1;

Fig. 5 is an enlarged, fragmentary view showing a portion of the structure of Fig. 4;

Fig. 6 is an enlarged, fragmentary cross-section taken along the line 6—6 of Fig. 5;

Fig. 7 is an enlarged, fragmentary view of a portion of the cell structure illustrating somewhat diagrammatically the position which the ink takes in one of the cells during filling;

Figure 8 is an enlarged, fragmentary view of a portion of the cell structure showing somewhat diagrammatically the manner in which the air lock is prevented;

Fig. 9 is an enlarged, fragmentary view of a portion of the cell structure showing somewhat diagrammatically the feeding of ink from a cell;

Fig. 10 is a fragmentary, longitudinal cross-sectional view through the forward, or nib end, of a second embodiment of the invention;

Fig. 11 is a fragmentary view, partially in longitudinal cross-section, of another form of my invention;

Fig. 12 is an exploded perspective view of a nib and an end closure member forming a portion of the pen shown in Fig. 11;

Fig. 13 is a transverse, cross-sectional view taken along line 13—13 of Fig. 11;

Fig. 14 is a transverse, cross-sectional view taken along line 14—14 of Fig. 11;

Fig. 15 is a side elevational view of a capillary filler element and feed forming a portion of the pen shown in Fig. 11;

Fig. 16 is an enlarged, fragmentary and somewhat diagrammatic view illustrating the arrangement of the fin-forming strips in one step in the formation of the capillary filler elements of Fig. 15;

Fig. 17 is a diagrammatic view of the fin-forming strips as they appear after bending and application of the backing sheet;

Fig. 18 is a reduced top plan view of the assembly of fin-forming strips and backing sheet prior to rolling into final form;

Fig. 19 is a side elevational view of the assembly of Fig. 18;

Fig. 20 is an enlarged, fragmentary, and somewhat diagrammatic top plan view of a portion of the structure shown in Fig. 18;

Fig. 21 is a longitudinal view partially in cross section of a pen embodying a further form of my invention;

Fig. 22 is an enlarged, fragmentary longitudinal sectional view of a portion of the structure shown in Fig. 21;

Fig. 23 is a transverse cross-sectional view taken along line 23—23 of Fig. 22;

Fig. 24 is a transverse cross-sectional view taken along line 24—24 of Fig. 22;

Fig. 25 is a fragmentary view, partially in cross-section showing the forward end of a cartridge generally similar to the cartridge of Fig. 21 only employing a modified form of feed member;

Fig. 26 is a top plan view of the feed member shown in Fig. 25;

Fig. 27 is a longitudinal sectional view of another form of fountain pen embodying my invention;

Fig. 28 is an enlarged, transverse sectional view taken on line 28—28 of Fig. 27 but omitting the pen cap;

Fig. 29 is an enlarged transverse sectional view taken on line 29—29 of Fig. 27;

Fig. 30 is an enlarged fragmentary view of the rear ends of the capillary tubes;

Fig. 31 is a view similar to Fig. 29 showing a modified arrangement for providing the longitudinal ink-carrying capillary passages;

It will be undersood that while a fountain pen of the pocket type is illustrated herein, the invention may, with suitable structure modifications, be adapted to fountain pens of the desk type, such as are normally used with desk stands, or to con-

vertible fountain pens which can be used as either pocket pens or desk pens.

Referring now particularly to Fig. 1, the fountain pen according to a preferred embodiment of the invention, includes an elongated body formed of a suitable material, such as hard rubber or plastic, as for example "Lucite" (methyl methacrylate resin). The body includes a hollow barrel 1 having a chamber 2 defining an ink reservoir which extends throughout a substantial portion of the length of the barrel.

A pen nib section 3 is secured in the forward or nib end of the barrel 1, as by screw threads 4, and may be positioned by a shoulder 5 which abuts the end of the barrel 1. A suitable writing element which may take the form of a nib 6, associated in a bore 8, extending through the pen nib section 3. The feed bar 7, which is essentially cylindrical in shape, is provided with a generally channel-shaped slot or groove 9 in its upper portion for a purpose which will be later explained. The groove 9 is open at its rear end and is closed at its forward end by an end wall 10, which is inclined to prevent the lower portion from bearing on the writing surface when the pen is held at the usual writing angle.

The pen nib 6 may be of conventional form, including a body 11 having a pierce 12 and a nib slit 13 extending therefrom and defining two nib sections. The nib 6 is firmly seated in the bore 8, and extends along the feed bar so that the nib section bear against and extend beyond the end wall 10; the feed bar 7 (Fig. 2) being relieved appropriately as at 14 to accommodate the body 11 of the nib.

A front end cap 15 may be provided for enclosing the nib end of the pen and may be secured to the barrel 1, as by screw threads 16, or in any other suitable and well known manner. The cap 15 is formed with a shoulder 17 adapted to abut the section 3 to prevent the cap 15 from being screwed down too far onto the barrel 1, and injuring the nib 6.

Removably secured on the rear end of the barrel 1 is a rear end cap 18, which closes the chamber 2 and forms with the adjacent end of the barrel 1 an end space or chamber 19. The rear end cap 18 preferably is attached to the barrel 1 by a bush 20 having a body 21 threaded into the barrel 1 and a reduced neck 22 onto which the rear end cap 18 may be screwed.

Means are provided for filling the pen by capillary action when the end of the pen is introduced into a supply of ink. Such means also is effective to maintain the ink in the pen entirely under capillary control (i.e. within a space of capillary dimensions) at all times so that there is no free body of ink within the pen which is subject to influences tending to cause leakage, such as changes in atmospheric pressure or changes in temperature of the air in the pen. During writing the capillary filler means aids in controlling the feed of ink to the nib to provide a continuous, even supply of ink to the nib.

The capillary filler means includes a capillary cell structure 23 extending substantially throughout the length and breadth of the ink reservoir, and which is formed by a plurality of walls or fins 24 extending in generally radial directions from adjacent the wall of the chamber 2 to short of the center. Each wall or fin 24 extends longitudinally substantially throughout the length of the chamber 2 and is formed from a suitable material which is wettable by the usual inks but is relatively inert thereto and will not deteriorate over a long period of use. In addition, the material has sufficient rigidity so that the fins retain their shape and position during use. A metal such as stainless steel has been found to be highly satisfactory for use in forming the fins, although often other materials such as silver, mica or a plastic may be used.

The fins 24 are spaced apart, preferably equally, to provide passages or cells 25 of capillary widths between adjacent fins. Owing to the radial arrangement of the fins, the spaces 25 taper inwardly and are generally wedge shape in cross-section. At their outer side edges the fins 24 preferably extend to the walls of the chamber 2 and are spaced apart as by arcuate, flange-like edges 26, each of which bears against the body of an adjacent fin 24 at the outer edge portion thereof (Fig. 5).

At their inner side edges, the fins 24 terminate short of the centre of the chamber 2 and thus a central space 27 is provided, which receives a feed element described hereinafter. The fins 24 are spaced apart at their inner side edges in a manner which will provide communication between all of the cells 25 and the central space or passage 27. For this purpose, alternate fins 24 may be provided with corrugations or beads 28 extending throughout a portion of the length of such fins. At least two of the corrugations 28 on each alternate fin project in opposite directions from the plane of the fin to bear respectively against the two adjacent fins on either side of the fin on which the corrugations are formed.

The fins 24 are made as thin as practicable, consistent with mechanical strength and rigidity, in order that the largest number of cells of predetermined wall-to-wall width may be provided in a chamber of predetermined size. Thus, by forming the fins of very slight thickness, the maximum

ratio capillary cells space to total volume of the ink reservoir is obtained.

The central passage 27 receives and is substantially filled by a feed element which may be formed as a wick 29. The wick 29 extends along the central passage 27 in feeding relation with the open inner side edges of the cells 25 and extends into the groove 9, and throughout the length thereof. The wick 29 fills the groove 9 and bears against the underside of the nib 6 whereby the capillary passages in the wick 29 are in ink feeding relation with the pierce 12 and slit 13. Preferably, the portion of the wick which extends forwardly of the capillary cell structure has a greater capillarity than the remainder of the wick. This may be accomplished by forming the groove 9 of such size that the wick is slightly compressed between the walls of the groove 9 and the top wall of the bore 8 rearwardly of the nib and between the walls of the groove 9 and the nib 6. This compression also ensures that the wick 29 is retained firmly in feeding relation to the nib pierce 12 and nib slit 13.

The wick 29 is formed from a large number of strands or fibers which provide a plurality of capillary paths extending in a generally longitudinal direction through the central passabe 27 and which are in communication with the capillary cells 25. Preferably the wick 29 is formed from a material which provides the necessary capillarity, which is sufficiently flexible to provide the desired contact with adjacent elements of the pen and which is sufficiently resilient to retain such contact. Preferably the material is non-absorbent and is not deteriorated by conventional inks. In one successful embodiment, the wick was formed by a bundle of essentially parallel 20 denier nylon threads each consisting of 20 filaments, although other materials such as other plastics, ceramic material or vegetables or animal fibers may be used.

A pad 30 may, if desired, be provided at the front end of the chamber 2 in surrounding engagement with the wick 29 and seated between the ends of the fins 24 and the adjacent ends of the pen nib section 3 and feed bar 7. The pad 30 is formed of a suitable material providing capillary passages having a greater capillarity than the capillary cells 25 and which material is wettable by the ink but preferably non-absorbent and will not deteriorate over a long period of use. It has been found that nylon or spun glass is very satisfactory for forming the pad. In order to assist in positioning the pad 30 and the fins 24, the barrel 1 is formed at its forward end with a shoulder 31 against which the pad 30 seats. When the pen nib section 3 and the feed bar 7 are in position their ends are flush with the shoulder 31 and provide additional seating for the pad 30. The pad 30 is formed with an opening 32 to accommodate the wick.

The fins 24 are held in position at their rear ends by a screen 33 which extends across the rear end of the chamber 2 and which preferably is secured between the bush 20 and a shoulder 34 formed in the barrel. When the bush 20 is screwed into place it forces the fins 24 firmly against the pad 30 which in turn is forced against its seat and thus fins 24 are firmly secured in position.

The screen is formed with openings which provide relatively free communication between the capillary cells and the chamber 19. Since the pen barrel is open across substantially its entire rear end area, the cells therefore have relatively free communication with the chamber 19 (and the exterior of the pen when the rear end cap 18 is removed) over substantally their entire rear end area. The screen may be formed of any suitable material which will retain its rigidity and which is not deteriorated by the ink. Metal such as stainless steel has been found suitable for forming the screen, although suitable plastics may be used.

Extending from the chamber 19 along the chamber 2 to the front end of the pen is a vent or pressure equalizer passage 35. This passage may be defined by a trough member 36, formed of suitable material, such as stainless steel, disposed in the upper portion of the chamber 2, and by a groove 37 (Fig. 2) formed in the upper wall of the bore 8, which extends through the pen nib section 3. In order to accommodate the trough member 36, portions of certain of the fins 24 may be cut away (Fig 4). Additional venting preferably is provided by one or more additional pressure equalizer passages which are generally similar to the passage 35, but spaced therefrom around the periphery of the chamber 2, and which may terminate at the forward end of the cell structure 23 or may extend through the pen section 3.

In order to provide communication between the passage 35 and the adjacent cells substantially throughout their lengths the trough member 36 is formed with openings 38, or it may be formed as a screen. Alternatively, the passage 35 may be provided by omitting a suitable number of fins 24 at the upper portion of the chamber, the spacing of the fins at either side of the sector shaped space created by the omission of fins being maintained by suitable spacer means (not shown) such as an extended flange on one of the fins.

The air passage 35 provides free air com-

munication between the interior of the pen and the atmosphere, when the front end cap is removed for writing or when the rear end cap is removed for filling the pen and thus, all of the ink in the pen is maintained at atmospheric pressure when either end cap is removed. The air passage serves to equalize the pressure in all portions of the pen so that when both end caps are in position closing the respective ends of the pen, the pressure within the pen body and within both of the caps is equal. It will be understood that when both caps are in position closing the ends of the pen, changes in atmospheric pressure may not be reflected immediately by similar changes within the pen; however, when either cap is removed, the pressure within the pen immediately is equalized with that of the atmosphere. Where either end cap is vented the presure wihtin the pen interior will remain at atmospheric pressure.

It will be seen that since each of the cells is in air communication with the chamber 19, the pressure of the air on the ink at the rear ends of all of the cells is substantially equal. However, in order to provide full and immediate equalization of pressure within all of the cells whenever any changes in pressure take place in any portion of the pen, a plurality of openings 39 may be provided in each of the fins.

The pen is filled by placing the capillary cells in capillary filling relation with a supply of ink. Preferably the pen is filled at the rear end by removing the rear end cap and inserting the rear end of the pen in a supply of ink to such depth that the rear ends of the cells are below the surface of the ink supply, and the cells are individually in capillary filling relation with the ink supply. The capillary action of the cells and the wick causes ink to be drawn into both the cells and wick and to rise therein. Since the cells are in substantially direct filling relation with the ink supply (through the openings in the screen) ink will be drawn directly into each cell. Since the cells are individually and directly in communication with the ink supply, through the openings in the screen and since the cells present a relatively large total cross-sectional area ink will be drawn into the pen at a relatively rapid rate and the filling operation will require a period of only a few seconds. The wick and the inner portions of the cells provide paths of higher capillary than the outer portions of the cells. Accordingly ink will rise along the former paths in advance of its rise along the portions of the cells remote from the wick. The formation which ink will assume in the cells is illustrated in a generally diagrammatic way in Fig. 7.

During the filling, ink will rise in the wick 29 toward its upper end until the wick is completely filled and will enter the nib slit 13. Ink also may be drawn from the wick 29 into the capillary spaces in the pad 30 to fill such spaces; in any event when the pen is placed in writing position, the pad will draw in ink from the adjacent ends of the cells and become saturated. Thus, the ink in the wick 29, the pad 30 and the cells 25 and nib slit 13 forms a substantially continuous body of ink all of which is in passages or cells of capillary size.

Air which is in the capillary cells and wick prior to filling the pen is forced out during the filling by the ink which is drawn into the cells and wick. This air is forced out of the front ends of the cells and out of the wick and into the air equalizer passage which vents the air to the atmosphere. Where the air equalizer is in direct communication with adjacent cells, as explained hereinbefore, air will also pass into the air passage directly from adjacent cells, and thence to the end of the passage. In order to ensure free venting the front end cap is loosened or preferably removed during filling.

The capillarities of the several passages and cells constituting the capillary system are so selected that ink will be drawn into the pen to fill the cells 25 to the desired extent. The height to which ink will rise in the pen and the rate of rise will depend upon a number of factors. However, for any particular pen, using any particular ink, the height of rise (and rate of filling) is influenced by the angle at which the pen is held relative to the surface of the supply of ink. The minimum height of rise (and rate of filling) will occur when the pen is held vertically and the capillary system should have sufficient capillarity to cause ink to rise to the desired height when the pen is held in this position. However, the pen may be held at a relatively small angle to the surface of the ink supply (for example, around 30°) with the result that the cell would be capable of drawing up more ink than if the pen were held vertically. Accordingly, the capacities of the cells and the capillarity of the capillary system are so selected that even if the pen is filled by holding it at a very small angle to the surface of the ink supply, no more ink will be drawn into the pen than can be retained in the cells by capillary action in any position of the pen. Hence, even if the pen is filled by holding it at a relatively small angle to the surface of the ink supply and then is moved into a vertical position, ink will be held in the pen by the capillarity of the cells and will not drain out or leak.

The height of rise and 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 such passages, the wettability of the surface of the ink used and the surface tension of the ink. In general, the viscosity of the ink also would be a factor but since most fountain pen inks at present in use have viscosities substantially equal to that of pure water, the viscosity for such inks may be assumed to be the same. In the pen of the present invention the practically straight, unobstructed passages defined by the cells and the relatively large total cross-sectional area presented to the supply of ink when the cells are in filling relation provide for relatively rapid filling action even though the cross-sections of individual cells are necessarily made relatively small in order to provide the necessary capillarity.

Inasmuch as the pen when used in writing is held with the nib end downwardly, the capillarity of the cells 25 must be such as to retain ink therein when the pen is in such position. Accordingly, the capillarity of each coil must be such as to support the weight of the column of ink which extends from the end of the nib to the upper surface of the ink in the cells.

The relative capillarities of the several portions of the capillary system ars so selected that ink will be drawn by capillary action to the nib and will be maintained there at all times so that the pen is always in writing condition. Ink which evaporates, or which is drawn off during writing thus is immediately replaced.

The wick 29 is formed so as to have a higher capillarity than the cells 25 and the pad 30. Thus, any ink withdrawn from the wick at the nib pierce or nib slit will be replaced immediately by ink drawn into the wick from the cells 25 or pad 30.

The pad 30 is formed so as to have a capillarity greater than the cells 25 but less than the wick 29. Thus, the pad 30 acts to draw ink out of the cells 25 at their forward ends, which action tends to maintain ink at the forward ends of the cells; however, since the wick 29 has a greater capillarity than the pad 30, ink is drawn from the pad 30 by the wick 29 and fed to the nib 6. The pad 30 normally will draw ink from the forward ends of the cells 25 and ink will be drawn from the pad 30 by the wick 20. However, the wick 29 is in feeding relation with each of the cells throughout the length of the reservoir and thus the wick will be supplied with ink substantially throughout its length.

Owing to the higher capillarity of the inner portions of the cells 25 relative to the remainder of the cell portions, any ink which is in a cell will be drawn toward the inner portion of the cell where it is in a position to be drawn into the wick 29.

In writing, when the pen nib is drawn across the writing surface, ink which is held in the nib slit by capillarity is brought into contact with the writing surface and the capillarity established between the nib and the writing surface is sufficient to overbalance the capillarity of the capillary filler element. The capillarity of the pen nib slit, the wick and the pad is such that ink is drawn from the capillary cells to replace ink which is withdrawn from the pen nib slit and left on the writing surface. Because the flow of the ink to the pen nib slit is governed by the relation of the capillarity of the capillary system in the pen to the capillarity established between the pen nib and the writing surface, a very uniform flow of ink to the writing surface is ensured. Since the capillarity of the capillary system of the pen is greatest at the pen nib slit, ink is always instantly available at the point of the pen nib for writing.

The cells are in communication individually with the capillary passages in both the pad and the wick so that the ink is in the form of a continuous body entirely under capillary control. Owing to the internal cohesion of the ink and to the fact that the continuous body is under capillary control, the continuity of supply from the cells to the pen nib slit is maintained at all times to replace ink which is drawn off during writing.

As ink is drawn from the pen in writing, air must be drawn into the pen to replace such ink. Air is admitted through the front end of the air passage 35 and enters the cells at their rear ends and also through the openings 39 in the fins 24. Ink normally will be drawn out of the cells at their inner side edges and at their forward ends as illustrated somewhat diagrammatically in Fig. 9. Air normally will enter the cells behind the body of ink therein and will gradually fill the cells from the rear toward the front and from the outer edges toward the inner edges.

It is essential that any and all conditions which might lead to air locks in the capillary system be eliminated for, as is known to those skilled in the art, air locks will prevent ink from being drawn into a pen during refilling. In addition, air locks will prevent ink from being written out of a pen fully and thus will limit the refill capacity. In some cases air locks may cause complete stoppage of the ink feed. In the pen illustrated herein, air locks are prevented by the provision of pilot feed passages of higher capillarity than the remaining portions of the ink reservoir. The central wick and the inner portions of the cells provide pilot

passages of higher capillarity than in the remaining portions of the cell and which maintain the continuity of the body of ink in the capillary system to ensure feeding even when air is present in the reservoir under such conditions as might cause an air lock were it not for the presence of such preventitive means.

The action of such pilot passages is illustrated somewhat diagrammatically in Fig. 8 to which reference is made to aid in an understanding of this action. If a globule "*a*" of ink is formed in one of the cells above, or enclosing, a quantity of air "*b*" the ink forming such globule will be drawn toward the inner portion of the cell and the wick, since the capillarity of these portions of the system is greater than the capillarity of the outer portion of the cell. The ink globule is thus drawn away from the outer portion of the cell, as indicated by the line "*c*" in Fig. 8, thereby, freeing the air entrapped forwardly or within the globule and allowing such air to join the air above the globule. The ink forming the globule may be entirely drawn into the wick. However, if the wick is saturated, the globule may not enter the wick, but it will pass down the cell along the inner edge portion thereof and eventually join with ink in the forward end of the cell, as indicated at "*d*" in Fig. 8.

The capillary action in all parts of the pen is sufficient so that the ink is maintained therein under all conditions of normal use such as changes in position and changes in temperature and pressure, but is caused to flow to the nib by capillary action when the nib is engaged with and moved along a writing surface. Since the ink in the reservoir is maintained substantially under atmospheric pressure, and is fed therefrom by capillary action, the ink will flow smoothly and evenly and will not alternately flood or starve as is often the case in pens of the type wherein ink is retained in the reservoir by partial vacuum and air enters the reservoir intermittently to replace ink which is drawn off in writing. Because the capillarities of the inner portions of the cells and the adjacent wick are higher than the capillarity of the cells at the outer portions, ink will be retained in the upper portions of the cells at the inner portions in the manner indicated in a very general diagrammatic manner in Fig. 9. However, since the central wick is in feeding relation with all of the cells throughout their lengths ink will be drawn out of the cells as the pen is emptied until the cells are substantially empty.

The wick provides a means of relatively large cross-section for supplying ink to the nib and thus a ready but controlled supply of ink is always available at the nib. Since the wick provides a large number of passages in parallel relationship, the clogging of one or more of the passages would not appreciably affect the availability of ink at the nib or the free flow thereto.

The novel features of the present invention may be embodied in pens of various sizes and forms. In one illustrative embodiment of the invention in which the pen barrel, pen section and nib were approximately of the size ordinarily used in a pocket pen, excellent results were obtained by employing an ink reservoir having an internal diameter of 0.375″ and an overall length of $1\frac{3}{4}$″ to 2″. The capillary cell structure was formed of fins, each having a length of $1\frac{3}{4}$″ and a width of 0.140″ providing a central opening having a diameter of 0.095″. The wick was formed with an uncompressed diameter of approximately 0.100″ to fill the central opening tightly. The fins which were 0.001″ in thickness were spaced apart to provide cells each having a width of 0.006″ at the outer edge and 0.001″ width at its inner edge. The air equalizer passage had a diameter of 0.050″. The pen had a total initial ink capacity of approximately 2.5 grams and a refill capacity of approximately 1.5 grams.

In Fig. 10 there is illustrated an embodiment of the invention wherein the pad is formed by a portion of the wick. Only the front end construction of the pen is illustrated, since the remainder of the pen may be similar to the pen illustrated in Fig. 1 and described above.

The pen includes a barrel 40 having a pen section 41 carrying a feed bar 42 and a nib 43 and generally similar to equivalent elements illustrated in Fig. 1.

A wick 44 co-operating with cell defining fins 45 is provided which extends along the feed bar 42 and into feeding relation with the nib 43, all in a manner generally similar to that described in connection with the structure of Fig. 1. However, in lieu of providing a separate pad at the forward ends of the capillary cells, a generally equivalent pad element is provided by expanding the wick laterally, as indicated at 46, to fill the space between the forward ends of the fins and the rearward end of the pen section. This is accomplished preferably by pushing toward each other the portions of the wick on either side of the pad-forming section 46 in the nature of an upsetting operation, thereby to cause the wick to bulge laterally.

A modified manner of forming the air equalizer also is illustrated in Fig. 10. The air passage 47 may be defined by a tube 48 extending throughout the chamber in the barrel. At the forward end, the tube 48 enters the end of a passage 49 formed in

the underside of the feed bar 42 which passage extends throughout the length of the feed bar and has its forward end open to the atmosphere.

It will be understood, of course, that either of the specific forms of pad illustrated in Figs. 1 or 10 may be used with any of the several forms of air passage described and vice versa.

Referring now particularly to Fig. 11 of the drawings, the pen includes a pen body or barrel including a front section 100 and a rear section 101, detachably connected to the front section as by a threaded joint 102. The body may be formed of any suitable material such as metal or a plastic and preferably is formed from a plastic such as "Lucite" (methyl methacrylate resin). The forward body section 100, which preferably terminates at its forward end in a tapered portion 103, is formed with a bore 104 extending longitudinally therethrough and opens to the exterior of the pen in a forward opening 105.

Carried at the forward end of the pen body is a writing element which preferably takes the form of a pen nib 106. The pen nib 106 (Figure 12) has the general form of a portion of a cone and at its rear end is provided with a split ring portion 107 adapted to resiliently and frictionally engage against a tapered portion 108 of the bore and to bear against a shoulder 109 for the purpose of positioning the nib within the forward end of the body with only the forward writing tip projecting therefrom. The nib 106 is formed with a slit 111 providing two flexible nib sections 112 and with a pierce 110 which registers with an air opening 115 formed in the upper wall of the forward pen body for a purpose which will hereinafter appear.

For the purpose of substantially closing the open forward end of the pen body and for retaining the feed element, hereinafter described, in ink feeding relation with the nib, an end piece or shoe 120 is provided which has a generally trough shaped body 121 adapted to fit into the tapered portion 108 of the bore forwardly of the nib 106. The edges of the body portion 121 are generally complemental in shape to the edges of the nib so that the end piece fits against the nib when these two members are in position in the pen body. The end piece is provided with a forward end wall 122 preferably inclined, as illustrated, and having its periphery conforming generally to the periphery of the opening 105 in the end of the pen body and providing, in effect, a continuation of the external contour of the pen body. The end wall 122 is formed with an ink inlet opening 123 below the center thereof for the purpose of admitting ink into the interior of the pen as hereinafter more fully described.

The interior of the forward body section adapted to be filled with ink by capillary action when the writing end of the pen is inserted in a supply of ink. This filling is effected by a capillary filler element 125 having a plurality of passages or ink storage spaces therein suitably connected and adapted to be placed in communication with the supply of ink and to draw ink therein by capillary action. The capillary ink spaces are of such capillarity that they retain the ink therein by capillary action when the pen is not in use and permit ink to be withdrawn therefrom when the pen is used in writing. The capillary storage spaces, together wih the ink feed means connected between these spaces and the nib slit maintain the ink in the pen entirely under capillary control at all times and there is no free body of ink within the pen subject to influencies which tend to cause leakage in fountain pens of the type having a reservoir containing a free body of ink.

The capillary filler element 125 includes a plurality of elongated partitions or fins 126 extending longitudinally of the pen body and disposed in generally radial arrangement to define therebetween a plurality of longitudinal spaces or passages 129 of generally wedge-shaped cross-section and of capillary width. The fins 126 terminate inwardly short of the center of the longitudinally extend-central space 132 which provides intercommunication between all of the capillary spaces 129.

The capillary spaces 129 are each connected in ink feeding relation with the nib slit 111 by a feed element 130 which is so formed as to provide a plurality of capillary passages extending from the inner open longitudinal edges of the spaces 129 to the nib slit 111. The capillary feed element 130 may be formed in various ways but preferably is formed as a wick consisting of a large number of fibers or threads of suitable material. In one specific embodiment obtained by forming the wick as a bundle of essentially parallel spun glass filaments. Other materials which have been found suitable for forming the wick are animal or vegetable fibers, or nylon and in one embodiment the wick was formed of 20 denier nylon threads each consisting of 20 filaments. Preferably the material should be one which is not absorbent and which is not detrimentally affected by inks of the types used with the pen. The feed element extends preferably throughout the entire length of the capillary filler element and at the forward end thereof projects beyond the end of the capillary filler element and into direct contact with the underside of the pen nib adjacent the slit therein. Preferably the feed element is of sufficent

length so that it is held against the underside of the pen nib and capillary parrages are maintained in ink feeding relation with the nib slit.

Equalization of pressure between the interior and exterior of the pen is effected by providing an air pressure equalizer or vent passage which extends longitudinally of the capillary filler element preferably throughout the length thereof and communicates with all of the capillary ink spaces in the capillary filler element. The vent passage preferably is provided by so forming the capillary filler element that a generally wedge shaped passage 131 is provided which extends inwardly into communication with the central space 132. The vent passage 131 communicates with ink of the cells in a manner hereinafter described in detail. The vent passage 131 extends to the space forwardly of the filler element which is in communication with the atmosphere through the nib pierce 110 and the air inlet opening 115. In certain cases it may be found desirable to provide a space within the interior of the pen body at the rear of the capillary filler element which serves to connect the rear ends of each of the capillary spaces 129 with the rear end of the air vent passage 131.

In order to provide the maximum ink capacity in a pen of any predetermined size, the ratio of total void space to the total volume of space within the ink reservoir is made as great as possible, consistent with the requirement that the capillary spaces be of suitably small width to provide the necessary capillarity to draw ink into these spaces and retain it therein by capillary action. Accordingly, the fins forming the capillary filler element are made as thin as practicable consistent with mechanical strength and rigidity thereby providing as great a number as possible of capillary spaces or cells of predetermined wall-to-wall width or thickness.

It will be understood that the narrower the cells the greater will be the capillarity exerted thereby on ink contained in the cells. The cells are made of such width that they exert sufficent capillarity to draw ink therein during filling to fill the cells substantially throughout their entire lengths and to retain ink therein when the pen is not in use. The capillarity of the cells, however, is not so great as to prevent ink from being withdrawn from the cells by capillary action established between the writing tip of the nib and a writing surface when the nib is placed in contact with the writing surface during writing. In order to ensure that ink will be drawn into the capillary cells during filling, when the end of the pen is inserted in a supply of ink, it is necessary that the cells have such capillarity as will lift the ink substantially to the top-most portion of the cells, at least at the narrowest portion adjacent the feed element, when the pen is held in filling position. The width of each portion of each cell at any point throughout the length of the cell theoretically should be such as to provide the necessary capillarity to lift a column of ink to that particular point of the cell during filling. However, for convenience in manufacturing, the cells are not dimensioned so that they increase in capillarity continuously from the writing end of the pen toward the rear end of the pen. In the two embodiments of the invention shown in Figs. 1—10 and 27—31, each cell is of uniform capillarity throughout its length, but in the three embodiments shown in Figs. 11—20, 21—24, and 25 and 26, the filler element is formed by a plurality of longitudinally adjacent sections in each of which the cells are of greater capillarity than the section next nearer the writing end of the pen.

This progressive increase in capillarity may be accomplished conveniently in a capillary filler element of the construction illustrated in Fig. 15 by providing a greater number of cells in the sections in which it is desired the cells shall have the greater capillarity. For example, the capillary filler element 125 is formed by three sets of fins 126, 127, and 128, the fins in the three sets being of different lengths. Thus, the cells provided in the forward section of the capillary filler element are defined only by the long fins 126; the cells provided in the second or intermediate section of the capillary filler element are defined by the long fins 126 and the fins 127 of intermediate length and the cells formed in the third or rear section of filler element are defined by the fins 126, 127 and the short fins 128.

The foregoing will be understood somewhat more clearly from an inspection of Fig. 18 of the drawings and from the following description of one mode of forming the filler element.

The capillary filler element may be formed in various ways, it being understood that the construction is such that the fins are suitably retained in radially extending position with their inner ends suitably spaced and their outer ends also spaced but at a greater distance than the inner ends so that the true radial arrangement and desired spacing of the fins is preserved. Preferably the fins of each set are equally spaced in order that the cells all are of similar cross-sectional dimension. The fins may be formed of any suitable thin sheet material, which has sufficient mechanical strength and rigidity, which is not deteriorated by the ink, and which does not

adversely affect the ink. The fins may be formed either from a suitable metal foil as, for example, silver, or from a plastic material, such as cellophane; for convenience in forming the filler element , I prefer to use a plastic.

One convenient mode of forming the fins into a filler element comprises arranging strips of thin plastic material of suitable dimensions in a repeated series, each of which series includes a strip of short length, a strip of intermediate length, a second short strip, and a long strip. The strips are disposed in parallel arrangement and spaced by spacing elements 135 of suitable thickness to provide the desired spacing and a width approximately equal to the desired width of the fins in the finished filler element. The strips are of sufficient width to extend beyond the side edges of the spacing members 135 a distance equal to at least the thickness of three spacing members and the corresponding strips. With the strips and spacing members held in compact condition the extending marginal portions of the strips are bent over at approximately 90° to the main or body portions of the strips so that each marginal portion overlies the bent over marginal portions of the next several strips, as illustrated somewhat diagrammatically in Fig. 17 of the drawings. Where the strips are of plastic material, the bent over marginal portions may then be united by the application of sufficient heat to cause them to fuse to one another and to take a permanent set in the bent over position. Thus, there is provided a unitary structure in which the bent over and overlapping marginal portions of the strips form, in effect, a substantially continuous backing web from which the body portions of the strips project substantially perpendicularly and form spaced parallel flanges or fins.

I prefer to attach to the outer face of the aforesaid web a separate backing sheet 136 which is fused to the web and thereby provides added strength to the structure and ensures the unitary nature of the structure. That is to say, by providing a single unitary backing sheet, several strips wil be retained in connected condition even in the event that one or more of the strips should not originally be securely connected to the adjacent strips or should later become disconnected. The backing sheet 136 is applied to the bent over marginal portions and is fused thereto. Preferably the fusing is accomplished by applying heat and pressure simultaneously which serves to "iron" over the marginal portions and provide a relatively smooth and flat backing web. The spacers 135 are then removed. The assembled structure resulting from the foregoing operations is illustrated somewhat diagrammatically in Figs. 18 and 19 of the drawings.

The assembled structure is then "rolled" into cylindrical form with the free ends of the fins innermost and the backing web outermost. The inner ends of the fins at the two side edges of the structure are brought into abutment but the outer edges do not come together but are spaced apart a sufficient distance to provide the vent passage 131 as illustrated in Figs. 13 and 14. It will be understood that the assembled structure may be held in rolled cylindrical form in any desired manner but preferably the dimensions of the filler element are such that it snugly fits within the ink reservoir space and is held in the desired cylindrical form when thus inserted therein.

Preferably, prior to rolling the structure into cylindrical form the feed element or wick 130 is laid onto the free ends of the fins and the structure rolled around the feed element to substantially enclose the latter when the filler element is rolled as above described.

It will be seen from the foregoing that the attachment of the marginal portions of the fin-forming strips to each other ensures that the fins are suitably spaced from each other at their outer edge portions. Means preferably are provided for spacing the inner edge portions of the fins in order to manitain the desired spacing when the structure is rolled into cylindrical form. Such means preferably takes the form of corrugations 137 formed on the inner edges of alternate fins which corrugations are adapted to abut the inner edge portions of adjacent fins when the structure is rolled into cylindrical form.

The capillary filler element 125 is so formed that its external contour conforms substantially with the internal shape of the interior of the forward body section whereby the capillary filler element is snugly held in the pen body and the maximum utilization of space within the pen body is ensured. Thus, when the forward end of the reservoir is tapered, and the filler element extends into such tapered portion, that end of the filler element is similarly tapered.

This may be accomplished in any suitable manner, as, for example, by providing a plurality of notches in the forward edge of the backing sheet to provide a series of tongues therein and by tapering the forward ends of the corresponding fin-forming strips, the tongues being pressed down onto the strips when the strips are attached to the backing strip.

The capillary filler element is of such length that it terminates short of the extreme forward end of the pen body and

therefore a space 138 is provided between the forward end of the capillary filler element and the floor 122 of the end piece, which accommodates the projecting end of the feed element 130. This projecting end abuts the underside of the nib and the inner face of the floor 122 and the capillary passages defined by the feed element are placed in ink-feeding communication with the nib slit.

Communication between the air vent passage 131 and each of the several capillary cells 129 is provided, preferably at spaced points throughout the length of the capillary filler element, by annular passages 139 which are spaced longitudinally of the capillary filler element. Preferably the passages 139 are formed by cutting grooves in a capillary filler element which grooves extend through the backing sheet and web and are cut into the fins at their outer marginal portions thereby providing relatively free air communication between the air vent passage 131 and the several capillary spaces 129.

The pen is filled by inserting the writing end of the pen into a supply of ink preferably a sufficient depth to immerse the ink inlet opening 123 and place the capillary passages 129 in the filler element 125 in direct feeding relation with the supply of ink. Ink is drawn into the filler element 125 and also the feed element 130 by capillary action and rises therein by capillary action to fill the capillary spaces therein.

Air which is in the capillary spaces 129 is forced therefrom by the incoming ink and finds its way out of the pen through the annular air passages 139, air vent passage 131, the nib pierce 110 and the air port 115. If desired, an air outlet passage and port (not shown) may be provided in the rear body section 101 for additional venting of the pen. Where the end of the pen is inserted into the supply of ink to such an extent that the air port 115 is below the level of the ink such manipulation will not prevent filling of the pen inasmuch as the capillary force exerted on the ink tending to raise it in the capillary filler element is sufficient to overcome the head of ink above port 115 in the ink supply and cause air to bubble up through the ink supply. However, it may be preferable to open the rear end of the pen by slightly unscrewing the rear section 101 during filling.

Owing to the fact that each of the capillary cells is placed in direct comunication with the ink supply the several cells will fill even though one or more of the cells should for any reason become blocked or fail to fill. However, owing to the construction of the cells, there is virtually no possibility of any of the cells becoming blocked, as for example by the formation of an air bubble which if allowed to form in the cell might prevent ink from being drawn upwardly in that cell. The present invention substantially eliminates any possibility of an air bubble forming in any of the cells and causing an "air lock". Each of the cells is of wedge-shaped cross-section and therefore the inner edge portion of the cell is narrower and of greater capillarity than the outer portion of the cell. Accordingly, ink tends to rise along the inner portion of each cell in advance of the ink at the outer portion of the cell. Thus, if an air bubble should tend to form at any portion of the cell, the ink would rise along the inner portion of the cell past such point and establish a continuous body of ink longitudinally of the cell thereby breaking up any such incipient air bubble.

In writing, when the point of the pen nib is placed in contact with the writing surface, the ink which is held in the nib slit by capillarity is withdrawn therefrom by the capillarity established between the nib and the writing surface, this capillarity being sufficient to overbalance the capillarity of the capillary system within the pen which holds the ink in the pen. The pen nib slit has a higher capillarity than the feed element 130 and draws ink from the latter to replace ink withdrawn from the nib slit. In a similar manner the capillary passages in the feed element 130 have a greater capillarity than the capillary cells of the filler element and thus withdraw ink from the latter to maintain the feed element 130 in substantially saturated condition, at least to the height above the writing end of the pen to which ink stands in the several capillary cells. Inasmuch as the capillarity of the several cells increases inwardly toward the feed element 130, ink is drawn inwardly of the pen and toward inner side edges of the capillary cells at which point it is drawn into the feed element 130. The capillary cells 129 in general are emptied from the rear toward the front end of the pen and therefore ink stands in the forward end of the cells until they are substantially emptied.

Because of the fact that each cell has an increasing capillarity toward the inner side edge portion thereof which is in communciation with the feed element and since the passages in the feed element have greater capillarity than the cell, ink is drawn from the cell toward and into the feed element and is delivered thereby to the nib. Thus, even after long periods of nonuse, during which the pen may be maintained in inverted position, a continuous column of ink will extend from the cells to the nib and the pen will remain in condition for substantially instant writing. This cell construction also ensures substan-

tially complete withdrawal of ink from the cells since the ink is drawn from the outer portions of lesser capillarity toward the inner portions of greater capillarity and thence into the feed element. In addition, each cell is connected substantially throughout its length directly to the feed element which construction ensures that ink will be drawn directly from the cells into the feed element throughout the principal portion of the length of the feed element. This contributes toward certainty of feed and substantially complete withdrawal of the ink from the cells. Moreover, there is substantially no possibility of air locks in the cells such as might otherwise prevent substantially complete withdrawal of ink and thus reduce the effective capacity of the pen.

Air to replace ink which is withdrawn in writing enters the pen through the air port 115, the nib pierce 110 and the air passage 131. From the air passage 131 air is drawn into the cells at the rear ends thereof and also by way of the annular air passages 139. Thus, ink is fed to the nib under capillary control at all times and the pen is not subject to any blocking of the flow by reason of a decrease in the air pressure within the pen.

In one practical embodiment of the invention comprising a fountain pen as illustrated in Figs. 11 to 15 of the drawings 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″ with its forward end extending to the nib pierce and approximately $\frac{1}{2}$″ from the writing end of the nib. The filler element was composed of 83 fins each 0.001″ thick and approximately 0.120″ wide. The overall diameter of the capillary filler element was approximately 0.320″ and the central space was approximately 0.080″ in diameter; the width of the air vent at its outer portion was approximately 0.070″. The fins of the longest series were approximately 2″ in length, the fins of the intermediate series were approximately 1.40″ in length and the fins of the shortest series were approximately 1.05″ in length. There were 20 fins of the longest series, 21 fins of the intermediate series and 42 fins of the shortest series. The capillary cells in the forward section of the capillary filler element each had an outer cell thickness of approximately 0.044″ and an inner cell thickness of approximately 0.011″; the cells in the intermediate section of the filler element had an outer cell thickness of approximately 0.021″ and and inner cell thickness of approximately 0.005″. The capillary cells in the rearmost section of the capillary filler element had an outer cell thickness of approximately 0.010″ and an inner cell thickness of approximately 0.002″ The pen had a refill capacity of approximately 1.4 grams of ink, that is, upon repeated filling and writing out, the pen upon each refilling operation took in approximately 1.4 grams of ink.

It will be understood that the present invention is not limited to the dimensions above stated and it will be understood that variations may be made in the dimensions given without departing from the scope of the invention as defined by the appended claims.

In certain cases it may be found preferable, instead of forming the capillary filler element from a plurality of fins of different lengths, as above described, to form it in a plurality of separate but abutting sections in each of which there are a different number of fins providing a different number of capillary cells of corresponding different capillarity. That is to say, the several sections forming such capillary filler element define cells of different capillarities the cells in the rearwardmost section being the most numerous and of the greatest capillarity and the cells in the forwardmost section being the fewest and having the least capillarity and the cells in the intermediate section or sections having intermediate capillarities progressively increasing from the forward end toward the rearward end of the pen.

A pen embodying the foregoing type of capillary filler element is illustrated in Figs. 21 to 24 of the drawings, to which reference now is made. The pen may embody any suitable type of casing or body but preferably the body includes a main or central section 140, a forward section 141, preferably tapering toward its forward end, an intermediate section 142, and a rear section 143; all of the sections preferably are connected by threaded joints, as illustrated. A friction ring 143*a* may be provided if desired at the juncture of the central and forward sections for co-operation with a slip cap of known construction. The central and forward sections of the pen body are of generally hollow form and together define a chamber 144 adapted to receive either a capillary filler element or a cartridge structure of the type hereinafter described in detail and including a capillary filler element and feed.

The forward end of the forward body section 141 is provided with a bore 145 which extends through the forward end of the pen body and is adapted to receive a writing element which preferably takes the form of a pen nib 146. The pen nib may be of known form and includes a split cylindrical body portion 147 and a tapered

writing end portion 148 provided with a pierce 149 and a slit 150. For the purpose of permitting flexing of the writing end of the pen nib and for maintaining a body of ink adjacent the nib pierce and slit, whereby the same are always maintained filled with ink and in condition for instant writing, a slight space 151 of capillary thickness is provided above the pen nib. This space may be provided by forming a counterbore 152 in the forward end of the pen which counterbore is of slightly greater diameter than the pen nib.

A capillary filler element is disposed in the chamber 144, which filler element is constituted by a plurality of sections 155, 156 and 157. While three such sections are shown in the present application it will be understood that any suitable number might be provided and that the capillary filler element may consist of two, three or more sections as desired. Each of the sections of the capillary filler element is formed preferably in a manner generally similar to the capillary filler element 125 except that the fins in any one section are of the same length and therefore all of the cells in any section are the same. That is, the fins 158 forming the section 155 are all of the same length. In a similar manner the fins 160 forming the section 157 are all of the same length although preferably they are of a different length from the fins 158.

A feed element 161, which may be generally similar to the feed element 130 shown in Fig. 10 of the drawings, extends centrally of the several sections 155, 156 and 157 of the capillary filler element. Preferably the feed element 161 is formed as a single element extending substantially throughout the length of the entire capillary filler element and has a forward portion 162 which extends to abut with the pen nib adjacent the slit 150.

For the purpose of retaining the several sections of the capillary filler element and the feed element in assembled relation I preferably provide an inner or cartridge casing member 163 formed of suitable material such as a plastic or thin metal, and preferably the latter. The cartridge casing 163 is shaped and dimensioned to snugly receive the several sections of the capillary filler element and to fit snugly within the pen body. Accordingly, the cartridge casing 163 may be tapered at its forward end but preferably it is formed with a plurality of cylindrical sections 164 and 165 of progressively decreasing diameters, suitably dimensioned so that they fit within the tapered forward body section 141. The sections 164 and 165 are of cylindrical rather than tapered form thereby permitting the use of capillary filler sections of cylindrical shape which as will be understood are somewhat easier to manufacture than sections of tapered form. The several sections 155, 156 and 157 are made to fit snugly in the corresponding sections of the cartridge casing and thus are held in proper position. In order to ensure that the capillary cells in each of the sections of the filler element are maintained in communication with the cells of the next adjacent section, the sections are held so as to abut firmly. This is ensured by making the sections 155 and 156 of slightly greater length than the corresponding portions of the casing so that these sections project rearwardly from such portions.

The cartridge casing 163 is provided with a forward, generally cylindrical extension 166 of reduced diameter adapted to extend through the cylindrical nib 146 which extension serves to confine the portion of the feed element 161 which extends beyond the forward end of the capillary filler element and at the same time to retain the forward portion 162 of the feed element in contact with the under side of the nib. The extension 166 is provided with a forward end wall 167 conforming generally to the contour of the pen body at this portion and which serves to confine the end 162 of the feed element. An opening 168*a* is provided in the upper wall portion of the extension 166 at the forward end thereof which permits the forward portion 162 of the feed element 161 to abut the underside of the pen nib 146.

The cartridge casing 163 is provided with an inwardly projecting, grooved portion or bead 168 which extends preferably throughout the length of the casing 163. The bead 168 thus provides between the casing 163 and the adjacent portion of the pen body a passage 169 which extends forwardly to an air port 170 and which extends rearwardly to the end of the cartridge. The passage 169 thereby constitutes an air vent passage which is in communication with the exterior of the pen through the port 170 and is in communication with the rear ends of the capillary cells defined by the capillary filler element through the space 171 rearwardly of the capillary filler element. Preferably a perforated plate or screen 172 extends across the rear end of the cartridge casing 163 for the purpose of retaining the capillary filler element in the casing and is suitably held in place, as by abutment of the end section 143. The screen is sufficiently open to permit air to pass freely therethrough between the rear ends of the capillary cells and the chamber 171.

Th bead 168 may be utilized to maintain the desired spacing between the endmost fins of each section of the capillary filler element to thereby provide an air vent

passage 173 which extends along each of the sections of the capillary filler element.

The section 165 of the inner casing 163 is provided with an end wall 174 formed with a plurality of openings 175 and the adjacent end wall of the chamber 144 in the forward body section is forwardly inclined to provide a space 176 which is in communication with the bore 145. A plurality, preferably two grooves 177 and 177*a* of U-shaped cross-section are formed in the walls of the bore 145 and extend from the space 176 to the end of the body; thus ink may enter the interior of the casing 163 through the forward end of the pen during filling.

In filling the pen the forward end of the pen is inserted in a supply of ink preferably of sufficient distance to immerse the end of the pen at least as far as the ends of the fins 158. Ink is drawn into the pen through the counterbore 152, the passage 177, the space 176 and the openings 175 and thence into the capillary filler element; ink also is drawn into the pen through the passage 177*a* above the nib 146 and into the space 176. Ink rises in the capillary spaces in a manner similarly to that described hereinbefore. Air which is in the capillary spaces at the beginning of the filling operation is expelled by the incoming ink and passes out of the capillary spaces through the screen 172, the chamber 171 and thence through the air vent passage 169 and out through the air port 170.

In writing, ink is drawn to the nib from the capillary spaces in a manner generally similar to that described in connection with the embodiment of the invention illustrated in Fig. 11 of the drawings. Air to replace ink which is withdrawn in writing is drawn into the pen through the air port 170 and passes to the capillary cells in a direction reverse to that in which air is expelled from the cells during filling.

Instead of forming the feed element 161 as a fibrous wick, as illustrated in Fig. 22 of the drawings, this may be formed as a solid bar as illustrated in Figs. 25 and 26. The feed element 178 may be formed of any suitable material but preferably is formed of a plastic such as "Lucite". This member preferably is formed with an elongated cylindrical body portion 179, adapted to extend substantially throughout the length of the capillary filler element, and a forward extension 180 which may be of slightly greater diameter than the body portion 179 and which is adapted to fit snugly in a forward tubular extension 166*a* of the inner casing 163*a* and an enlarged head 180*a* adapted to abut the forward end of the extension 166*a* to position the feed element 178 within the casing 163*a*. The feed element 178 is formed with a feed slot 181 preferably of capillary width, extending throughout its length and preferably at least two such slots are provided. The slots 181 provide capillary ink feed ducts which serve to deliver ink by capillary action from the capillary filler element to the nib in a manner generally equivalent to that in which the feed element 161 serves to feed ink to the nib as above described. The ink feed slots 181 extend at their forward ends to the underside of the nib and are in communication with all of the capillary cells by the provision of transverse feed slots 182 of capillary width which are arranged in a spaced series longitudinally of the feed element 178 and which extend circumferentially around the feed element 178 and intersect the longitudinally extending feed slots 181.

Referring now to the form of pen shown in Figs. 27 to 30, the barrel 183 is a hollow elongated tubular member and may be of any desired cross-sectional shape; however, in the embodiment shown the barrel is circular. The front end of the barrel is adapted to receive a conventional type of closure cap 184 provided with a clip 185. The cap may be secured to the barrel by means of threads 186 or by frictional engagement, as desired. The rear end of the barrel 183 is closed by a removable cap 187 which, in the embodiment shown, is secured thereto by threaded engagement with the threaded end 188 of a tubular member 189 which extends into the barrel 183 and is embraced by the inner wall of the barrel in close fitting frictional engagement therewith. Preferably, the barrel 183 is counterbored to receive the member 189 and the latter is of the same interior diameter as the normal diameter of the barrel.

The front end of the barrel 183 is provided with a removable sheath member 190 which engages the interior of the barrel in close fitting frictional engagement, the portion extending into the barrel being preferably of reduced diameter in order to avoid any offset between the exterior of the barrel 183 and the sheath 190. If desired, the sheath may be secured to the barrel by threaded engagement therewith. The member 190 functions as an extension of the barrel and as a guard for the writing nib 191. The nib 191 is of conventional type, being provided with a writing tip 192 and the usual ink slot (not shown) extending from the tip back a substantial distance toward the rear of the nib 191. The nib 191 is secured in close frictional engagement between the sheath 190 and the feed member 193. The feed member 193 is provided with conventional transverse slots 194 to form a suitable "comb" arrangement for holding any excess ink. The exterior of the feed member 193 is preferably

relieved as indicated at 195 to receive the rear portion of the writing nib 191. The sheath is offset at 196 in order to provide a guard portion 197 spaced from the nib 191. The feed member 193 engages the interior of the sheath 190 in close fitting frictional engagement.

The interior of the barrel 183 is filled with a large number of small tubes 198 which are longitudinally disposed within the barrel. These tubes 198 extend throughout the length of the ink chamber portion of the barrel 183, the tubes at their rear ends terminating adjacent a metallic screen guard 199 or other suitable perforated guard member, and the tubes 198 at their front ends terminate at a point adjacent the front end of the barrel 183, preferably just short of the sheath member 190. The tubes 198 are of an interior diameter such that each of them functions as a capillary longitudinal passage. The tubes 198 may be of glass, metal, plastic or any other suitable material.

The interior of the barrel 183 is provided with a tube 200, the rear end of which terminates beyond the outer side of the screen guard 199 and the front end of which opens into a passage 201 in the feed member 193, the passage 201 being provided with a vent 202. The tube 200 has an interior diameter which is sufficient that it will not materially function as a capillary passage. By means of this arrangement the pressure in the rear of the barrel 183 is always the same as the pressure in the front end of the barrel and such pressure equality is constantly maintained irrespective of sudden changes in temperature or atmospheric pressure.

Each of the tubes 198 should have an interior diameter such that when one end is dipped into a supply of ink a capillary action will result whereby the ink will flow into the tube and substantially completely fill it within a reasonably short interval of time. However, the diameter of the tubes should be sufficiently large to permit the flow of ink from the tubes when the pen is in use. With tubes of too small diameter most, or in some instances substantially all, of the ink will remain in the tubes as the capillary action may be so strong as to tend to "lock" the ink within the tubes.

In order to avoid possible "locking" of ink in the tubes, particularly because of air bubbles, and to ensure that substantially all of the ink will flow from the tubes 198 to the writing nib 191, there extends throughout the length of each tube 198 a small thread 203 of fibrous material. It is preferred to extend each length of thread from the front end of each tube 198 and converge them into a mass or bundle 204 which is carried in a suitable channel 205 provided in the upper side of the feed member 193 and extending along the under side of the writing nib 191 and terminating just short of the writing tip 192. By this arrangement the ink will flow along the fibres of the threads to the writing nib, the capillary action of the threads assuring that the flow will continue until the supply of ink in the tube 198 is substantially exhausted. The threads 203 may be made of any suitable fibre; however, I prefer to employ a non-absorptive type of fibre such as "Nylon", glass or the like.

Practice has demonstrated that satisfactory results have been obtained employing glass tubes having an interior diameter of from about 0.013 to 0.018 inches and a 40 fibre "Nylon" thread of about 40 denier.

In the embodiment shown, the threads 203 are longer than the minimum length necessary to extend throughout the length of the channel 205 of the feed member 193, whereby when the pen is in assembled condition, the extra length of the threads results in sufficient "bunching" of the threads, as shown at 206 of Fig. 27 to cause the threads to substantially fill the enlarged space between the ends of the tubes 198 and the channel 205, thus assuring sufficient capillary action to cause substantially all of the ink to flow from the tubes 198 into and through the channel 205.

It is to be understood that the longitudinal capillary passages in the barrel 183 may be formed by suitable means other than the tubes 198. For example, these capillary passages may be formed as shown in Fig. 31. In this particular embodiment the barrel is filled by a plurality of coaxial cylinders, each formed by rolling together two sheets of suitable material, such as plastic, thin metal or the like, one of the sheets having a smooth even surface and the other being transversely undulated or corrugated to form, in co-operation with the even surfaced sheet, the capillary passages 207. Each passage 207 is provided with a thread 203 which may be place in position during the rolling process.

Since a fountain pen built in accordance with my invention is inherently capable of adapting itself to sudden changes of atmospheric pressure, the caps 184 and 187 may engage the barrel 183 in an air tight manner, both of the caps 184 and 187 being ventless, whereby the interior of the pen is completely sealed. Thus, even though the pressure within the pen may be materially different from that of the surrounding atmosphere, upon either cap being removed, the pressure in the opposite end of the barrel will, by reason of the free communication provided by tube 200,

immediately change so as to be equal to that at the end from which the cap has been removed.

In operation of the pen hereinabove described, the rear cap 187 is removed and the rear end of the barrel is dipped into a supply of ink. Any air trapped in the open end 188 of tubular member 189 escapes through holes 208 as the end 188 enters the body of ink. The barrel is dipped into the ink to a sufficient depth to cause the ink to come into communication with the open rear ends of the tubes 198 whereupon the ink will flow upwardly into the tubes by capillary action. During the filling operation, it is desirable that the front cap 184 be removed. After the necessary time interval to permit the filling of the longitudinal ink passages, the cap 187 is restored and the pen is ready for use. The capillary action of the threads 203 is such as to assure a prompt and constant flow of ink from the longitudinal capillary ink passages in the barrel 183 to the writing nib 191.

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

1. A fountain pen including a pen body or housing having a reservoir section and a feed section with a writing element carried at one end of the pen body, a capillary filler and ink storage element in said reservoir section having walls defining an ink storage space of sufficient capillarity to draw ink thereinto by capillary attraction when the filler and ink storage element is placed in communication with a supply of ink and to retain ink therein by capillary attraction when the pen is not in use, characterised in that the ink storage space includes a plurality of substantially parallel elongated capillary passages or cells extending longitudinally substantially throughout the filler and ink storage element, each of said passages or cells embodying means extending longitudinally therealong which is of greater capillarity than the remainder of the passage or cell, for ensuring continuity of the body of ink in the passage or cell, and further characterised by ink feed means providing a capillary passage or passages of at least as great capillarity as said means extending longitudinally along said passages or cells for connecting said cells in capillary ink feeding relation to said writing element.

2. A fountain pen as claimed in Claim 1 in which said passages or cells are defined by walls which are closer together at one part of the cross section of said passages or cells so as to form said means of greater capillarity.

3. A fountain pen as claimed in Claims 1 or 2 in which said passages or cells are defined by radially arranged walls forming substantially wedge shaped passages or cells.

4. A fountain pen as claimed in either of claims 2 or 3 in which the inner edges of said walls are spaced apart by projections on alternate walls adapted to abut against adjacent walls.

5. A fountain pen as claimed in any of the preceding claims in which the portions of said cells or passages farther from the writing element are narrower and of greater capillarity than those nearer the writing element.

6. A fountain pen as claimed in Claim 5 including a larger number of narrower cells or passages at the end thereof farther from the writing element than at that nearer the writing element.

7. A fountain pen as claimed in Claim 6 in which said cells or passages are defined by partitions of varying length arranged alternately so that some of said partitions extend over only a part of the filler and ink storage element whilst others extend over substantially the whole of said element.

8. A fountain pen as claimed in any of Claims 5 to 7 in which the capillarity at any portion of the filler and ink storage element is approximately proportional to the distance of such portion from the writing element.

9. A fountain pen as claimed in any of Claims 5 to 8 in which the filler and ink storage element comprises a number of separately formed sections of different capillarity, the sections being of increasing capillarity the farther they are from the writing element.

10. A fountain pen as claimed in any of the preceding claims in which a longitudinally extending space is provided substantially centrally of said filler and storage element with which all of said cells or passages communicate.

11. A fountain pen as claimed in Claim 10 in which all of said cells or passages are open along their inner edges so as to communicate with said longitudinally extending space.

12. A fountain pen as claimed in Claims 10 or 11 including a wick-like feed element disposed in said longitudinally extending space and serving to connect said cells or passages in ink feeding relation to said writing element.

13. A fountain pen as claimed in Claim 10 or 11 including a rigid feed bar having one or more capillary passages therein disposed in said longitudinally extending space and serving to connect said cells or passages in ink feeding relation to said writing

element.

14. A fountain pen as claimed in any of the preceding claims in which said passages or cells are open at both their ends, the front ends being connected in ink feeding relationship to the writing element and the rear ends being connected to an air vent so as to maintain substantially atmospheric pressure in the interior of the pen.

15. A fountain pen as claimed in any of the preceding claims including an air vent chamber at the rear end thereof and an air outlet port adjacent the writing end thereof, a vent passage being provided which connects said chamber and said port.

16. A fountain pen as claimed in Claim 15 in which two or more vent passages are provided said passages being located at the exterior of said cells or passages adjacent the wall of the pen body.

17. A fountain pen as claimed in Claim 15 in which said vent passage comprises a wedge shaped passage formed between two of said cells or passages.

18. A fountain pen as claimed in any of Claims 15 to 17 in which said cells or passages have openings in their walls to provide communication with the air vent passage at points spaced along said passage.

19. A fountain pen as claimed in any of the preceding claims in which openings are provided in the walls of said cells or passages to provide communication between adjacent cells or passages.

20. A fountain pen as claimed in Claim 12 including a shoe like member adapted substantially to close the end of the pen and serving to retain said wick like feed element in ink feeding relation with the writing element.

21. A fountain pen as claimed in any of the preceding claims having a nib with a capillary slit therein the capillary passage or passages of said feed element being in ink feeding relationship with said capillary slit.

22. A fountain pen as claimed in any of the preceding claims in which the filler and storage element and the feed means are housed in a casing and are removable therewith as a unit from the pen body.

23. A fountain pen as claimed in Claim 22 in which said pen body and said casing are each provided with a filling opening at their front ends serving to admit ink when the front end of the pen is inserted into a supply of ink.

24. A fountain pen as claimed in any of the preceding claims including a tube of larger than capillary size which communicates at one end with the interior of the pen body and at the other end with the exterior of the pen body.

25. A fountain pen as claimed in any of the preceding claims in which the filler and ink storage element is formed by a plurality of thin strips of material each having a marginal portion bent over and secured together in spaced relationship to each other to form a web of said strips defining a plurality of capillary cells or passages.

26. A fountain pen as claimed in Claim 1 in which said cells or passages are formed by a plurality of elongated capillary tubes.

27. A fountain pen as claimed in Claim 26 in which each of said tubes has a wick-like feed element extending therethrough of greater capillarity than the remainder of the tube.

28. A fountain pen as claimed in Claim 27 in which the ends of said wick-like feed elements are brought together into a single feed element in feeding relation with the writing element.

29. A fountain pen as claimed in Claim 1 in which said cells or passages are formed by a plurality of coaxially arranged cylinders corrugated so as to form said cells or passages, a wick-like feed element being disposed in each of said cells or passages.

30. A fountain pen substantially as described or as shown in the accompanying drawings.

Dated this 27th day of November, 1947.

For the Applicant,
FRANK B. DEHN & CO.,
Chartered Patent Agents,
Kingsway House, 103, Kingsway,
London, W.C.2.

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Fig. 1

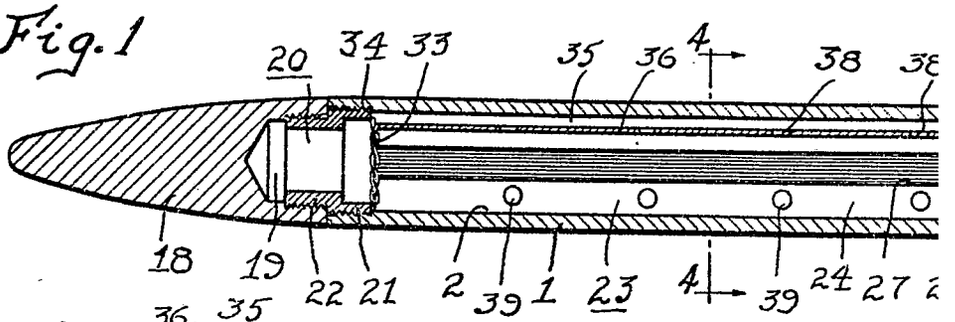
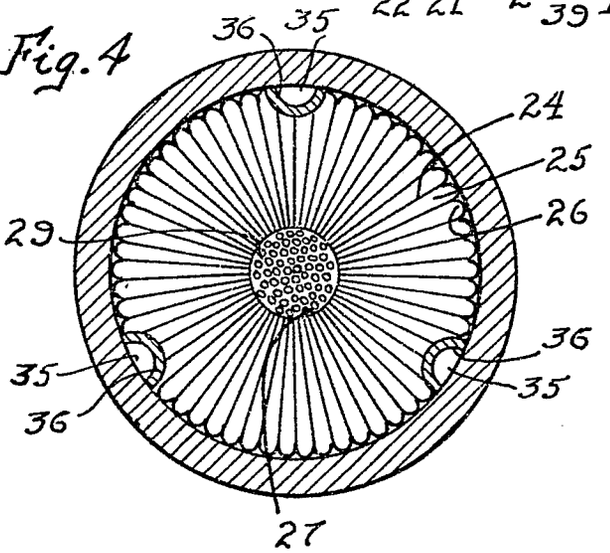


Fig. 4



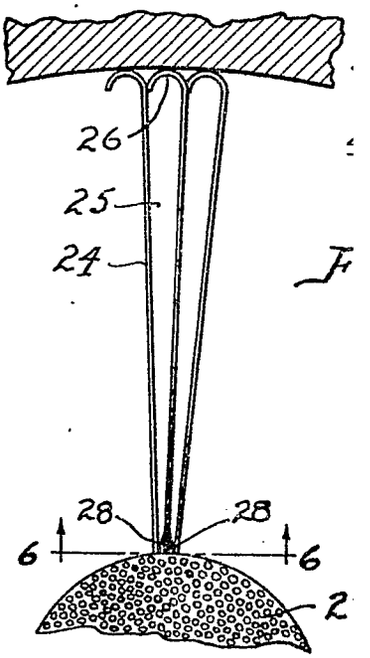


Fig. 5

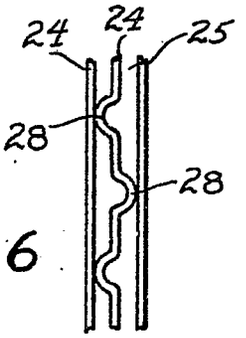
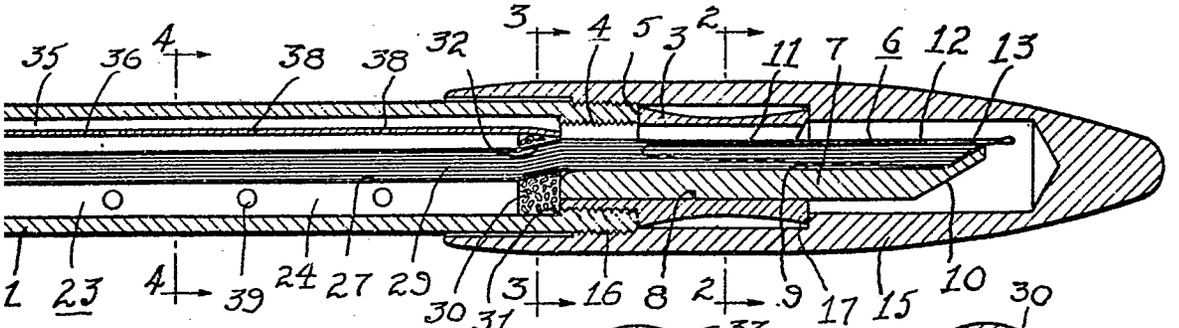


Fig. 6



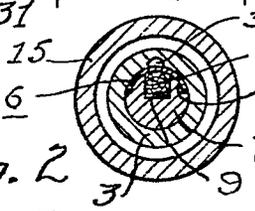


Fig. 2

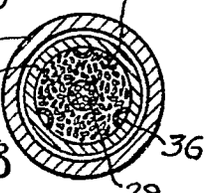
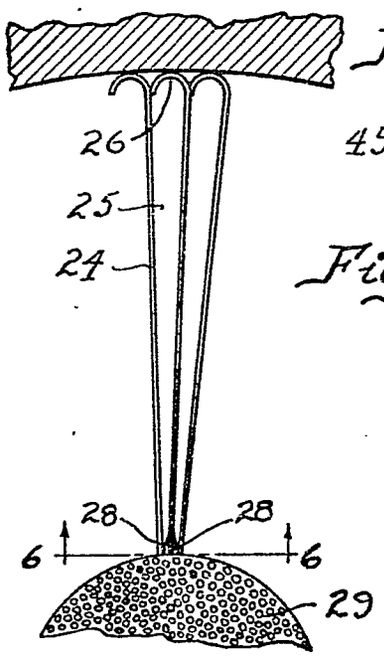


Fig. 3



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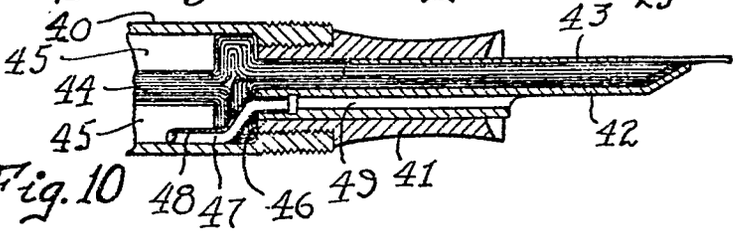

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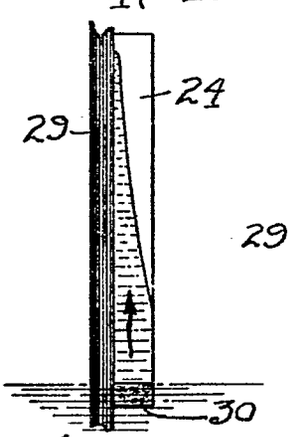

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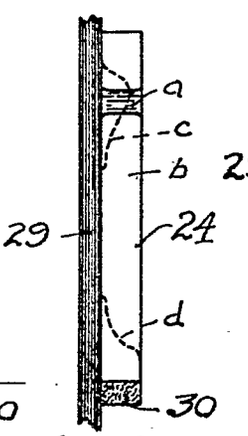

Fig. 8

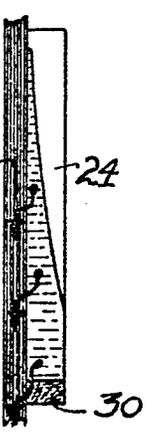

Fig. 9

642,437 COMPLETE SPECIFICATION

5 SHEETS
SHEET 1

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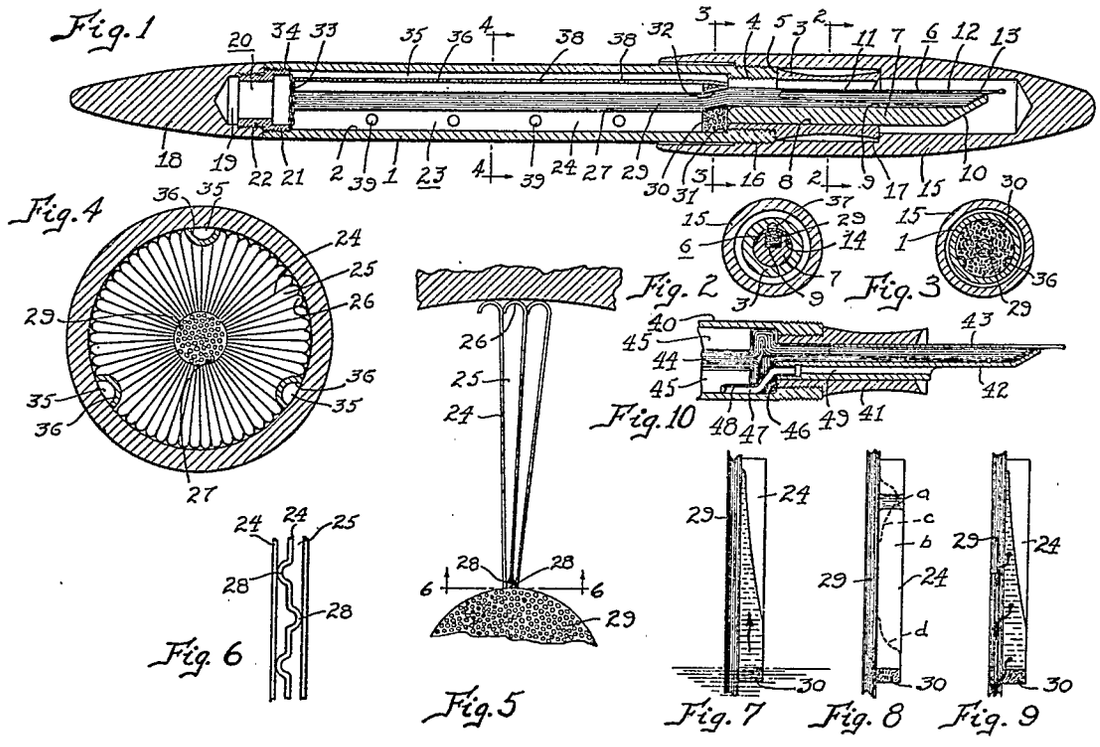

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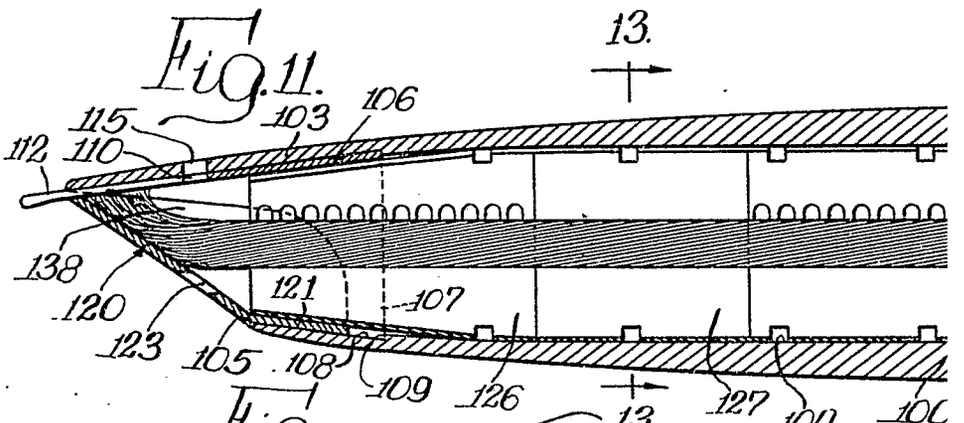
Fig. 11.



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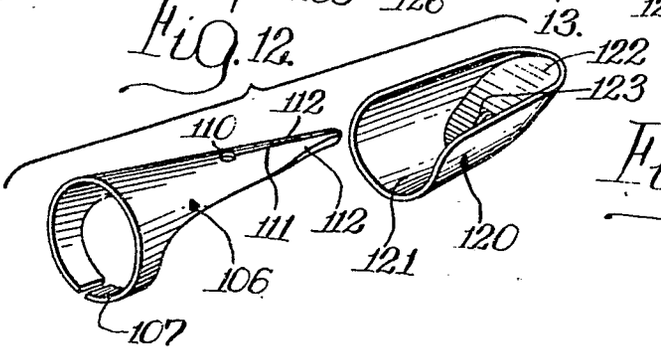


Fig. 13.

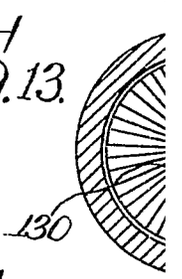
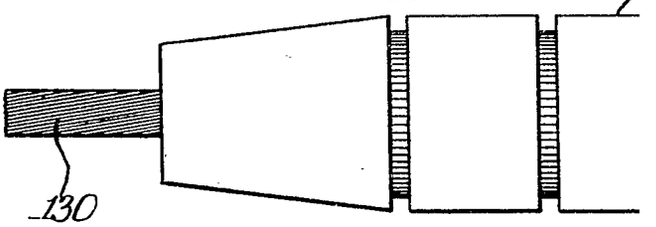


Fig. 15.



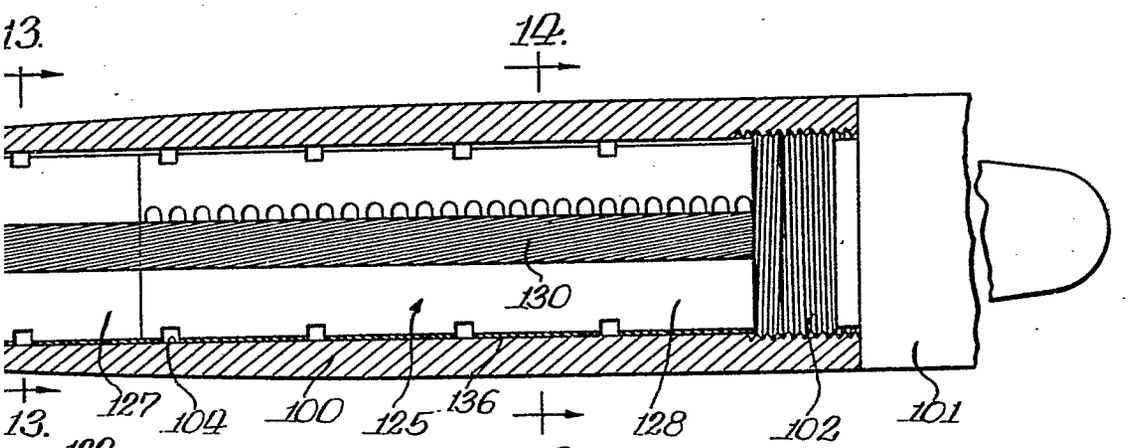
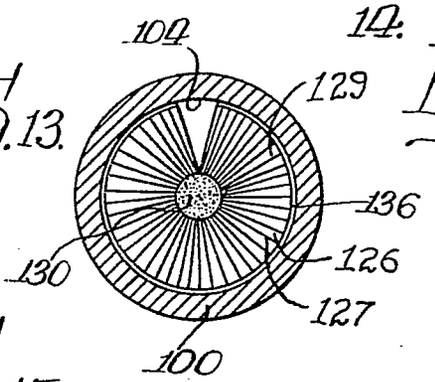


Fig. 13.



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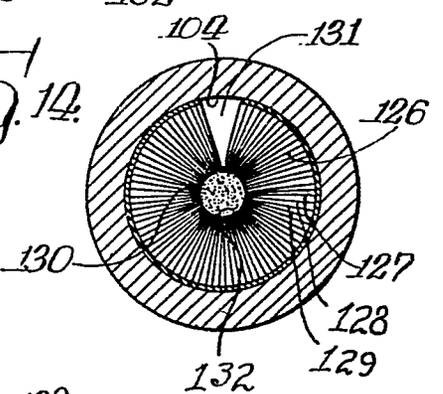

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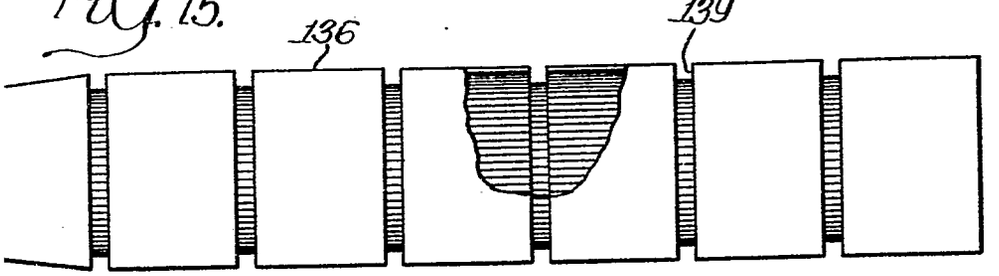

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5 SHEETS
SHEET 2

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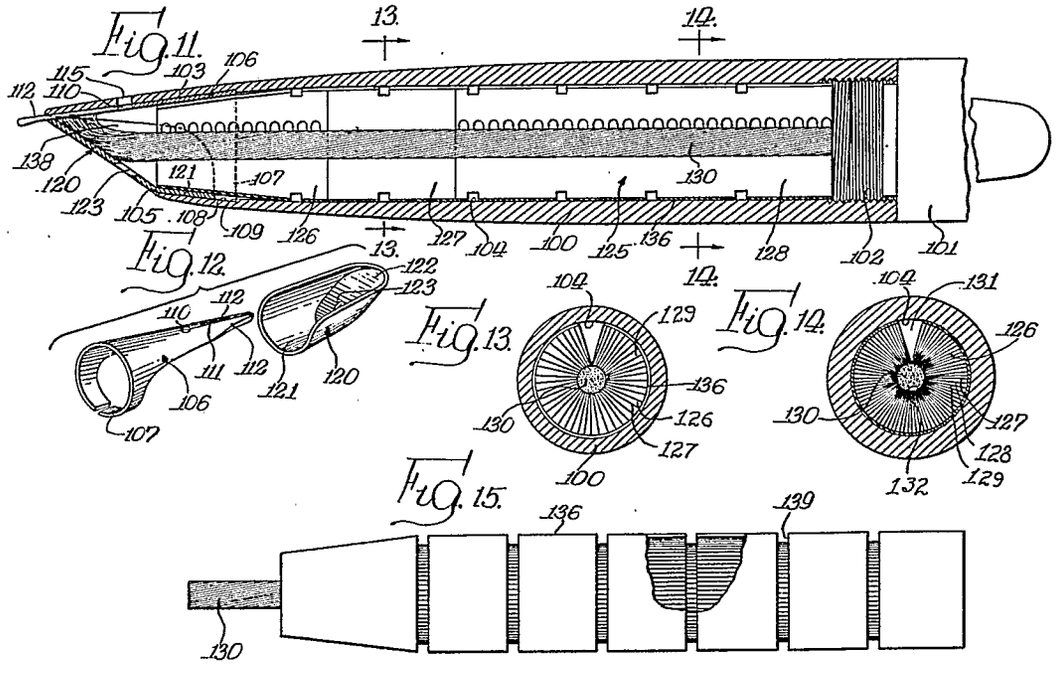

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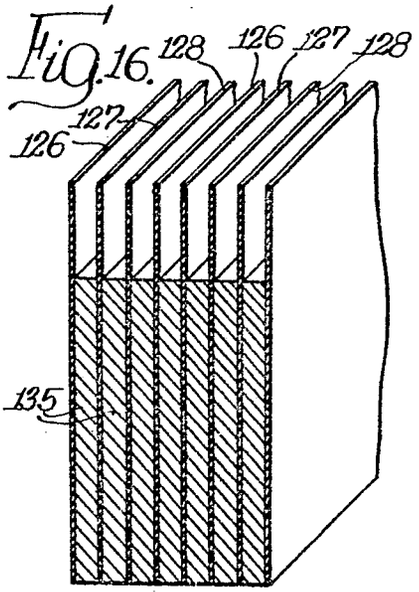
Fig. 16.



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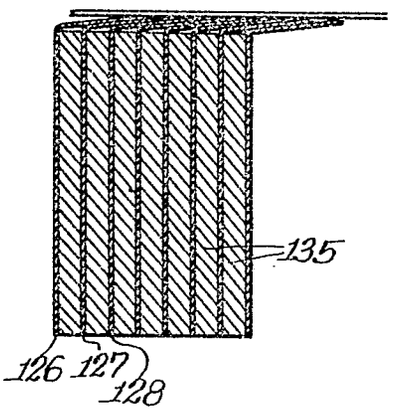

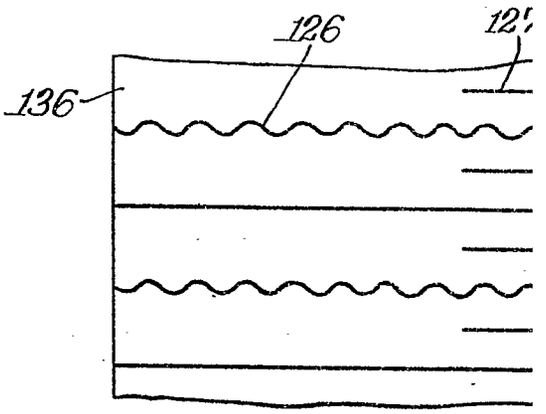

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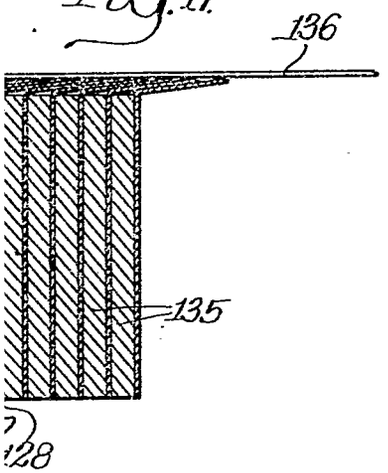

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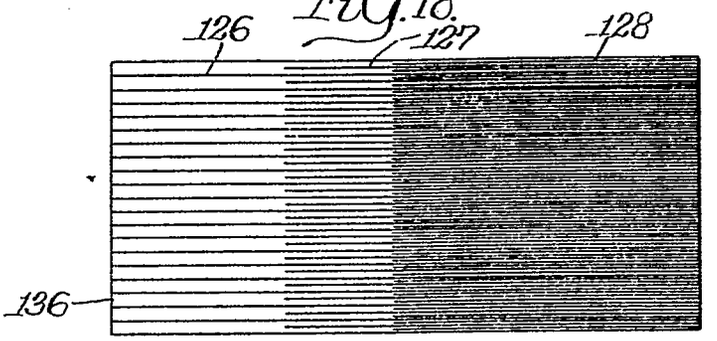

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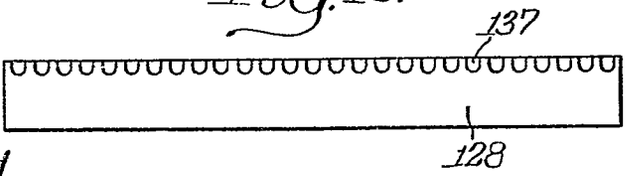
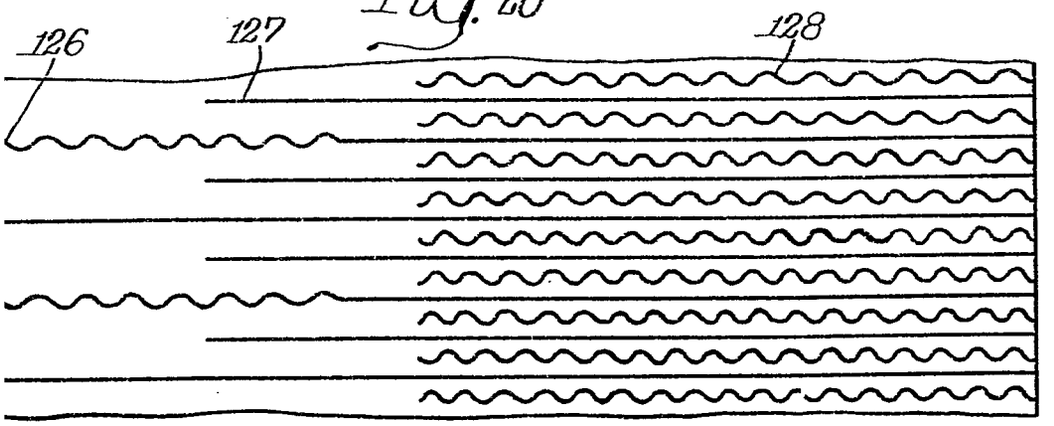


Fig. 20.



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5 SHEETS
SHEET 3

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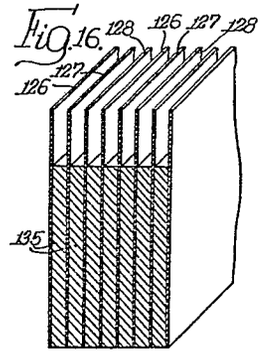
Fig. 16.



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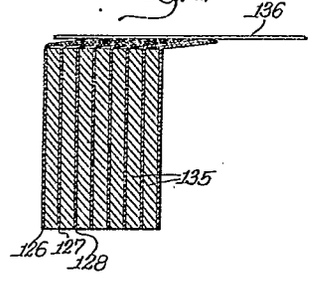

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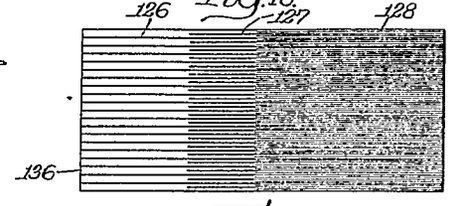

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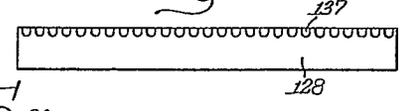

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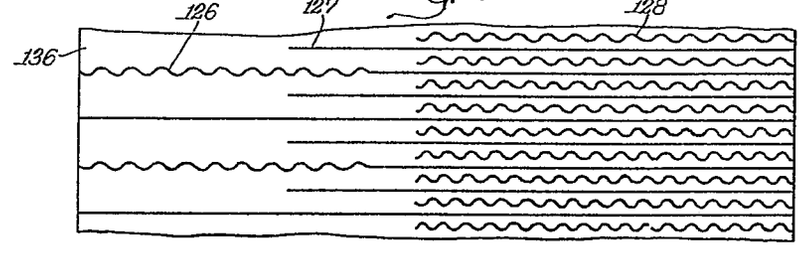

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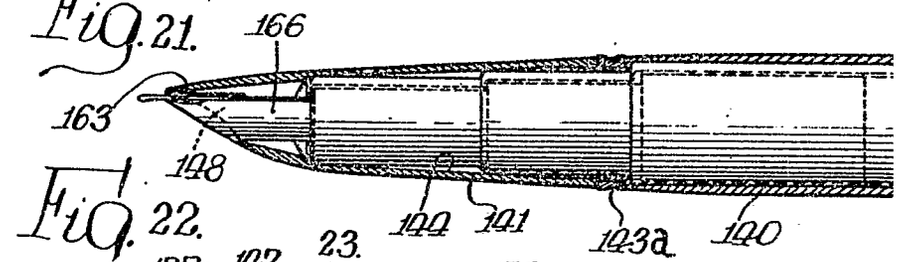
Fig. 21.



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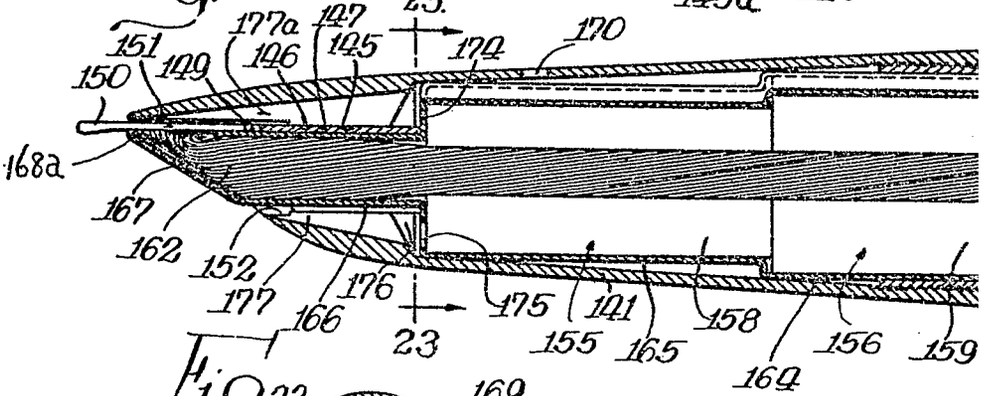

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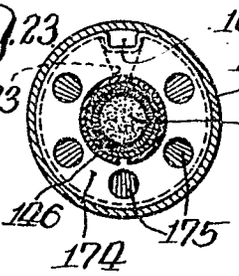

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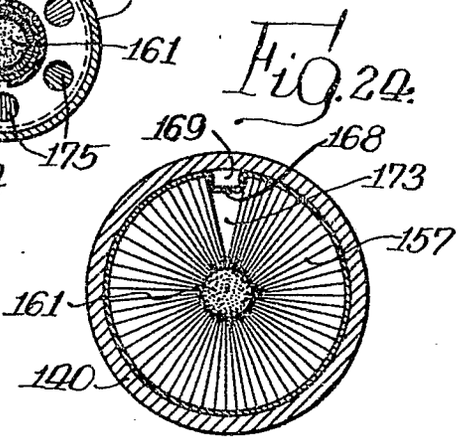

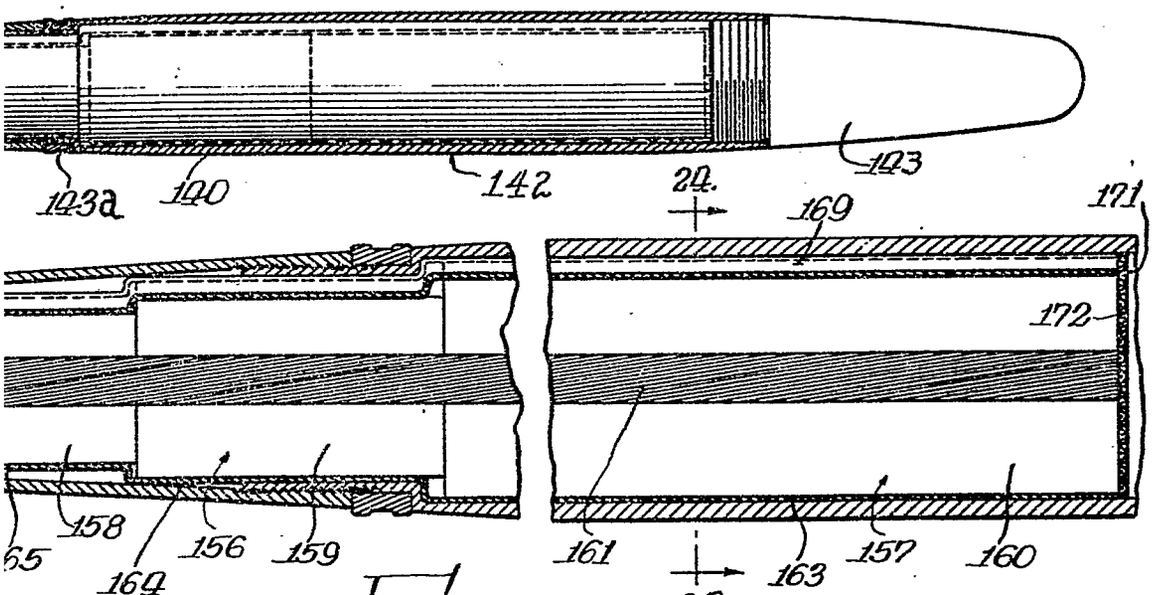
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Fig. 25.

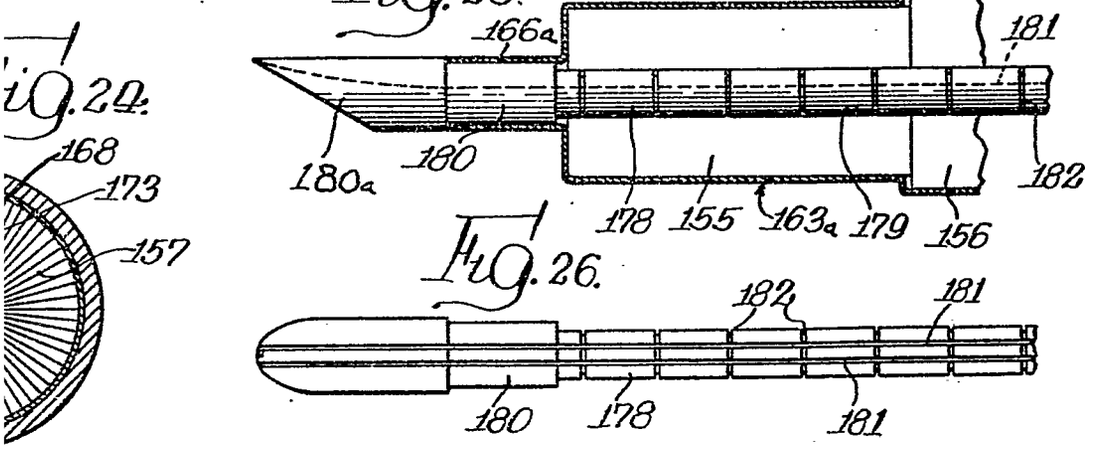
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Fig. 26.

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5 SHEETS
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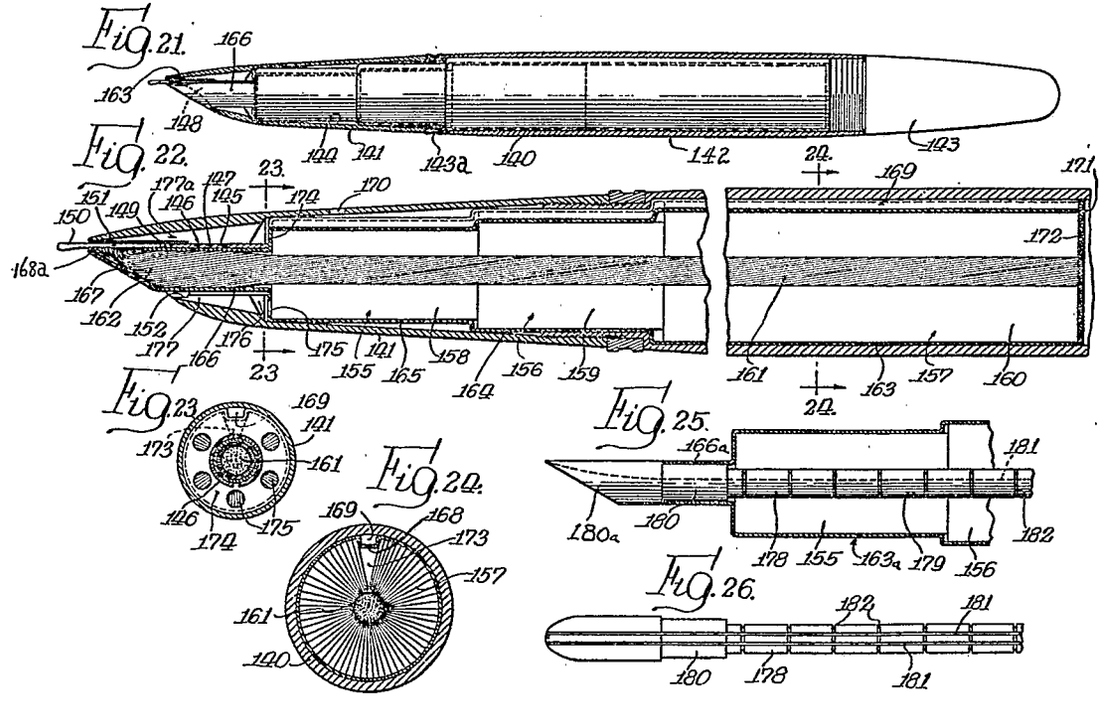

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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 27.

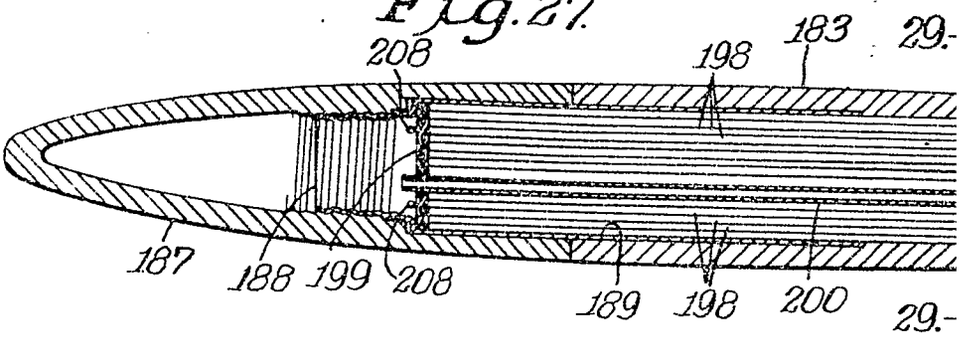
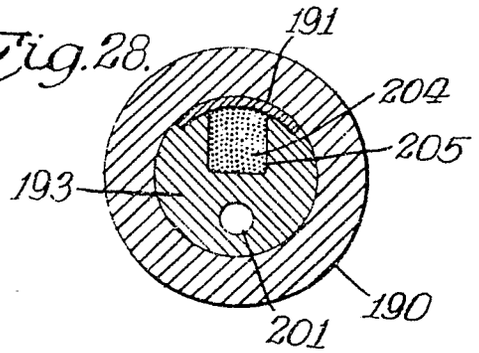


Fig. 28.



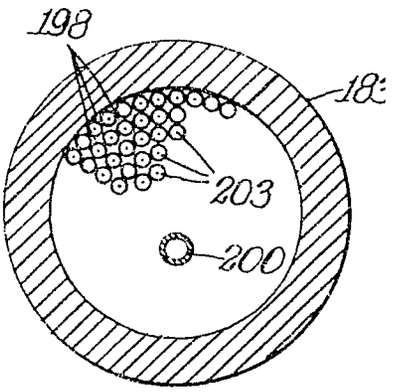


Fig. 29.

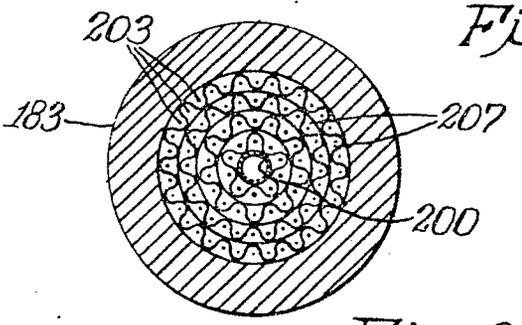
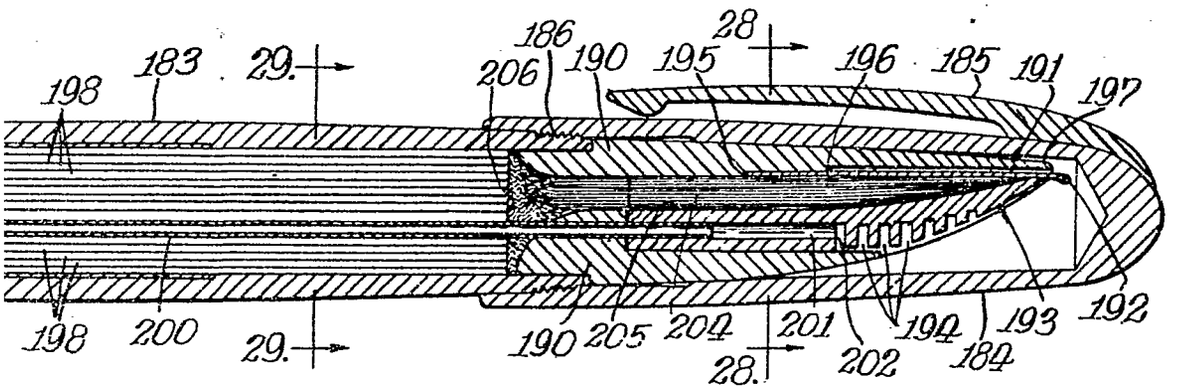


Fig. 31.



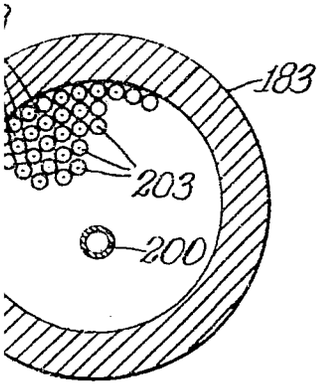


Fig. 29.

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7.31.

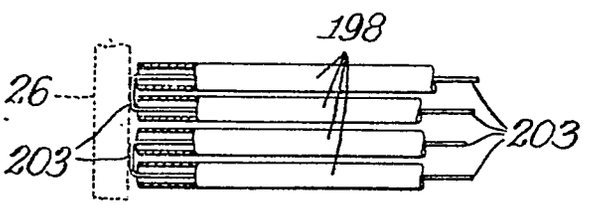


Fig. 30.

Fig.27.

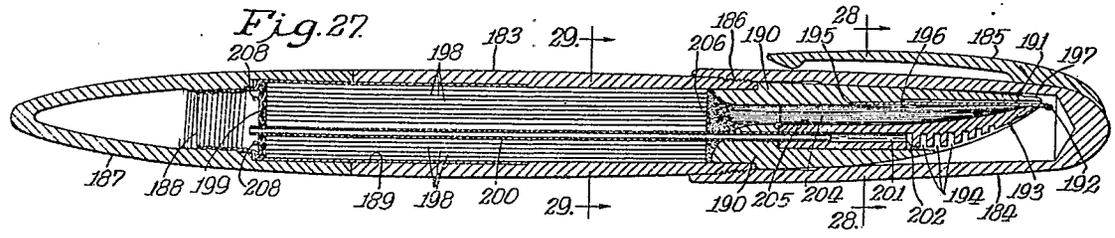
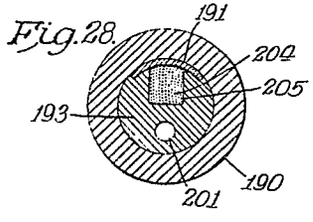


Fig.28.



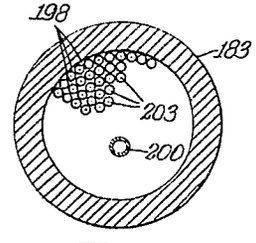


Fig.29.

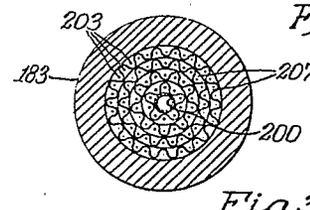


Fig.31.

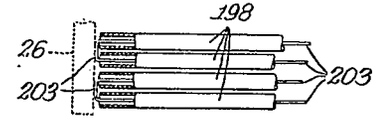


Fig.30.

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