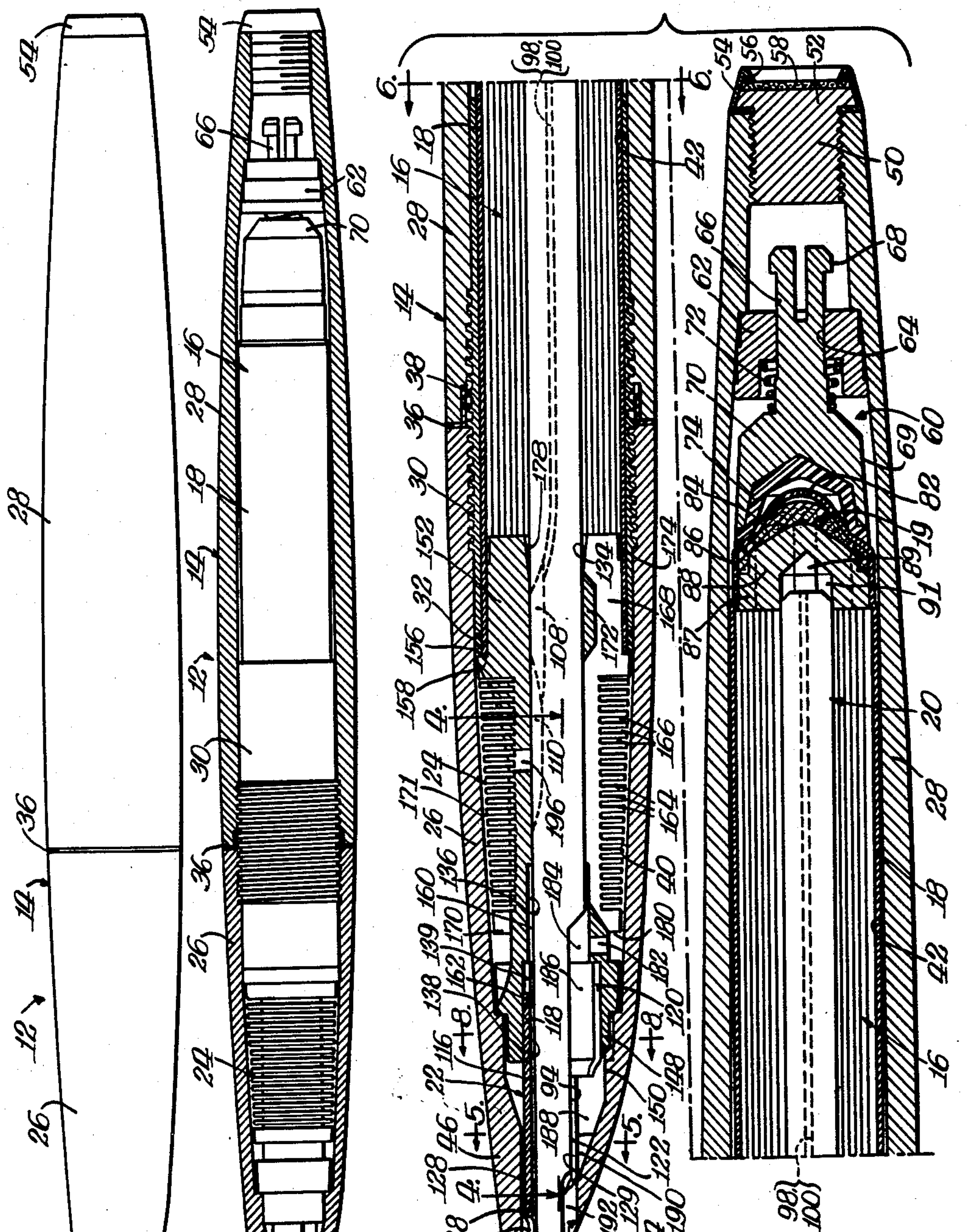
May 3, 1960 F. R. WITTNEBERT ET AL 2,935,044

FOUNTAIN PEN

Original Filed Oct. 24, 1955 4 Sheets-Sheet 1



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Original Filed Oct. 24, 1955 4 Sheets-Sheet 2

Fig. 4.

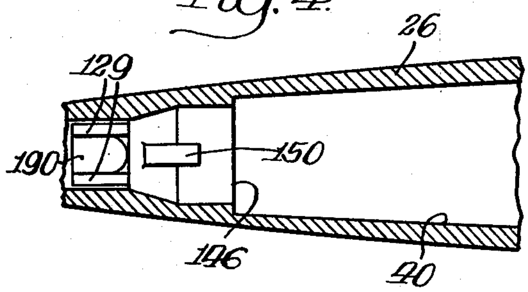


Fig. 5.

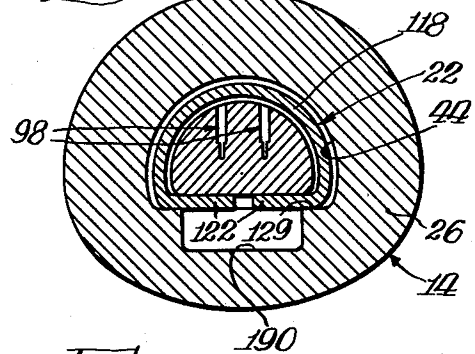


Fig. 7.

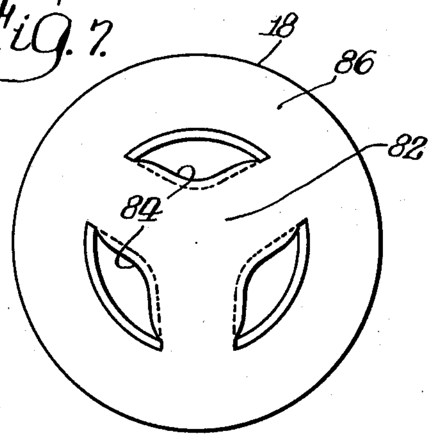
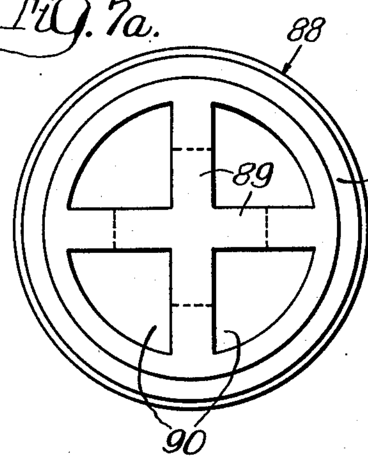


Fig. 7a.



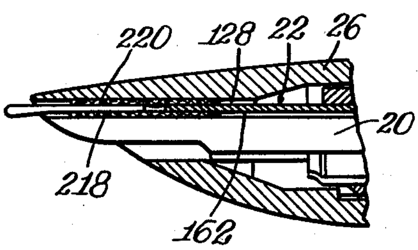


Fig. 25.

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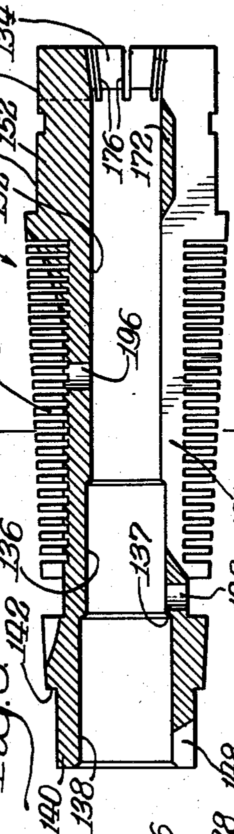

Fig. 9.

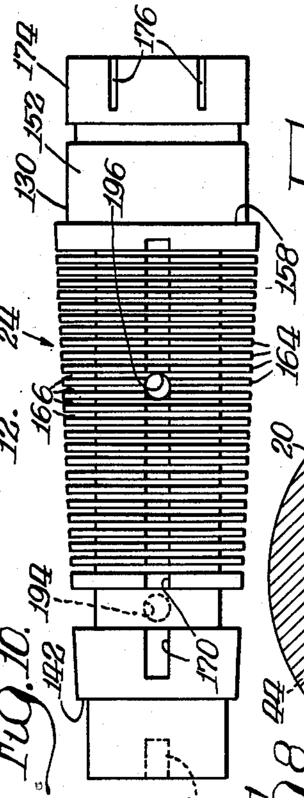

Fig. 10.

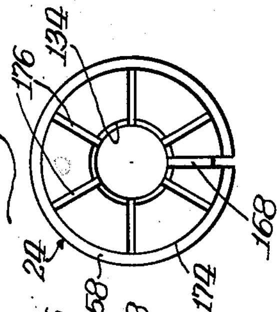

Fig. 11.

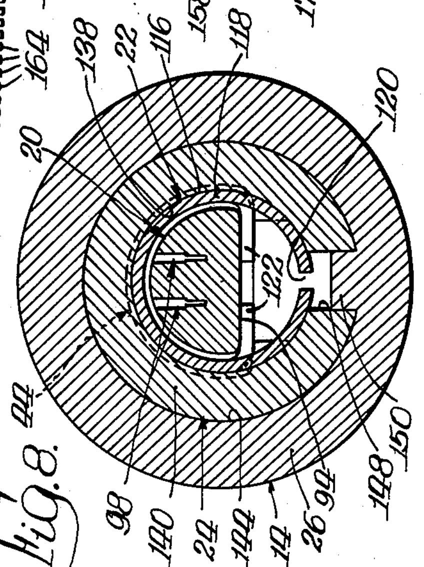

Fig. 8.

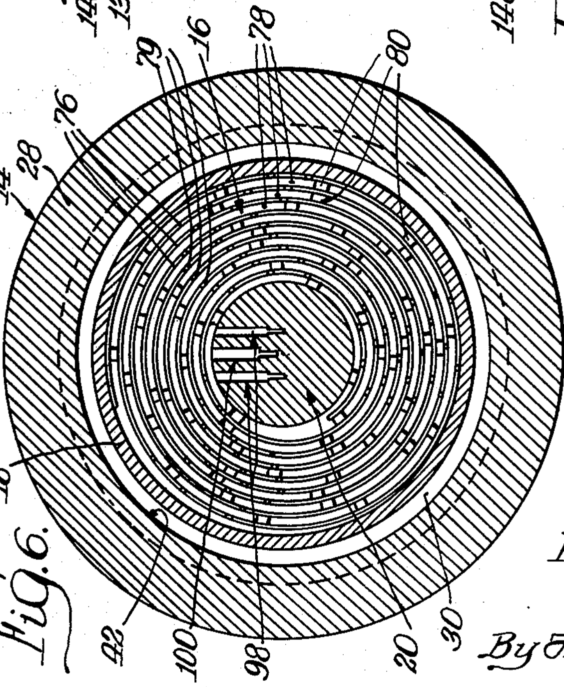

Fig. 6.

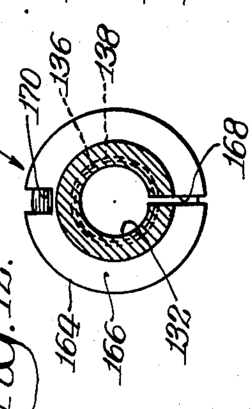

Fig. 12.

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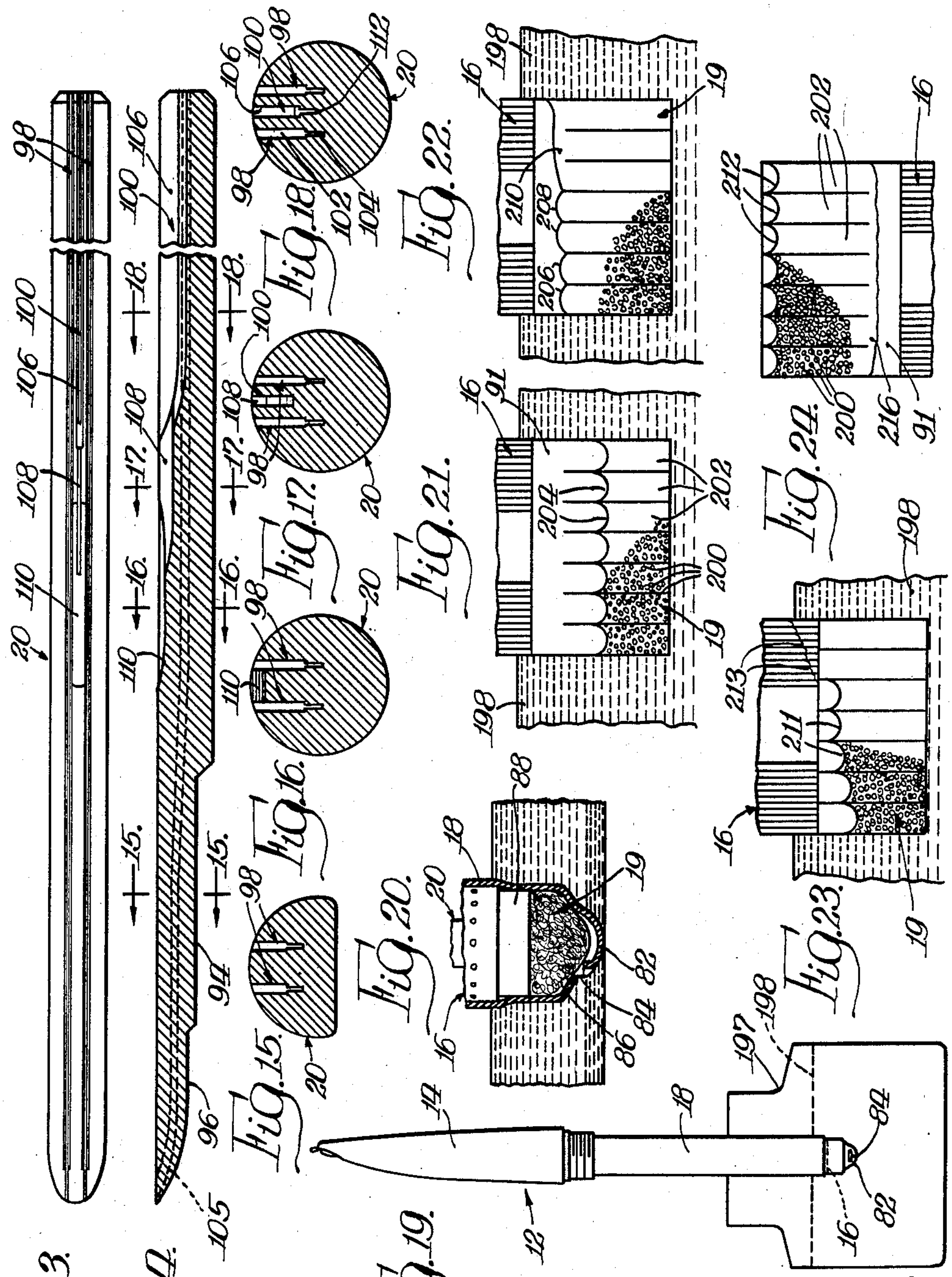

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United States Patent Office

2,935,044

Patented May 3, 1960

2,935,044

FOUNTAIN PEN

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Continuation of application Serial No. 542,224, October 24, 1955. This application January 15, 1959, Serial No. 787,321

7 Claims. (Cl. 120—50)

This application is a continuation of application Serial No. 542,224, filed October 24, 1955, now abandoned.

The present invention relates to a fountain pen.

The invention is directed to a fountain pen of basically new concept including desirable features of a capillary pen and a vacuum-reservoir pen.

A broad object of the invention is to provide a fountain pen having the characteristics with respect to filling of a capillary pen, and with respect to feed control the desirable characteristics of a vacuum-reservoir pen.

A capillary pen as heretofore known is a pen that fills solely by capillary action, retains the ink in the pen by capillary action until it is written out through the writing element or nib which is also by capillary action. The ink is retained or held by capillary means which includes a main reservoir portion and a feed portion of substantially lesser capacity than the reservoir portion leading from the latter to the nib. The feed means also serves as a reservoir means, to the extent of its capacity, but that is not its primary purpose. The capillary means constitutes the sole means for filling the pen and storing ink therein. It fills merely upon inserting an end of the capillary means, either the reservoir portion or feed portion, in a body of ink. The ink is held therein normally in a stable or balanced condition by balanced forces acting thereon, including the capillary attraction of the capillary means, and gravity. When the writing element is applied to a surface as in writing, a greater capillary force is established, designedly, between the writing element and surface which destroys the balanced condition mentioned, and because of the greater capillarity so established, the ink is drawn out of the capillary means onto the writing surface. Such feed or drawing out of ink is free of the metering cycle effect of a vacuum-reservoir pen, but the feed gradually diminishes as the pen empties. The weight of the ink, or head pressure (i.e., gravity, as noted above) is a factor in the control of the ink; when the reservoir means is full, for example, the head of ink exerts a relatively great force and tends to cause the ink to pass or flow more freely out onto the writing surface, but as the ink is written out and the head lowers, the lesser head does not have the same force in causing the ink to flow out, and as a result there is a tendency for the capillarity of the capillary means to exert a relatively greater force and hold the ink back from being written out freely and uniformly through the writing element. The result would be for the line formed to be progressively fainter, and the flow of ink not to terminate abruptly. This condition has been greatly overcome by providing graded capillarity in the capillary means, decreasing in direction toward the writing element, so that as the ink is progressively written out and the head lessens, the reduced head is compensated by the lesser capillarity progressively nearer the writing element, and constant and uniform flow of ink is assured until it is completely written out. However, the desired graded capillarity, although attainable to a high degree of perfection, requires great precision in manufacture,

and it is desired that the necessity for such precision be overcome, and it is overcome by this invention.

An object therefore of the invention is to provide a capillary-filling fountain pen in which more perfect flow of ink in the writing-out operation is attained, and more particularly that the ink flows freely and uniformly until the reservoir means is essentially emptied.

Another feature of the invention has to do with the feature whereby the pen fills by capillary action and the feed-out is under control of a vacuum-reservoir condition. The same capillary action that fills the pen tends to retain the ink in the pen after filling, and in order that the vacuum-reservoir condition be effective for the purpose intended the capillary action must be insufficient to hold the ink in the pen in writing notwithstanding the fact that it is effective for lifting the ink into it in filling. This arrangement can be brought about by changing the attitude of the pen with respect to the filling position and the writing position, i.e., in the filling position the capillary reservoir element is so disposed that it is capable of substantially filling by capillary action but in writing position it is so disposed that it is incapable of retaining ink therein.

It is therefore a further and more specific object to provide a pen of the general character noted having a capillary reservoir element and capillary feed means between the reservoir element and writing nib in which by inserting the rear end of the reservoir element in a body of ink it substantially fills, and when it is in writing position with its point end down the reservoir element is positioned above the feed means so that the reservoir element and feed means form a continuous capillary means and the capillary holding power of the reservoir element is insufficient to retain the ink at the height of the reservoir element and feed means combined.

Another object is to provide a capillary-filling pen having a novel construction including an overflow collector for receiving ink in excess of that required for writing.

A further object is to provide a fountain pen having an overflow collector of substantial capacity for receiving ink in excess of that required for writing purposes, in which any ink that may be in the collector is drained back into the reservoir in response to the pen being turned to point-end-up position.

Another object is to provide a fountain pen with provision for drain-back of the collector, of the character just noted in which because of the drain-back, possibility of leakage of the pen is greatly reduced.

Still another object is to provide a fountain pen that fills by capillary action and has removable means for closing the reservoir for enabling a vaccum condition to be produced therein, in which novel valve means is provided which enables ink to pass therethrough in the filling operation but forms at least a temporary closure for producing a vaccum condition in the reservoir immediately after filling and when the pen is reinverted to point-end-down position, and until the removable closure means is applied to the pen.

Another object is to provide a capillary-filling fountain pen that is highly resistant to leakage due to jarring.

A further feature of the invention has to do with a phenomenon of capillary means with respect to its capillary holding power. The capillary reservoir element of an ordinary capillary pen is constantly exposed to air (to whatever extent it is not filled) and is under attack by the impurities in the air which eventually may impair its capillary qualities, with consequent relaxation of the holding power thereof. Such a condition is not necessarily related to defect in the device, but the result of deterioration from age as in the case of any device. In such event and when the pen is jarred, the liability to leakage is increased.

Another object therefore is to provide a pen in which the advantages of capillary filling are attained while a closed reservoir and vacuum-pressure condition is utilized in holding the ink in the reservoir whereby to insure against leakage of ink through loss of capillary holding power.

A still further object is to provide a fountain pen having a capillary reservoir element that fills by capillary action, and novel feed and control means including a capillary passage with an ink control weir therein and an extension of the passage into the capillary reservoir element arranged so that the weir senses the head of the ink in the extension of the passage, the arrangement being such that the ink in the passage assumes substantially the same head as in the reservoir element with the advantage that the reservoir element with its vast number of ink storage spaces, as it must have, need not be constructed with precision in order to produce good flow control since the accuracy required may be provided in the feed passage which can be done with facility.

Another object is to provide a fountain pen having a capillary reservoir element and feed means interconnecting the reservoir element and a writing nib, in which a novel arrangement is provided for efficiently feeding ink from the reservoir element to the feed means.

A further object is to provide a pen utilizing vacuum-reservoir condition for controlling flow of ink to the nib, in which irregular line intensity through a breathing cycle, as has heretofore occurred, is substantially reduced.

Another object is to provide novel means for capillary transfer of ink to the writing nib including a capillary resilient pad associated with or on the nib, eliminating necessity for precision in manufacturing certain parts of the pen.

A further object is to provide a novel mechanical construction of pen capable of carrying out the broader objects set out above.

Other objects and advantages of the invention will appear from the following detail description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a side elevational view of a pen embodying our invention;

Fig. 2 is a view of the pen with the barrel shown in section and the internal elements in elevation;

Fig. 3 is a longitudinal sectional view of the pen, on an enlarged scale relative to Figs. 1 and 2;

Fig. 4 is a sectional view of a portion of the barrel as viewed on line 4—4 of Fig. 3;

Fig. 5 is a cross-sectional view, on an enlarged scale, taken on line 5—5 of Fig. 3;

Fig. 6 is a cross-sectional view, on an enlarged scale, taken on line 6—6 of Fig. 3;

Fig. 7 is an elevational view of the rear end of the reservoir casing;

Fig. 7*a* is an elevational view of the rear end of the filler valve plug;

Fig. 8 is a cross-sectional view, on an enlarged scale, taken on line 8—8 of Fig. 3;

Fig. 9 is a longitudinal vertical sectional view of the collector;

Fig. 10 is a plan view of the collector;

Fig. 11 is an end view of the collector as viewed from the right of Figs. 9 and 10;

Fig. 12 is a sectional view taken on line 12—12 of Fig. 9;

Fig. 13 is a plan view of the feed bar;

Fig. 14 is a longitudinal vertical sectional view of the feed bar;

Fig. 15 is a cross-sectional view taken on line 15—15 of Fig. 14;

Fig. 16 is a cross-sectional view taken on line 16—16 of Fig. 14;

Fig. 17 is a cross-sectional view taken on line 17—17 of Fig. 14;

Fig. 18 is a cross-sectional view taken on line 18—18 of Fig. 14;

Fig. 19 is a view illustrating the manner in which the pen is filled;

Fig. 20 is a large scale sectional view of a portion of the rear end of the reservoir casing showing the details of the structure of the casing and its relation to the filling operation;

Fig. 21 is a semi-diagrammatic view representing a certain step in the filling operation of the pen;

Fig. 22 is a view similar to Fig. 21 showing another step;

Fig. 23 is a semi-diagrammatic view representing a step in filling a modified form of reservoir element;

Fig. 24 is a semi-diagrammatic view representing a phase of capillary action in holding ink in the pen; and

Fig. 25 is a fragmentary view of the writing-tip portion of a pen showing a modified form of nib.

The pen embodying the principles of our invention is shown as a whole in Figs. 1, 2 and 3. The pen is shown without a cap, since it may be supplied with an ordinary cap for carrying in the pocket, or alternatively the pen may be designed for use as a desk set pen in which case the pen is inserted in a receptacle on the base of the set. In the present instance, the pen represented is of suitable proportions for use with a cap for carrying in the pocket. It may assume any external shape insofar as its relation to the internal elements are concerned, but from the standpoint of appearance it preferably assumes a long tapered or curved shape as best shown in Fig. 1. For convenience the writing-tip end may be referred to as the front or lower end, and the opposite end as the rear or upper end.

GENERAL

Reference is first made to the main parts of the pen and their general location relative to each other, each of which will be described in detail later. The pen includes a barrel **14**, a capillary reservoir element **16**, a casing **18** for the reservoir element, a feed bar **20** leading from the reservoir element to a nib **22** at the forward end of the barrel, and a collector **24** interposed generally between the reservoir element and the nib.

The various elements of structure making up the pen may be of any desired materials except as hereinafter specifically pointed out. Generally speaking, the materials unless so specifically referred to may be made of the usual plastics and metals heretofore in use in manufacturing fountain pens.

Barrel

The barrel **14** is made of two sections detachably secured together, one of the sections being readily removable from the other by the user for filling purposes. The two sections include a front section **26** and a rear section **28** secured together by suitable means such as a connector sleeve **30** externally threaded for engagement with cooperating internal threads on the respective barrel sections. The front section is sometimes popularly referred to as a shell and the rear section simply as the barrel. Preferably the front section **26** is semi-permanently secured to the connector sleeve by means of suitable cement of such character that the user may not readily detach the section from the sleeve but that a repairman may detach it under proper circumstances. The sleeve **30** extends into the front section and forms a shoulder **32** for cooperation with certain other elements in the assembled pen. A barrel band **36** of generally L shape cross-section surrounds the connector sleeve, with an axial portion engaging the sleeve and a radial portion engaged between the meeting and edge surfaces of the barrel sections. This barrel band, and particularly the radial portion thereof, serves as an abutment for engagement by the barrel sections and also to form a ring on the pen which imparts a decorative effect. The barrel band may be secured in place by suitable means such as by a cement or by a press fit. The forward open end of the rear barrel section has a counterbore 38 to receive the axial portion of the barrel band.

The barrel forms an internal chamber which includes a feed section 40 in the front end portion and a reservoir section 42 in the rear portion, the feed and reservoir sections not necessarily corresponding exactly to the barrel sections 26 and 28. The front barrel section 26 is provided with a reduced dimension bore 44 opening through its front end, and has a tapered hood portion 46 overlying a substantial portion of the nib and providing at least in its upper portion a cylindrical surface 48 cooperating with the nib. The underside of the barrel is brought back rearwardly in a steep taper resulting in an inclined end opening of the bore. The front section 26 of the barrel includes certain other internal configurations which will be described later in connection with the various internal elements in the pen.

The rear end of the barrel is finished with a decorative piece which may also serve to generally close the barrel, although the barrel is preferably vented, either through the rear end or elsewhere. This rear end closure piece includes a screw 50 threaded into the rear end of the barrel section and having a head 52 on its outer end which grips and clamps a trim piece 54 having a rear inturned flange 56 engaging a screen element 58, the latter serving as a decorative piece.

The rear barrel section 28 includes therein a sealing valve assembly 60 operative for closing and sealing the rear end of the reservoir casing 18 when the barrel section is applied to the front section. The assembly 60 includes a valve guide 62 which may suitably be tapered to conform with the taper of the inner surface of the barrel section and fitted in place in any suitable manner such as by a cement. The valve guide 62 has a bore 64 receiving a stem 66 of a valve plunger 69 the rear end of which is slotted and shaped to have an enlargement 68. The slot enables the end of the stem to be compressed for projection of the enlargement through the bore. The forward end of the stem is provided with a forwardly opening cup 70, and a compression spring 72 surrounds the stem between the element 62 and cup for biasing the plunger 69 in forward direction. Secured within the cup 70 is a resilient valve seat 74 which itself is cup-shaped for engaging the rear end extremity of the casing 18 and closing the latter when the barrel section is in place. The element 74 may be of desired material, such as a plastic, having suitable resilient and sealing characteristics, and which of course is not deleteriously affected by the ink used in the pen. This element may be secured in the cup 70 by any suitable means such as by a cement.

Reservoir element (and filler valve and casing)

The reservoir element 16 is of capillary nature, i.e., it fills by capillary action in response to an end of the element being inserted in a body of ink. The element is more exactly referred to as a "filler-and-reservoir" element because of its comprehensive nature in being capable of filling and holding ink by capillary action. For convenience herein, however, it will be referred to simply as a reservoir element. The element constitutes substantially the whole reservoir means for holding ink in the pen.

The reservoir element includes one or more sheets of thin material rolled in spiral fashion to form a plurality of radially spaced wall elements. These wall elements form between adjacent ones thereof ink storage spaces of capillary dimension, (e.g., .008" in wall-to-wall dimension, see below), which, due to the spiral-wrap construction, extend longitudinally of the element. Figs. 3 and 6 show to best advantage the detail construction of the reservoir element 16. The radially spaced wall elements 76 are spaced apart by projections 80, these wall elements forming capillary spaces 78. The wall elements are provided with apertures 79 interconnecting the spaces 78. The capillary spaces 78 are actually portions of a continuous space since the convolutions or wall elements form a spiral space, but for practical purposes they may be considered discrete spaces disposed relatively radially. A suitable reservoir element of the above general nature is disclosed and claimed in Bartell Patent No. 2,522,555, dated September 17, 1950.

The spiral reservoir element surrounds the feed bar 20, the latter extending rearwardly or upwardly throughout the length of the reservoir element as will be brought out in detail later in connection with the manner of feed of ink from the reservoir element to the nib.

The reservoir element 16 is encased in the casing 18 which for the greater portion of its length is cylindrical in shape, and which at its front end is secured to the collector 24. A filler valve 19 is positioned in the rear end of the casing and covered by the end element of the casing which includes a central dome portion 82 around the periphery of which are a plurality of filling apertures 84, there being also an internal shoulder 86 surrounding the dome portion. The end element is compressed or formed to "fin" shape. The shoulder forms a stop element for engagement by the filler valve 19 which also engages the dome portion and is exposed through the filling apertures. The filler valve is in the form of a slug, of generally cup-shape form, and is made of high-capillarity material—of greater capillarity than the reservoir element—preferably felt, but other material having the desired characteristics such as sponge, mesh, etc. may be utilized. The valve 19 of which the specific purpose will be explained presently, may be spaced from, or engage, the reservoir element 16. In the present instance the valve is spaced from the reservoir element, although it is not intended that the invention be limited to such spacing. Inwardly of the valve is a filler valve plug 88 engaging the filler valve 19 and having a front annular portion 87 engaging the reservoir element. The portion engaging the valve 19 is in the form of radial ribs 89 (Fig. 7*a*) defining apertures 90 establishing communication between the filler valve and reservoir element. The ribs receive the rear end of the feed bar 20 with a loose fit and prevent excessive side play of the feed bar. A space or void is thus formed between the filler valve 19 and reservoir element 16, this space including the space 91 and apertures 90. It is within the compass of the invention, however, to have the reservoir element engage the filler valve.

The dome element 82 and the specific arrangement of the filling apertures in addition to providing protection for the filler valve 19, serves to prevent sediment in the bottom of a bottle of ink from being drawn into the reservoir element while at the same time eliminating any tendency to trap air. Filling of the pen is accomplished by removing the rear barrel section and inserting the rear end of the casing 18 into a body of ink as represented in Figs. 19 and 20. If the level of the ink is low, as in Fig. 20, there may be a tendency for any sediment that happens to be in the bottle to pass into the pen but the dome element 82 prevents this occurrence by spacing the apertures 84 and filler valve 19 from the extreme bottom of the bottle. The apertures are closely adjacent the transverse plane including the outer surface of the filler valve, and any tendency of air to be trapped in the pen due to the upward movement of ink from the bottle into the pen is eliminated since the air will readily flow out through the filling apertures, particularly since the felt forming the valve 19 is curved, having its convex surface exposed outwardly or rearwardly and disposed in or closely adjacent the filling apertures 84.

The front end of the reservoir element 16 engages the rear end of the collector 24. Feed of ink is accomplished mainly through passages in the feed bar 20 but also and at least partially through the collector 24 and partially through spaces formed by the feed bar and collector together, as well as spaces formed by feed bar and nib.

Feed bar

The feed bar 20 may be of such material as plastic, and extends from a point closely adjacent to the writing tip of the nib to the rear end of the reservoir element 16. The material of the feed bar has sufficient rigidity that passages of determinate dimensions can be formed therein to compensate for lack of this property in the reservoir element, as explained fully hereinafter. The feed bar is generally cylindrical from its rear end to a position adjacent the front end where a cut-away portion forms a flat 94 forwardly of which is a second flat 96. The feed bar extends through the reservoir element, as pointed out above, and through the collector 24 from which it extends into and nearly through the nib as well as the reduced bore 44. The forwardmost tip of the feed bar closely approaches or engages the under surface of the nib in an arrangement working toward accurate spacing between the feed bar and nib.

Capillary forces play a great part in the feed of ink from the reservoir to the nib, as well as in the reservoir element itself as in this case. The term "capillary" as used herein is intended to denote a space or passage of sufficient capillarity to lift ink a substantial distance. Such meaning of the term as used in fountain pens will be understood by those skilled in the art.

The feed bar has a plurality of passages or channels of capillary dimension extending substantially throughout its length. These passages or channels are in the form of grooves or slots and are represented most clearly in Figs. 13 to 18, inclusive. The passages include two primary feed passages 98 flanking a central control passage 100. The feed passages 98 are uniform in cross section, and uninterrupted, throughout their length which is substantially the length of the feed bar. Each of the feed passages 98 includes an outer wide portion 102 and an inner narrower portion 104, both of which are of capillary dimension. As an example of suitable dimensions that may be utilized, the outer portion may be .005" and the lower portion .002", in wall-to-wall dimension. The outer larger portion determines substantially the capacity of the passage for conveying ink, from a practical standpoint, while the inner and smaller portion serves as a pilot passage for facilitating feeding ink from the reservoir element toward the nib after the ink has been drained back from the outer larger portion, as will be explained in detail later.

The purpose of the control passage 100 is to control reservoir vacuum pressure and hence control the ink flow, but the passage is arranged so that any ink that should flow downwardly therefrom, which would be only in extraordinary circumstances, would find its way to the nib. The control passage 100 includes a segment 106 beginning at the rear ends of the feed channels 98 and leading to a second segment 108, which will be referred to as a weir, which in the assembled pen is located below the reservoir element. The weir is of lesser effective dimension and greater capillary than the upper segment 106 and serves as the portion of all of the passages through which any air passes from the exterior into the reservoir when any such air is needed to replace ink withdrawn from the reservoir. Hence the weir serves as the sensing and control means for controlling the flow of ink from the reservoir to the nib. The direct action of the weir is to hold ink therein by reason of its capillary dimensions. It acts indirectly to control passage of air into the reservoir means, and thus may be referred to also as a "weir-vent." The location of the weir is not necessarily as illustrated, but may be higher or lower than that location. The illustrated location is as desired however, in consideration of such factors as the length of the column of ink to be controlled and desired relative dimensions of the weir and other portions of the ink feed passages and reservoir spaces.

Leading forwardly from the weir 108 is a third segment 110 which may be larger than capillary dimension for receiving any ink that should flow from the weir. This segment opens laterally into and communicates with the feed channels 98 (Figs. 13 and 16) and terminates forwardly a substantial distance rearwardly of the front end of the feed bar. Hence the central control passage 100 does not communicate directly with the nib but it communicates therewith indirectly through the side feed passages 98. The segment 106 of the control passage, similarly to the feed passages 98, is provided with an inner pilot portion, such as 112, the purpose of which is to provide counterflow of ink in forward direction as air is flowing rearwardly through the outer larger portion, as will be explained more fully hereinafter.

As an example of the dimensions of the segments of the control passage 100, the rear segment 106 (outer large portion) may be .009" wide, the weir .007" wide, and the front segment 110 .040" wide (between the outer side walls of the feed passages) and .015"–.020" deep. In all cases where the depth is not indicated, it may be considered great relative to the width and not affecting the capillarity as determined by the width.

The feed passages 98 and control passage 100 extend rearwardly substantially to the rear end of the reservoir element so that the ink storage spaces in the reservoir element have direct communication with the ink passages at all points along the length thereof. Fig. 6 represents the relation between the ink storage spaces 78 and the passages 98 and 100, where it will be seen that the open sides of the passages communicate directly with the innermost ink storage space 78. This communication extends longitudinally the length of the reservoir element and ink easily finds its way from that innermost space 78 into the passages. Ink also easily passes through the apertures in the wall elements, from the outer spaces 78 to and through the inner spaces, in radial direction, and hence flow of ink from the outermost portions of the reservoir element to the central portion is readily accomplished. Air flow as well as ink flow takes place through the apertures in the reservoir element, so that, as the ink flows out, air readily replaces it. As will be pointed out later, ink also passes longitudinally in the spaces and through the front end of the reservoir element.

Nib

The nib 22 includes a writing point 114 and a rear body portion 116. The rearmost part of the body portion is generally tubular as at 118 (Fig. 8), but split on its under side at 120 for providing the desired resiliency for engaging with the collector 24 in which it is mounted. This portion is self-biased outwardly for frictionally engaging the inner surface of the collector. Forwardly of the tubular portion is a pair of wings 122 (Figs. 5 and 8) bent inwardly in a transverse plane and engaging the flat surface 94 of the feed bar. This engagement serves as an interlock between the nib and feed bar to prevent undesired rotation and displacement of the nib. The nib forwardly of the wings tapers to the writing point 114 which is provided with a slit 124 leading from the writing point rearwardly. A pierce 126 may also be provided in a suitable location, e.g., at the rear end of the slit. The nib has firm mounting in the collector, and by that mounting its forward portion is normally held out of engagement with the surface 48 and it thereby forms a space 128 therewith. In such position of the nib, the wings 122 rest on the shelf 129 in the lower surface of the bore 44. The nib thus has support at its rear end in the collector and it further receives firm mounting through engagement between the wings 122 and the undersurface of the feed bar, and the shelf 129 under the wings. The wings exert an upward influence on the front end of the feed bar, as will be brought out more fully hereinafter.

Collector

The collector 24 has certain capillary passages formed therein, and forms with the feed bar and nib certain passages, together forming communication between the reservoir and the nib. The collector also is provided with a plurality of capillary overflow cells for receiving ink in excess of that required for writing purposes. As a mechanical matter, the collector serves to aid in solidly mounting other elements of the pen, being of substantial size and directly engaging the front barrel section 26 or other solid portions of the pen.

The collector is generally of tubular form having a body 130 and a bore therethrough, the bore including a main portion 132 of substantially uniform dimension and extending a substantial portion of the length of the collector. Rearwardly of the main bore portion is a rearwardly diverging portion 134 of short length, forming a funnel, and forwardly of the main bore portion is a counterbore 136 and a second counterbore 138 of greater diameter than the first. The feed bar extends through the collector, receiving mounting in the main bore portion 132 and forming certain passages with the surfaces of other bore portions. The front end of the collector has a reduced portion 140, forming a shoulder 142, which is fitted in a similarly dimensioned bore portion 144 in the front barrel section. The elements are relatively dimensioned to provide a sliding and snug fit to enable the collector to be easily inserted and removed, but preventing undue play thereof in the assembled pen. The shoulder 142 engages a corresponding shoulder 146 in the barrel section for limiting forward movement of the collector, and on the underside of the reduced portion 140 is a notch 148 receiving a corresponding lug 150 in the front section to interlock the collector with the barrel section against relative rotation therebetween. The rear end of the collector includes a portion 152 telescoped into the front end of the casing 18 and secured thereto, this securement being by any suitable means such as a heat stake arrangement of known kind. In this arrangement, the rear end of the collector is engaged by the front end of the reservoir element as was pointed out above. The casing 18 has snug engagement with the connector sleeve 30 whereby the collector has solid engagement at its ends with the barrel or elements solidly mounted in the barrel. The internal elements, it will be observed, constitute a self-contained unit, these elements including the collector, feed bar, nib, reservoir element, and casing which can be removed as such unit from the front section, upon removal of the connector sleeve 30 as by a repairman. So long as the connector sleeve 30 remains in the front barrel section, it serves as the means for retaining the unit therein. This is done through the shoulder 32 acting through a resilient sealing ring 156 which in turn engages a shoulder 158 on the collector forwardly of the rear portion 152. This sealing ring engages those two shoulders, the forward end of the casing 18, and the inner surface of the barrel section at that location. All of the elements in the unit mentioned are thus sealed against leakage from the front barrel section. When the rear barrel section is removed, the front section and casing 18 form an enclosing envelope for the reservoir element, feed means and nib.

The feed bar snugly fits the surface of the bore portion 132 of the collector, and is preferably heat staked thereto, in a known manner. The cylindrical portion of the feed bar extends forwardly beyond the bore portion 132 so that it forms an annular passage 160 between itself and the surface of the counterbore 136. This passage is of capillary dimension and is annular in form from its rear end to the flat 94, and from that point forwardly it is at least arcuate in cross section where it is continued in similar dimension by a passage 162 between the feed bar and the nib. As will be observed now, the rear body portion 118 of the nib has mounting in the counterbore 138. The radial increase in dimension of the counterbore 138 over the counterbore 136 approximates the thickness of the material forming the nib whereby the dimension of the capillary space 162 approximates that of the capillary space 160. The spaces 160 and 162 are continuous, the rear end of the nib abutting against the shoulder 137 formed between the counterbores. The rear end of the nib has a notch 139 utilized in manufacture of the nib, but which does not figure in the function of the assembled pen, and which does not materially affect the space 162. The space 162 continues from the rear end of the nib forwardly to a point closely adjacent the front end of the feed bar. The spaces 160 and 162 may be, for example, approximately .006" in wall-to-wall dimension. The space 128 over the nib, i.e., between the nib and surface portion 48 of the bore 44, is of similar dimension.

The normal axis of the feed bar 20 as a whole coincides with that of the collector 24, which in turn coincides with that of the pen. The parts are so relatively shaped and located that there is a tendency to interference between the wings 122 of the nib and the feed bar. The feed bar is slightly flexible and susceptible to having its front portion lifted or bent slightly upwardly. The wings thus exert such upward influence, as mentioned above, while the wings receive support from the shelf 129. The effect of the collector-feed bar-nib relation is to retain the front end portion of the nib downwardly to form the space 128 and to retain the top surface of the feed bar in engagement with or closely adjacent the under surface of the nib.

The capillary overflow cells in the collector for receiving the excess ink are formed between a plurality of radial fins 164 surrounding the bore of the collector. These cells 166 communicate through certain passages with the reservoir element, and with the nib. The principle of operation of the overflow collector is fully described in Baker Patent No. 2,223,541 dated December 3, 1940, but reference to certain phases thereof is made herein for convenience. Briefly, it may be stated that the cells of the collector receive or draw in excess ink when an overflow condition exists and later release it to the nib in writing. Later reference thereto is made hereinbelow. The cells extend circumferentially of the collector except as interrupted by a capillary passage 168 in the lower side and a passage 170 in the upper side which serves as an air channel. The passage 170 is substantially greater in dimension (.040") than the passage 168, and herein regarded as of greater than capillary dimension. The collector and front barrel section are so relatively dimensioned as to form a space 171 between the fins 164 and surface of the barrel section. This space is of capillary dimension and will under the most adverse conditions serve as an overflow space.

The passage 168 may be referred to as an overflow and drain-back passage. It is approximately .005" in wall-to-wall dimension and is cut entirely through the fins, communicating with all the cells, and through the body of the collector into the central bore where it communicates with the passage 160. The passage 168 continues rearwardly through the length of the collector and opens through the rear end thereof. A linking portion 172 bridges the passage in the rear portion of the collector to provide a circumferentially continuous rear end portion. This link is of minor radial dimension, of sufficient size to provide the necessary strength but small enough to provide great radial dimension, and corresponding capacity, of the passage 168 at that location. The passage 168 rearwardly of the link 172 communicates with the diverging bore portion 134 in the rearmost extremity 174 of the collector. This portion of the collector may be referred to as a spider since it contains a plurality of additional grooves or slots 176. The latter slots are radially disposed, extending the full radial dimension of the spider and opening rearwardly therethrough where these slots as well as the passage 168 communicate directly with the ink storage spaces in the reservoir element. The diverging surface of the bore portion 134 forms with the feed bar a rearwardly diverging space 178 which at its rear end and greatest dimension is of capillary dimension and of course its capillarity increases in forward direction. As an example, the radial dimension of this space at its rear end is approximately .006".

The radial slots and passages 176, 168 receive ink from the forward end of the capillary reservoir element and convey it radially inwardly into the space 178, and because of the immense capillarity of that space at its forward end, the ink quickly fills it in circumferential direction. This ink progresses rearwardly to completely fill the space and then readily passes into the capillary passages 98, 100 in the feed bar. In this manner, therefore, the passages in the feed bar receive ink from the space 178 in augmentation of that received directly from the ink storage spaces in the reservoir element.

The upper air passage or slot 170 in the collector cuts across and communicates with all of the cells 166 in the collector. This passage has communication with the exterior for free flow of air into and out of the passage which is provided in the following series of passages: annular recess 180 forwardly of the cells; aperture 182 in the wall of the collector communicating between the annular recess and the counterbore 136; passage 184 formed in the counterbore by the flat 94 on the feed bar; passage 186 leading forwardly from passage 184 and formed between the flat 94 and lower tubular portion of the nib; passage 188 below the wings 122; passage 190 cut through the shelf portions 129; and finally passage 192 between the flat 96 of the feed bar and the lower surface of the bore 44.

Aperture 196 communicates between the passage 170 and the bore of the collector and in that way provides free flow of air into the collector and into the control passage 100 in the feed bar through which it passes into the reservoir space when there is need for air in that space to replace ink withdrawn therefrom.

Operation

Since the pen fills by capillary action, the pen should be open for filling, i.e., arranged so that a free air passage is provided whereby ink in entering by capillary action through one passage forces the air out through another passage. Such arrangement is provided in the present case, the pen fills through the rear end, and air is forced out through the front end. To fill the pen, the rear barrel section is removed from the front section and the rear end of the casing is inserted in a body of ink as represented at 197 in Fig. 19, to a depth that the ink level is above the rear (then lower) end of the reservoir element 16. The hydrostatic head of the body of the ink forces ink through the filler valve 19, fills the space between the valve and the reservoir element (when such space exists), and then enters the reservoir element. The design and relation between the parts are such that the ink will rise in the reservoir element, by capillary action, to at least a near-full extent. Ink may also flow into the feed means. After a predetermined time the pen is removed from the ink and re-inverted to point-end-down position, the ink then feeds down to the nib, and in consequence of the ink so feeding down, or in being written out on a writing surface, tension is imposed on the column of ink and air enters into the reservoir space. The capillarity of the passages in the feed means is greater than that of the reservoir element and this relation is utilized to start and facilitate flow of ink from the reservoir element to the nib.

The design of the reservoir element is such that its capillarity is sufficient to hold ink at a height substantially equal to its own length but not the length of both itself and the feed means. It will be noted that the length of the feed means, from the front end of the reservoir element to the extreme front end of the nib, is a substantial portion of the length of the reservoir element. Thus, if the capillarity of the reservoir element is such as to sustain a column of ink therein substantially equal to its own length, it follows that it would not hold a column equal to the length of the reservoir element and feed means combined. This would be true whether or not the capillarity of the passages in the feed means is sufficient to lift the ink to the nib when the pen is in filling, point-end-up position, because regardless of the capillarity of those passages, the capillarity of the reservoir element is insufficient to hold a column of that length. It is within the scope of the invention to provide for so filling the passages in the feed means, particularly after initial filling. If the pen should have an open reservoir and be turned to point-end-down position after filling, the ink would run out the front end until the column of ink reached a length, measured from the front end of the nib, which could be sustained by the reservoir element and/or feed means according to the capillary strength of each.

Hence, although the pen is filled by capillary action, the ink feeds out freely and not according to capillary holding power, so that a condition is established in which the feed-out can be controlled by vacuum-reservoir condition, and it is so controlled. The valve assembly 60 in the rear barrel section ultimately closes the reservoir, but until the rear barrel section is applied to the pen, other means must be provided for temporarily accomplishing that purpose, and this is done by the filler valve 19. The capillarity of the valve 19 is greater than that of the reservoir element, and great enough that it will easily hold the ink therein when the pen is re-inverted. However, the flow resistance is not so great as to prevent efficient flow of ink therethrough when the rear end of the pen is inserted in the body of ink. Figs. 21 to 23 represent the action that takes place in the flow of ink through the filler valve and Fig. 24 indicates the manner in which the ink in the valve produces a temporary sealed condition in the reservoir. These figures are semi-diagrammatic in nature for facilitating representation of the phenomena involved. Reference is made first to Figs. 21 and 22, where the rear end of the pen is shown inserted in a body of ink 198 and has the reservoir element 16, and valve 19, with the space 91 therebetween. (See below for reference to the filling action where the space 91 does not exist.) The pen is inserted in the ink to such depth that the level of the ink is above the lower end of the reservoir element. The hydrostatic head of the body of ink then forces ink through the capillary filler valve 19. This valve includes cells or passages, which, although communicating with one another, may be considered as discrete from the standpoint of flow of ink therethrough by capillary action. The spaces or cells of the valve are represented at 200, but for the sake of simplicity in explaining the action, passages such as 202 are included in the representation. The action is the same in both cases. As the ink enters the passages (e.g. 202), meniscuses 204 are formed, and as in known by those skilled in the art, such meniscuses serve to draw ink upwardly in those spaces, adding to the effect produced by the hydrostatic head of the body of the ink. After the level of the ink in the spaces reaches the upper end of the element 19 as shown in Fig. 22, the meniscuses no longer aid in lifting the ink since they are convex and extend upward beyond the walls forming the spaces. The convex meniscuses 206 are individual to the capillary spaces, but as the ink rises they join and lift from the walls of the spaces and unite as indicated at 208. Finally all of the meniscuses form a fluid united body as indicated at 210 and all forces provided by the meniscuses are dissipated and a fluid head is formed in the space 91 and lifted by the hydrostatic head of the main body of ink until it reaches the reservoir element 16. The ink then flows by capillary action into the reservoir element and fills it to its capacity.

When the pen is removed from the body of ink and re-inverted to point-end-down position, the capillarity of the filler valve is sufficient to sustain the column of ink in the reservoir. When the column of ink in the reservoir element below the valve drops and a rarefied space forms between that column and the filler valve, the ink is retained in the filler valve against the pressure exerted thereon by the atmosphere. The drop or fall of the column of ink would take place initially because of the feed of ink from the reservoir element into the feed means, or if the feed means is full, because of the feed of ink from the nib onto the writing surface. Whether the filler valve and reservoir element are spatially separated or not, a space or void will form between the ink in those two elements, the separation of the elements not being essential to the parting of the portions of the ink. The filler valve thus acts as a plug to close and seal the rear end of the reservoir space.

Fig. 23 indicates the manner of filling in the absence of a space (such as 91) between the filler valve and reservoir element. The ink enters the filler valve, meniscuses 211 form in the valve, in the manner described in connection with Figs. 21 and 22, and without interruption form meniscuses 213 in the reservoir element, and fill the latter by capillary action.

Fig. 24 represents the action taking place when the filler valve 19 produces a holding action on the ink in the reservoir element. This figure represents the pen re-inverted to point-end-down position so that the valve is uppermost and the reservoir element lowermost. Meniscuses 212 are formed at the upper end of the capillary spaces 202, which exert an upward force on the ink and hold the column of ink against the force of gravity tending to lower it. The united fluid portion 216 is held against dropping by the meniscuses 212.

Upon sealing the reservoir space, a vacuum condition therein is produced in response to feed of the ink therefrom. The feed of ink from the reservoir to the nib is controlled by that vacuum condition together with the control through the capillary passages and particularly the weir 108.

It will be understood that the requirement of the filler valve to seal the reservoir space need be only temporary, and until the rear barrel section is applied. When the latter act is accomplished, the valve assembly 60 closes the rear end of the casing 18 and the filler valve 19 then no longer is relied on for producing the vacuum condition. The ink may eventually migrate out of the filler valve into the reservoir element, but this would be only incidental and inconsequential.

When the pen assumes its point-end-down position pursuant to filling, such as a writing position, the ink in the reservoir element feeds through the feed means to the nib. The feed means includes the feed bar 20 and the collector 24, as well as a space between the feed bar and nib. The primary feed is through the feed passages 98 in the feed bar, but ink in those passages may also feed by capillary action into the arcuate passages 160 and 162. The ink passes from the latter passages into the nib slit 124 as in the case of fountain pens heretofore known. The writing tip 114 of the nib may curve downwardly on its undersurface to facilitate engagement thereof with the feed bar.

Ink also flows into the control passage 100 and feeds down this passage and into the weir 108 conveniently but not necessarily, the weir being located below the reservoir element and above the overflow cells 116. The control passage 100 is of such dimensions throughout all of its segments that when air must pass into the reservoir element to replace ink withdrawn therefrom, it flows through such control passage normally to the exclusion of other passages which include the primary feed passages 98 and the passages 168. The weir is the smallest portion of this control passage, that is to say, it is the smallest portion in a linear succession of large portions, and it exerts the greatest holding power for the ink and determines the condition under which air will pass therethrough into the reservoir. For example, assume as a starting point a condition of balanced forces, and a state of equilibrium in the pen. The primary feed passages 98 are filled and ink stands in the control passage 100 down to and including the weir. The vacuum condition in the space above the ink is of sufficient force (and usually greater) to hold the ink in such state of equilibrium, but not great enough to pull ink out of the weir. As writing begins, ink is drawn out of the nib onto the paper, and replenished in the nib from the passages 98. Ink, in passing down the passages 98 to the nib, depletes the quantity of ink in the reservoir and a more rarefied or higher-vacuum condition exists. The vacuum condition then increases until air breaks through, and, as noted above, the air passes through the weir and the control passage 100. The air in so passing through the weir does so in the form of small bubbles which pass upwardly through the weir and into the segment 106 of the passage and then into the space rearwardly of the column of ink in the reservoir element.

The pressure of the body of ink in the reservoir element is manifested in the weir and such pressure in the weir is the condition that directly controls the passage of air into the reservoir. The weir, although relied on to modulate the degree of vacuum by means of the pressure exerted by the ink, can be cognizant of the pressure of the ink column only at the height of the weir. This pressure is the result of a relationship in the present case which includes an additional factor as compared with a conventional vacuum-reservoir pen. In order to avoid possible conflict in the use of conventional terms such as "positive" and "negative" with respect to pressure, the pressures referred to herein will be designated "downward" and "upward" according as they exert influence on the ink in the pen. In a vacuum-reservoir pen, the pressure of the ink, as at the weir, is the sum of the upward pressure in the reservoir space above the ink, and the downward pressure exerted by the head of ink in the reservoir above the control element (weir). As referred to herein, the sum of the pressures involved is the algebraic sum, i.e., upward and downward pressures added algebraically. In the pen of the present invention the pressure at the weir is the result of the two pressures mentioned above and the capillary strength of the reservoir element. The latter is an upward pressure. Such capillary strength is exerted at all times by the reservoir element and assists the vacuum condition in retaining the ink therein. When air breaks through into the reservoir space it partially relieves the vacuum in the manner described above, and facilitates further feed of the ink to the nib. The vacuum condition normally exceeds that required to support the column of ink at any given height, and entry of additional air decreases the vacuum pressure and acts to enable the ink to flow or pass more freely to the nib.

The control of the feed of ink to the nib also involves the factor of capillarity of the reservoir element. The capillarity aids in maintaining the head of ink. In a perfect capillary (reservoir) element the ink storage spaces would all be of exactly the same size and the head in all parts of the element would be at exactly the same height. As a practical matter, and as is well known, absolute accuracy is difficult of attainment in manufacturing methods and in the case of the reservoir element herein used, it is quite difficult because the wall elements are formedf by sheet material of a thickness in the region of .001". Such sheet material obviously can only with the most extreme difficulty be made absolutely accurate. Thus such inaccuracies cause the head at different points to stand at different heights. The feed bar with its control passage 100 is extended throughout the length of the reservoir element and the column of ink in that passage is utilized for providing the head for sensing the column of ink in the reservoir element. The ink in this passage forms a continuous column and it is the only body of ink to which the weir is sensible. The column is the result of the pressures exerted by the different portions of the column in the reservoir and is representative of those pressures. Filling of the control passage **100** is assured by filling directly from the reservoir element in radial direction, or from the funnel space **178** in the event it does not readily fill directly from the reservoir element. The column of ink in the control passage responds in height quite readily to the conditions in the reservoir element so that the desired pressures and consequent flow-control of ink are attained.

The control passage **100** can be easily formed to accurate dimensions by ordinary manufacturing methods. The feed bar is made of material such as plastic, having sufficient rigidity as noted above, so that by ordinary and well known methods a slot or groove can be formed of determinate dimensions and within extremely close limits. This therefore eliminates the necessity for accurate dimensions of the spaces of the reservoir element.

Ideally, the control passage **100** should be of the same wall-to-wall dimension as the ink storage spaces of the reservoir element, and hence equal to the mean capillarity thereof. This condition is closely approximated, but because of other considerations, modification therefrom is advisable. In the present instance, the wall-to-wall spacing of the reservoir element is in the neighborhood of .008″ while that of the control passage is .009″. Because of this slight difference, the level of the column of ink in the control passage will be slightly less than in the reservoir. However, the conditions are such that this relation may be taken into account and the control exercised by the weir is determined according to the column of ink in the control passage for controlling the condition in the reservoir space. The spacing of the reservoir element is selected as that capable of providing the necessary capillary filling and holding characteristics and at the same time permitting the ink to feed out in writing. The dimension of the control passage (.009″) is that dimension as nearly as possible equal to the reservoir spacing, but appreciably greater than the dimension of the weir (.007″). The relation between the control passage and weir has two distinct advantages, one in manufacturing techniques and another in functioning of the pen. Manufacturing techniques make it desirable that no less than a .002″ difference exist in order to eliminate objectionably close tolerances. With respect to the functioning of the pen, air bubbles abruptly increase in speed in passing from the weir into the control passage, and continue at a relatively great speed in flowing up the passage. The air bubbles are quite small relative to the passage (i.e., segment **106** thereof) and in passing through the ink, the ink is enabled to flow around the bubbles, and it is not necessary for the bubbles to push the column of ink ahead of them in passing up the passage. Thus air lock from this source is eliminated. Continuity of flow of ink through the passage is improved. In this connection reference is also made to the pilot passage **112** in the control passage, as the air bubbles pass upwardly in the outer large portion a continuous column is maintained in the pilot passage to the weir. Hence, the construction and relation operate to minimize variation in line intensity in the breathing cycles. The dimension of the weir (.007″) is selected as the proper dimension to maintain the column of ink according to the various pressures described above.

Normally ink does not flow downwardly from and out of the weir but if it should, in unusual circumstances, it would flow in to the portion **110** of the passage, and into the feed passages **98** and thus to the nib, as set out above.

The overflow collector cells **166** receive ink in amounts in excess of that required for writing purposes when an overflow condition develops. Such a condition would develop, for example, when the air in the reservoir space is expanded. When that air is expanded, the ink is forced in the direction out of the pen. This expansion may be caused by increase in temperature as in holding the pen in the hand, or by a drop in atmospheric pressure, such, for example, as when carrying the pen to elevated altitudes in an airplane. The ink, on expansion of the air, flows through the passage **168** in the collector and into the cells **166**. This passage is of substantial capacity because of its relatively large radial dimension. The cells are of greater wall-to-wall dimension than the passage and hence of lesser capillarity, and the total capacity of the cells is quite great whereby to contain and convey a substantial quantity of ink. The ink, in entering into the passage **168**, first flows along the full length of the passage and between the meeting faces of the end portions of the fins before entering into any of the cells because of the greater capillarity of the passage relative to the cells. However, upon the passage **168** being filled, continued expansion of the air and consequent movement of the ink causes the ink to flow into the cells, as brought out in the Baker patent referred to above.

A reverse and corresponding action takes place in emptying the cells in a writing-out operation. In writing, the capillarity between the nib and writing surface draws ink out of the pen. The ink to replenish ink drawn from the nib proceeds from the overflow cells in preference to the reservoir element, as also explained in the Baker patent mentioned. The flow of ink is from the cells into the passage **168**, and then through spaces **160** and **162** to the nib in the manner explained above. After the cells empty, ink is drawn from the reservoir element in the normal manner.

As mentioned above, the cells **166** are of lesser capillarity than the passages in the feed means (e.g., passage **168**), being of greater wall-to-wall dimension. They range, as an example, from approximately .007″ at the rear to .009″ at the front. Ideally, the cells would be graded in size uniformly, but because of preferred manufacturing techniques, they are formed in groups, with those in each group all of the same size and those of successive groups progressing in size as mentioned. This gradation of cell size provides the necessary capillary holding power in each cell according to its height above the nib.

The positioning of the capillary passage **168** and air flow passage **170** on opposite sides of the collector works to a beneficial effect. The ink in entering the cells **166** does so from the passage **168** and migrates upwardly and drives the air out ahead of it, eliminating any possibility to air lock in this action. For further details of the action with respect to the collector, reference may be made to the Baker patent mentioned above.

The ink in flowing into the passage **168** may do so directly from the end thereof from the open end ink storage spaces in the reservoir element. Ink may also flow into the other radial slots **176** and then into the funnel space **178** and from there into the passage **168**.

Another important advantage of the invention is the provision for drain-back of the collector. If the collector should fill or partially fill, and later the pen be turned to point-end-up position, the collector is emptied substantially immediately. The ink in the reservoir element forms a continuous column as will be understood because of the capillary nature of the reservoir element. This ink column is continued uninterruptedly to the passage **168** and overflow cells. Thus when the pen is inverted to point-end-up position, the ink in the passage **168** and overflow cells **166** returns to the reservoir element. Ink may also return to the reservoir element from the ink feed passages, namely, the two main passages **98**. As a consequence, a ready ink supply may not be available at the nib for instant writing were it not for provision to avoid that circumstance; in the present construction, such condition is avoided by the pilot channels **104** at the bottom of the ink feed passages. These channels are of very small dimension, as indicated above (.002″), and remain substantially full (after initial filling) even though the pen remains for a long period of time in point-end-up position. Thus when the pen is again re-inverted to point-end-down position after the collector and main large portions of the feed passages have been drained, the pilot channels quickly supply ink to the nib. The pen is accordingly always ready for instant writing.

Drain-back of the collector obviates an objection to previous pens from the standpoint of leakage due to expansion. Comparison is made with collector arrangements previously known in which the ink once forced into the collector remained there in normal functioning of the pen until drawn out through the nib in writing. In that case, if a second expansion condition occurred while the collector was full, the pen would likely leak, but in the present case the collector would be emptied by drain-back (if not by writing) before a second expansion condition occurred.

There may be feed of ink to a limited extent from the reservoir element through the passage **168** and spaces **160** and **162**. However, this condition is incidental to the normal function of the pen and the communication between the passage **168** and space **160** is primarily for the purpose of writing out the ink from the overflow cells.

The capability of the pilot channels **104** to hold ink when the pen is in point-end-up position prevents nib dry-out which might otherwise occur because of drain-back, were it not for the pilot channels. Ink forms a film in the narrow arcuate capillary space **162** in register with the nib slit **124**, which maintains the nib in moist condition. Ink also finds its way into the space **128** between the nib and surface **48**. Hence a film of ink is maintained on each side of the nib. The desired relationship between the elements for maintaining the capillary-dimension spaces is accomplished by the solid mounting of the collector, feed bar and nib. The collector has firm support at each end in the front barrel section; the feed bar is of great length and has firm bearing support in a substantial portion of the bore of the collector; and the nib has firm support at its rear end in the collector and at the shelf **129**.

The foregoing pen provides for substantially uniform line intensity throughout its full range from full to empty condition; leakage is substantially eliminated from the sources mentioned, and also any leakage that may otherwise result from jarring the pen, because of the tortuous path of the various passages between the reservoir element and the exterior; any disadvantages from loss of capillary holding power are obviated since the feed-out of ink is under control of vacuum condition of the reservoir.

If it is desired, e.g., for manufacturing reasons, not to maintain the precision in the dimensions of the parts to attain the accuracy of spacing mentioned, the transfer of ink to the nib may be aided by a capillary pad on or associated with the nib. Such a construction is shown in Fig. 25 where pad elements **218** and **220** are utilized, the former between the feed bar and nib, and the latter between the nib and the surface **48**. These two pad elements may be separate pieces, or in the form of a sleeve fitted over the nib. These pad elements fill the spaces in wall-to-wall direction and maintain constant contact between the nib and the related elements. Thus any inaccuracies, that may occur in any of the three elements between which they are placed, are overcome. It will be understood that the pad elements are in overlying relation to or in register with the nib slit. It is not necessary that a pad element be provided in each of the spaces mentioned since it may be desirable to have such a pad in only one of the spaces, either below or above. Having a pad below in the space **162** is more desirable, but it may also be desired to have a pad above the nib so as to produce a compressing action thereon when the nib sections are flexed in writing. This action facilitates transfer of ink from the pad to the nib slit, the pad obtaining its ink from the lower pad through the nib slit and possibly from the film of ink already in the upper space **128**. The pad or pad elements may be made from such materials as cotton flock, plastic synthetic cobwebs, thinly sliced sponge rubber, natural cotton fibres, synthetic plastic sponge-like structures, cloth, etc. It is also alternatively proposed that such pad or pad elements be formed by spraying material such as plastic cobwebbing on the nib at the desired location, the material bonding to the nib. Such pad or pad elements may be used to great advantage between other elements of a pen where it is desired to assure effective capillary transfer of ink between those elements. This may be in association with a nib, or it may be between other elements.

We claim:

1. A combination vacuum-capillary reservoir fountain pen comprising: a writing point; a capillary reservoir element for holding ink therein by capillary action; feed means having capillary passages connecting said reservoir element with said point and with atmosphere, said capillary passages holding ink therein by capillary action; and means closing off said reservoir element from direct air venting connection with atmosphere so that said reservoir element's only connection with atmosphere is through ink in said capillary passages; whereby a partial vacuum is created in said reservoir element in response to flow of ink therefrom, said partial vacuum acting to hold ink in said reservoir element, said partial vacuum being increased by flow of ink from the reservoir element and decreased solely by air bubbling through ink in one of said passages and into said reservoir element; the ink flow of the fountain pen thus being jointly controlled by the capillarity of said capillary reservoir element and the partial vacuum.

2. The invention defined in claim 1 further provided with means for exposing the closed off reservoir element directly to atmosphere through a path other than said capillary passages to enable filling of said capillary reservoir element solely by capillary action upon insertion of it into a body of ink and for closing said element after filling to enable writing under combined vacuum and capillary control.

3. The invention defined in claim 1 further characterized in that the capillary reservoir element has a capillary strength sufficient to sustain a column of ink of substantially its own length but insufficient to sustain a column of ink of the combined length of itself and said feed means.

4. The invention defined in claim 1 wherein said capillary reservoir element has a filling entrance at the rear thereof and wherein there is provided a porous member covering said filling entrance, said porous member having a porosity permitting the passage of ink therethrough during filling and retaining ink therein after filling for prohibiting the passage of air therethrough after filling thereby effectively sealing said filling entrance to enable writing under combined vacuum and capillary control.

5. The invention defined in claim 1 wherein said reservoir element has a filling entrance at the rear thereof and where there is provided a removable and replaceable member for exposing the filling entrance to permit filling of the reservoir element and for closing the filling entrance after filling to seal said filling entrance to permit writing under combined vacuum and capillary control.

6. The invention defined in claim 1 wherein said capillary reservoir element has a filling entrance at the rear thereof, and wherein there is provided a porous member covering said filling entrance and a removable and replaceable closure member for covering and uncovering said porous member to thereby expose said porous mem-

ber for filling said reservoir element therethrough and to thereafter close off said porous member and said entrance and said reservoir element for writing under combined vacuum and capillary control.

7. The invention defined in claim 1 wherein said feed means includes an overflow ink collector having capillary overflow cells communicating with said capillary passages.

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CERTIFICATE OF CORRECTION

Patent No. 2,935,044 May 3, 1960

Frederick R. Wittnebert et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 60, for "capillary" read -- capillarity --; column 12, line 61, for "as in" read -- as is --; line 68, for "upward" read -- upwardly -- same line 68, for "The" read -- These --; column 13, line 31, for "pen-" read -- pen --; line 51, for "the", first occurrence, read -- The --; same column 13, line 70, for "116" read -- 166 --; column 14, line 1, for "passages" read -- passage --; line 70, for "formedf" read -- formed --; column 17, line 48, for "full", second occurrence, read -- fully --.

Signed and sealed this 25th day of October 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents