

RESERVE COPY. PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Fountain Pens

We, THE PARKER PEN COMPANY, a Corporation organised under the laws of the State of Wisconsin, United States of America, of Janesville, Wisconsin, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The present invention relates to a fountain pen.

15 The invention is directed to a fountain pen of basically new concept including desirable features of a pen having a capillary reservoir, and a fountain pen wherein the reservoir maintains ink therein under sub-atmospheric condition as ink is written out.

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

25 A capillary pen as heretofore known is a pen that fills solely by capillary action, and retains the ink in the pen by capillary action until it is written out through the writing element or nib, also by capillary action. The ink is retained or held by capillary means which includes a main reservoir portion and 30 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 35 filling the pen and storing ink therein. It fills merely upon inserting either the reservoir portion or feed portion of the capillary means into 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 40 to a surface as in writing, a greater capillary force is established, designedly, between the writing element and the surface, which destroys the balanced condition mentioned,

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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 or fountain pen. This metering cycle effect produces an irregular line intensity, the line getting progressively fainter as ink is written out until an air bubble enters the reservoir to lessen the rarefied air condition therein, whereupon the line starts out to be heavier, over repeated cycles. On the other hand, however, in a pen having a capillary reservoir, 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. An object therefore of the invention is to provide a capillary-filling fountain pen in which an improved flow of ink in the writing-

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out operation is attained, and more particularly that the ink flows uniformly until the reservoir means is essentially emptied.

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

- 10 A fountain pen according to the present invention has an ink reservoir, a writing point, and feed means connecting the reservoir and the writing point, the reservoir including a capillary element capable of substantially filling with ink by capillary action, a filling entrance leading to the capillary element, and means for closing the filling entrance to create a sub-atmospheric pressure in the reservoir during write-out of ink therefrom, and the feed means including one or more passages through which ink is fed from the reservoir to the writing point and through which air from the atmosphere enters the reservoir to replace ink written out from the latter and to vary the sub-atmospheric pressure therein.

- 15 Preferably there are one or more passages for ink feed distinct from one or more passages for air entry, but the same operation may be obtained by the use of a single passage, part of the cross section of which serves for ink feed and part for air entry.

- 20 Such a pen can be arranged so that the pen fills by capillary action and the ink feed is under control of a vacuum-reservoir or sub-atmospheric condition. The same capillary action that fills the pen tends to retain the ink in the pen after filling, and in order that the sub-atmospheric 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.
- 25 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 disposed with its rear end in a body of ink so that it is capable of substantially filling by capillary action but in writing position it is disposed point end down so that it is incapable of retaining ink therein.

- 30 Preferably a pen according to the present invention has an overflow collector of substantial capacity for receiving ink in excess of that required for writing purposes, arranged so that 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.

- 35 Preferably means is provided which enables ink to pass into the reservoir in the filling operation but forms at least a temporary closure for enabling a sub-atmospheric condition to be produced 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.

- 40 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 any 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.

In pens according to the present invention the advantages of capillary filling are attained while a closed reservoir and sub-atmospheric or vacuum condition is utilized in holding the ink in the reservoir whereby to reinsure against leakage of ink caused by capillary "let down," which is the deterioration or diminishing of the capillary strength of the capillary reservoir element as a result of being constantly vented or exposed to atmosphere, and therefore under attack by atmospheric elements.

Preferably the feed means includes a capillary ink feed passage and a control passage having a portion of capillary dimension forming a weir that in response to the pressure differential on ink therein will permit air bubbles to pass upwards through it to modify the sub-atmospheric pressure acting on the ink in the reservoir the arrangement being such that the ink in the control 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 control passage which can be done with facility.

Another object of this invention is to provide an improved capillary reservoir element of the type having thin walls spaced apart by spacers projecting from the walls.

Cylindrical capillary filler-and-reservoir elements of this type are known wherein perforated thin walls are spaced apart radially by spacers of either generally cylindrical or dome-like shapes.

These prior art elements have the disadvantage that, if the spacers are relatively small and spaced relatively far apart, the thin walls bend or sag at various places thereby preventing the walls from being uniformly spaced apart a distance equal to the height of the spacers. The bent portions of the wall may partially or totally block or cover the perforations in an adjoining wall and may also block a portion of the space between a pair of adjoining walls. The sagging or bending of the walls thus impedes the flow of ink through the spaces, both axially (longitudinally) and radi-



ully (laterally) of the reservoir element.

These prior art elements also have the disadvantage that, if the circular or dome-like spacers are either increased in size or placed close together, to provide sufficient radial support throughout the element for uniformly spacing the walls by preventing sagging or bending, the ink storage capacity of the reservoir element is prohibitively decreased and the flow of ink axially (longitudinally) and radially (laterally) is prohibitively impeded.

It has been discovered in connection with this invention that the provision of generally rectangular elongated spacers patterned properly on the walls overcomes the above disadvantages. If the spacers are disposed with their elongated dimension parallel to the axis of the cylindrical element they present the least impedance to axial (longitudinal) ink flow but they then have the disadvantage of being extremely difficult to radially (laterally) align to provide proper radial support for obtaining non-sagging walls and uniform wall spacing. If the spacers are disposed with their long dimension perpendicular to the longitudinal axis of the element they can be conveniently radially aligned to provide proper support for obtaining non-sagging walls and uniform wall spacing but they then have the disadvantage of presenting the maximum possible impedance to the axial flow of ink.

All of the above disadvantages are overcome by this invention by providing a plurality of generally rectangular elongated spacers with their elongated dimensions lying on the walls at an acute angle to the longitudinal direction of the element in a pattern which provides lateral support for obtaining non-sagging walls and uniform wall spacing and provides ink paths for the effective flow of ink longitudinally and laterally through the element.

Examples of pens according to the invention are given in the following detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a side elevational view of a pen embodying the 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 view of the pen with the barrel and certain of the internal elements shown in section on an enlarged scale relative to Figs. 1 and 2;

Fig. 4 is a fragmentary sectional view of a portion of the front section of the barrel with the internal elements removed 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. 7a 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 step in the closing of the filling end of the reservoir after filling;

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

Fig. 26 is a plan view of a sheet having spacers arranged thereon in accordance with one embodiment of the invention;

Fig. 27 is an enlarged view of a portion of the sheet shown in Fig. 26;

Fig. 28 is a sectional view taken along line 28—28 of Fig. 27

Fig. 29 is an isometric view illustrating how a capillary reservoir element may be formed from a sheet as is shown in Fig. 26;

Fig. 30 is an isometric view of a capillary reservoir element embodying the invention;

Fig. 31 is a sectional view taken along line 31—31 of Fig. 30; and

Fig. 32 is a sectional view taken along line 32—32 of Fig. 30.

Referring now to the drawings, and more particularly to Figs. 1, 2, and 3 thereof, there is shown, for purposes of illustration, a whole pen embodying the principles of the invention. 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 in 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 filler-and-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 suitable materials except as hereinafter specifically pointed out. Generally speaking, the materials unless so specifically referred to may be made of the usual synthetic 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 repair man 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. 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 in-turned flange 56 which engages and retains a decorative element, such as a screen 58, over the rear end of the barrel.

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 valve guide 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 valve seat 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 valve seat 74 may be secured in the cup 70 by any suitable means such as by a cement.

RESERVOIR ELEMENT (and Filler Valve and Casing)

The capillary filler-and-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 Patent No. 646,726. The preferred reservoir element is shown in Figs. 26—32 and is described in detail when referred to herein-after.

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 filling apertures 84 are formed, for example by stamping so as to be spaced from the central or rearmost point of the dome portion 82, and so that portions of the material displaced to form the apertures 84 are bent to form fins projecting into the generally cylindrical casing 18 (see Figs. 7 and 20). The shoulder forms stop element

for engagement by the filler valve 19 which also engages the fins of 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 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. 7a) 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 synthetic 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. 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 in-

cludes 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 capillarity than the upper segment 106 and controls the passage of air 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 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 14) 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 the 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 com-

5 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
 10 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
 15 accomplished. Air flow as well as ink flow
 takes place through the apertures in the reser-
 voir 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 reser-
 voir element.

NIB

20 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
 25 mounted. This portion is self-biased out-
 wardly for frictionally engaging the inner sur-
 face 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 en-
 30 gaging 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 writ-
 35 ing point 114 which is provided with a slit
 124 leading from the writing point rearwardly.
 A pierce 126 may also be provided in a suit-
 able 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
 40 normally held out of engagement with the sur-
 face 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 sup-
 45 port at its rear end in the collector and it fur-
 ther receives firm mounting through engage-
 ment between the wings 122 and the under-
 surface of the feed bar, and the shelf 129
 under the wings. The wings exert an upward
 50 influence on the front end of the feed bar, as
 will be brought out more fully hereinafter.

COLLECTOR

55 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
 60 receiving ink in excess of that required for
 writing purposes.

The collector is generally of tubular form
 having a body 130 and a bore therethrough,
 the bore including a main portion 132 of sub-
 stantially uniform dimension and extending

65 a substantial portion of the length of the col-
 lector. Rearwardly of the main bore portion
 is a rearward diverging portion 134 of short
 length, forming a funnel, and forwardly of the
 70 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, being mounted in the main bore
 portion 132 and forming certain passages with
 the surfaces of other bore portions. The front
 75 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 (see Fig. 8). The elements
 are relatively dimensioned to provide a slid-
 80 ing 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
 85 movement of the collector, and on the under-
 side 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 there-
 90 between. The rear end of the collector in-
 cludes a portion 152 telescoped into the front
 end of the casing 18 and secured thereto, this
 securement being by any suitable means. In
 this arrangement, the rear end of the collector
 95 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 en-
 gagement at its ends with the barrel or ele-
 100 ments solidly mounted in the barrel. The
 internal elements, it will be observed, con-
 stitute a self-contained unit, these elements
 including the collector, feed bar, nib, reser-
 voir element, and casing which can be re-
 105 moved 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
 110 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
 115 inner surface of the barrel section at that loca-
 tion. All of the elements in the unit men-
 tioned are thus sealed against leakage from the
 front barrel section. When the rear barrel
 section is removed, the front section and cas-
 120 ing 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
 secured thereto by any suitable means. The
 125 cylindrical portion of the feed bar extends for-
 wardly 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 Patent No. 534,657 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 is 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 serves to receive overflow ink when the cells of the collector are filled.

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 linking portion 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 the 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 reser-

voir 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. 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 will feed out from the reservoir when the pen is in point-end-down position, so that a condition is established in which the feed can be controlled by vacuum reservoir or sub-atmospheric pressure 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 sim-

plicity 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), menisci-
 5 cuses 204 are formed, and as is known by those skilled in the art, such menisci-
 10 cuses 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
 15 spaces reaches the upper end of the element 19 as shown in Fig. 22, the menisci-
 20 cuses no longer aid in lifting the ink since they are convex and extend upwardly beyond the walls forming the spaces. These convex menisci-
 25 cuses 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 menisci-
 30 cuses overflow the walls of the spaces and unite to form a body of ink 210 and all forces provided by the menisci-
 35 cuses are dissipated. This body of ink 210 is formed in the space 91, and is lifted by the hydrostatic head of the main body of ink until it reaches the reservoir element 16.
 40 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
 45 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
 50 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
 55 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, menisci-
 60 cuses 211 form in the valve, in the manner described in connection with Figs. 21 and 22, and without interruption form menisci-
 65 cuses 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. Menisci-
 70 cuses 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 menisci-
 75 cuses 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 is located below the reservoir element and above the overflow cells 166. 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 passage 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
 130

n 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 perfectly formed 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 formed 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 such a width or wall-to-wall dimension that it has a capillarity equal to the mean capillarity of the ink storage spaces of the reservoir element. 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 neighbourhood of .008" while that of the control passage is .009". Because of this slight difference, the height 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 sub-atmospheric 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 width or dimension of the control passage (.009") is that dimension as nearly as possible equal to the reservoir spacing, but appreciably greater than the width or 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 width or 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 into 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 aeroplane. 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 Patent No. 534,657 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 Patent No. 534,657. 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 dimensions. 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 Patent No. 534,657, 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 to the reservoir of ink from 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-

c¹-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,
 5 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 provi-
 sion to avoid that circumstance; in the present
 construction, such condition is avoided by the
 10 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 fill-
 15 ing) 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
 20 drained, the pilot channels quickly supply ink
 to the nib. The pen is accordingly always
 ready for instant writing.

Drainback of the collector obviates an ob-
 jection to previous pens from the standpoint
 of leakage due to expansion. Comparison is
 25 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
 30 condition occurred while the collector was
 full, the pen would likely leak, but in the pre-
 sent case the collector would be emptied by
 drain-back (if not by writing) before a second
 expansion condition occurred

35 There may be feed of ink to a limited ex-
 tent from the reservoir element through the
 passage 168 and spaces 160 and 162. How-
 ever, this condition is incidental to the normal
 function of the pen and the communication
 40 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
 45 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 main-
 50 tains 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 main-
 tained on each side of the nib. The desired
 55 relationship between the elements for main-
 taining 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
 60 section; the feed bar is of great length and
 has firm bearing support in a substantial por-
 tion of the bore of the collector; and the nib
 has firm support at its rear end in the col-
 lector and at the shelf 129.

65 The foregoing pen provides for substan-
 tially uniform line intensity throughout its full

range from full to empty condition, as con-
 trasted with an open or vented capillary reser-
 voir pen which writes out a progressively
 fainter line as the reservoir empties; leakage is
 70 substantially eliminated from the sources men-
 tioned, and also any leakage that may other-
 wise result from jarring the pen, because of
 the tortuous path of the various passages be-
 tween the reservoir element and the exterior;
 any disadvantages from loss of capillary hold-
 75 ing 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 construc-
 80 tion 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
 85 pad elements fill the spaces in wall-to-wall
 direction and maintain constant contact be-
 tween the nib and the related elements. Thus
 any inaccuracies, that may occur in any of the
 three elements between which they are placed,
 90 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
 100 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
 105 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
 110 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, synthetic plastic filaments, thinly sliced
 sponge rubber, natural cotton fibres, synthetic
 115 plastic sponge-like or porous structures, or
 cloth. It is also alternatively proposed that
 such pad or pad elements be formed by spray-
 ing material such as plastic filament on the
 nib at the desired location, the material bond-
 120 ing to the nib. Such pad or pad elements may
 be used to great advantage between other ele-
 ments of a pen where it is desired to assure
 effective capillary transfer of ink between
 those elements. This may be in association
 125 with a nib, or it may be between other ele-
 ments.

The preferred form of the reservoir element
 is shown in Figs. 26—32. A sheet 320 of
 perforated thin walled material such as plastic
 or metal foil having secured thereto a plur- 130

ality of generally rectangular elongated relatively rigid spacers 321 all projecting an equal distance height from the sheet, the sheet being capable of being spirally rolled upon itself to form a generally cylindrical reservoir element 322, as shown by Figs. 30—32 inclusive, having uniformly radially laterally spaced convolutions or walls 323 defining capillary ink storage spaces 324 therebetween which extend axially longitudinally of the element. The sheet has perforations 325 therethrough.

The axial or longitudinal direction of the reservoir element is shown horizontally in Fig. 30 and vertically in Figs. 26 and 27. The radial or lateral direction is shown in Figs. 30, 31, and 32. The terms axially and longitudinally are used herein interchangeably and are synonymous. The same is true with reference to the terms radially and laterally.

The spacers 321 may be of any suitable material such as plastic or metal and are preferably imperforate, the perforations preferably being through the sheet proper, thereby eliminating the possibility of forming burrs thereon thus better ensuring that all the spacers will be of their intended height to thereby space the walls 323 the intended distance. The elimination of burrs on the spacers also eliminates ink and air traps being formed where the rough burred ends thereof would engage an adjacent wall.

To the end that the reservoir element 322 has laterally uniformly spaced non-sagging walls and has effective ink paths both laterally and longitudinally of the element, the spacers 321 are rigid relative to the thin walls 323 and are arranged on the walls in a pattern particularly advantageous to these ends. The spacers are disposed in spaced apart relation leaving gaps therebetween so that the ink may flow in the inter-wall spaces in all directions. The spacers are spaced axially and convolutely, and the inter-wall spaces are connected radially by perforations 325 in the walls. The ink can thus effectively flow axially (longitudinally), convolutely (circumferentially) and radially (laterally).

The spacers 321 lie on the walls acutely angularly of the longitudinal direction of the reservoir element 322 formed by the walls 323. Acute angularly as used herein means at a finite acute angle less than ninety degrees. The spacers are arranged to align intersectingly, as best can be seen in Figs. 30 and 31. "Intersect," "intersecting" and "intersectingly" as used herein do not mean actually technically intersecting as two lines meeting at a common point but mean intersecting in the broader sense as more commonly understood, as an underground cable intersects a highway and as a bridge intersects a river, where two lines "intersect" although they may be in different and parallel planes.

The spacers preferably lie at the acute angle

of forty-five degrees to the longitudinal axis of the element and the spacers preferably intersect perpendicularly, although satisfactory results can be achieved with acute angles other than forty-five degrees and with inter-sections other than perpendicular.

Fig. 31 effectively illustrates the radial (lateral) alignment of the spacers and further illustrates how the lengths of the spacers on adjacent walls progressively increase from the innermost wall to the outermost wall.

Fig. 32 clearly illustrates the intersecting alignment radially (laterally) and shows the spaces intersecting perpendicularly.

Fig. 26 shows one manner of disposing the spacers on a sheet to be spirally rolled upon itself to form a generally cylindrical capillary filler-and-reservoir element having radially spaced walls. The spacers 321 are attached or secured to the sheet 320 in any suitable manner and may be formed integrally therewith. The spacers are preferably all disposed on one side of the sheet—the inside of the sheet when spirally rolled as shown in Fig. 29, to form the convolute, generally cylindrical reservoir element shown in Fig. 30. The horizontal direction in Fig. 26 is referred to herein as the convolute or circumferential direction and the vertical direction as the axial or longitudinal direction.

The spacers 321 are arranged in a plurality of parallel convolute rows. Each spacer in each convolute row is disposed one complete convolution from a transversely disposed spacer so that when spirally rolled up, the spacers radially align intersectingly. Each of the convolute rows contains groups of spacers. Each of these groups extends convolutely one complete convolution and contains therein an equal number of spacers spaced apart evenly convolutely. Thus when the sheet is spirally rolled into the cylindrical form of reservoir element each spacer in each group is in radial alignment with a corresponding spacer in each adjacent group.

The spacers within each group are parallel to each other but perpendicular to the spacers within each adjacent group and thus, when the sheet is rolled up, each spacer 321 on any one convolution or wall 323 is not only in radial alignment with but also intersects perpendicularly a corresponding spacer on each adjacent convolution or wall 323.

The convolute rows of spacers are spaced apart evenly axially and the perforations 325 are conveniently arranged in parallel convolute rows intermediate the convolute rows of spacers.

The spacers in adjacent convolute rows are staggered or unaligned so as not to impede flow of ink axially (longitudinally) of the reservoir element. This is accomplished by arranging the spacers so that the spacers in alternate convolute rows form parallel rows axially of the element. This staggered or



attered pattern of the spacers allows the ink flow effectively axially of the reservoir element through the ink storage spaces.

5 Within each group in every row, the spacers are parallel and evenly spaced convolutely a sufficient distance to prevent ink from forming a meniscus bridging two convolutely spaced spacers to thus impede or block ink flow axially of the element. The convolute distance
10 each between groups, i.e. from the last spacer in each group to the first spacer in the next group is also of a sufficient distance to prevent such menisci and the attendant blocking of or imped-
15 ance to axial ink flow.

20 The spacers in each convolute row increase in length from the innermost convolution or wall 323 to the outermost convolution or wall 323, as the convolutions themselves increase in convolute or circumferential length. The
25 spacers on the inner convolutions need not be as long as they must be on the outer convolutions to give the walls the rigidity and support necessary for uniform or even wall spacing. This arrangement results in a reservoir ele-
30 ment of more storage capacity than would be the case if the same sized spacers were used throughout the element as were used on the outermost wall, and also results in a saving of
35 the material from which the spacers are made. As shown in Fig. 26 the spacer lengths increase, group by group, i.e. the spacers within each group are all of the same length but of a
40 different length than the spacers within any other group. The spacers, however, can be arranged to continuously increase in length throughout each convolute row and need not
45 increase group by group, or they can be arranged so that two or more adjacent groups contained spacers of equal lengths but of different lengths than the spacers in groups
50 convolutely disposed from said two or more groups.

55 One of the important advantages of having the spacers increase in length from the innermost convolution to the outermost convolution is that this facilitates the substantial radial alignment of the spacers during the winding operation. Winding tolerances can thus be less
60 strict than would be the case if the spacers were all of the same length. Thus, even though the centre points of the spacers are not perfectly aligned radially because of lack of perfection in the practical manufacturing winding techniques, the spacers will intersect at points
65 other than their centre and still provide the necessary radial support for giving the desired rigidity and wall to wall spacing. The deviations from perfection in the winding technique are thus compensated for by providing spacers of varying lengths, increasing in length from the inner convolution to the outer convolution.

The spacers may all be of the same height to thereby space all of the walls the same distance apart, or the height of the spacers may be varied group by group or continuously, in

a manner similar to that described above for the length of the spacers, to accomplish a progressively varying wall spacing throughout the reservoir element. It may, for example, be desirable to space the inner walls more closely than the outer walls. The spacers are shown in Figs. 28, 31, and 32 as all being of equal height, but spacers of varying height are within the scope of this invention.

70 The height of the spacers of course must be such to provide the reservoir element with the wall spacing which obtains the necessary and desired capillarity. The filler-and-reservoir element is designed so that when used in a writing instrument it will have sufficient capil-
75 larity to fill itself by capillary action and to maintain ink therein under all normal circumstances but insufficient to prevent withdrawal of ink during writing. The width of the spacers
80 should be as small as possible so that the spacers do not unnecessarily decrease the ink storage capacity of the reservoir element. The length of the spacers is selected to give the necessary rigidity to the walls to aid in main-
85 taining uniform wall spacing but not to interfere with the rolling operation in forming the reservoir. Dimensions will depend to some extent upon the thickness of the walls and upon the materials used for walls and spacers. Dimensions which have proved satisfactory but
90 are not to be construed as limiting the invention are as follows:

95 For a sheet of plastic material about .001" thick, spacers of plastic may be about .017" wide, about .008" high, and may have lengths of about .050" for the spacers in the group on the innermost wall, the lengths increasing as
100 above explained to about .125" for the spacers in the group on the outermost wall.

105 It will be recognized that the invention is applicable to reservoirs including other forms of capillary elements, such as a cylindrical reservoir element comprising a plurality of radi-
110 ally spaced concentric tubes, a reservoir element comprising a plurality of flat walls spaced apart to form capillary spaces therebetween, and other reservoir elements, although such
115 embodiments of the invention have not been shown.

WHAT WE CLAIM IS:—

1. A fountain pen having an ink reservoir, a writing point, and feed means connecting the reservoir and the writing point, the reservoir including a capillary element capable of sub-
120 stantially filling with ink by capillary action, a filling entrance leading to the capillary element, and means for closing the filling entrance to create a sub-atmospheric pressure in the reservoir during write-out of ink there-
125 from, and the feed means including one or more passages through which ink is fed from the reservoir to the writing point and through which air from the atmosphere enters the reservoir to replace ink written out from the
130 latter and to vary the sub-atmospheric pres-



scattered pattern of the spacers allows the ink to flow effectively axially of the reservoir element through the ink storage spaces.

5 Within each group in every row, the spacers are parallel and evenly spaced convolutely a sufficient distance to prevent ink from forming a meniscus bridging two convolutely spaced spacers to thus impede or block ink flow axially of the element. The convolute distance
10 between groups, i.e. from the last spacer in each group to the first spacer in the next group is also of a sufficient distance to prevent such menisci and the attendant blocking of or imped-
each 15 ance to axial ink flow.

15 The spacers in each convolute row increase in length from the innermost convolution or wall 323 to the outermost convolution or wall 323, as the convolutions themselves increase in convolute or circumferential length. The
20 spacers on the inner convolutions need not be as long as they must be on the outer convolutions to give the walls the rigidity and support necessary for uniform or even wall spacing. This arrangement results in a reservoir element
25 of more storage capacity than would be the case if the same sized spacers were used throughout the element as were used on the outermost wall, and also results in a saving of the material from which the spacers are made.
30 As shown in Fig. 26 the spacer lengths increase, group by group, i.e. the spacers within each group are all of the same length but of a different length than the spacers within any other group. The spacers, however, can be
35 arranged to continuously increase in length throughout each convolute row and need not increase group by group, or they can be arranged so that two or more adjacent groups contained spacers of equal lengths but of
40 different lengths than the spacers in groups convolutely disposed from said two or more groups.

45 One of the important advantages of having the spacers increase in length from the innermost convolution to the outermost convolution is that this facilitates the substantial radial alignment of the spacers during the winding operation. Winding tolerances can thus be less strict than would be the case if the spacers
50 were all of the same length. Thus, even though the centre points of the spacers are not perfectly aligned radially because of lack of perfection in the practical manufacturing winding techniques, the spacers will intersect at points
55 other than their centre and still provide the necessary radial support for giving the desired rigidity and wall to wall spacing. The deviations from perfection in the winding technique are thus compensated for by providing spacers
60 of varying lengths, increasing in length from the inner convolution to the outer convolution.

65 The spacers may all be of the same height to thereby space all of the walls the same distance apart, or the height of the spacers may be varied group by group or continuously, in

a manner similar to that described above for the length of the spacers, to accomplish a progressively varying wall spacing throughout the reservoir element. It may, for example, be desirable to space the inner walls more closely than the outer walls. The spacers are shown in Figs. 28, 31, and 32 as all being of equal height, but spacers of varying height are within the scope of this invention.

70 The height of the spacers of course must be such to provide the reservoir element with the wall spacing which obtains the necessary and desired capillarity. The filler-and-reservoir element is designed so that when used in a writing instrument it will have sufficient capillarity to fill itself by capillary action and to maintain ink therein under all normal circumstances but insufficient to prevent withdrawal
75 of ink during writing. The width of the spacers should be as small as possible so that the spacers do not unnecessarily decrease the ink storage capacity of the reservoir element. The length of the spacers is selected to give the necessary rigidity to the walls to aid in maintaining uniform wall spacing but not to interfere with the rolling operation in forming the reservoir. Dimensions will depend to some extent upon the thickness of the walls and upon the materials used for walls and spacers. Dimensions which have proved satisfactory but are not to be construed as limiting the invention are as follows:

For a sheet of plastic material about .001" thick, spacers of plastic may be about .017" wide, about .008" high, and may have lengths of about .050" for the spacers in the group on the innermost wall, the lengths increasing as above explained to about .125" for the spacers in the group on the outermost wall.

It will be recognized that the invention is applicable to reservoirs including other forms of capillary elements, such as a cylindrical reservoir element comprising a plurality of radially spaced concentric tubes, a reservoir element comprising a plurality of flat walls spaced apart to form capillary spaces therebetween, and other reservoir elements, although such embodiments of the invention have not been shown.

WHAT WE CLAIM IS:—

1. A fountain pen having an ink reservoir, a writing point, and feed means connecting the reservoir and the writing point, the reservoir including a capillary element capable of substantially filling with ink by capillary action, a filling entrance leading to the capillary element, and means for closing the filling entrance to create a sub-atmospheric pressure in the reservoir during write-out of ink therefrom, and the feed means including one or more passages through which ink is fed from the reservoir to the writing point and through which air from the atmosphere enters the reservoir to replace ink written out from the latter and to vary the sub-atmospheric pres-

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sure therein.

2. A pen according to claim 1, in which the capillary reservoir element has a capillary strength sufficient to sustain a column of ink substantially of its own length but insufficient to sustain a column of ink of the combined length of itself and the feed means.

3. A pen according to claim 1 or 2, in which the reservoir is capable of substantially filling by capillarity when the rearmost end thereof is inserted in ink, and in which a barrel encloses the reservoir, the barrel having a rear portion which is detachable to expose the reservoir for insertion thereof into ink.

4. A pen according to claim 3, in which the filling entrance is in the rearmost end of the reservoir, and in which the closure means for the filling entrance are provided in the detachable rear portion of the barrel, and are removable with the rear portion.

5. A pen according to any of claims 1 to 4, in which the reservoir element is substantially enclosed in a casing wherein the filling entrance is provided, and in which a porous member covers the filling entrance, the porous member having passages sufficiently large to permit ink to pass therethrough in response to hydrostatic pressure, but sufficiently small to provide necessary capillarity to hold ink therein and prevent the passage of air therethrough following filling and when the rear end of the pen is disposed upwardly.

6. A pen according to claim 5, in which the closure means associate with the casing to cover the porous member when a detachable rear portion of the barrel is in place on the barrel.

7. A pen according to claim 5 or claim 6, in which the casing for the reservoir element has a dome element superposed over the porous member and having a central closed portion projecting away from the reservoir.

8. A pen according to any of claims 1 to 7, in which the feed means includes a capillary ink feed passage and a control passage having a portion of capillary dimension forming a weir that in response to the pressure differential on ink therein will permit air bubbles to pass upwards through it to modify the sub-atmospheric pressure acting on the ink in the reservoir.

9. A pen according to claim 8, in which the control passage includes linearly successive portions of such dimensions relative to the ink feed passage that air passes through the control passage before it does the ink feed passage in response to a rarefied air condition in the reservoir, and in which the weir portion of the control passage is of only minor length relative to the total length of the control passage and is of greater lateral dimension than the remaining portions of the control passage, and is located forward of the reservoir element.

10. A pen according to claim 9, in which the control passage rearward of the weir in-

cludes as portions extending substantially throughout the remainder of its length a main relatively large portion through which air can bubble up into the reservoir and a second portion communicating with the first along its length and of relatively minor dimensions and great capillarity.

11. A pen according to any of claims 8 to 10, in which the ink feed passage extends longitudinally between the reservoir element and the writing point, and includes as portions extending substantially throughout its length a main relatively large portion determining substantially the capacity of the passage for carrying ink from the reservoir to the writing point and a second pilot portion communicating with the first, of relatively minor dimensions and great capillarity, both portions of the feed passage being of greater capillarity than the reservoir element.

12. A pen according to any of claims 8 to 11, in which the feed means includes a feed bar extending through the reservoir element and having a longitudinal control passage with a segment within the reservoir element having a capillarity closely approximating the mean capillarity of the reservoir element.

13. A pen according to any of claims 8 to 12 in which the feed means includes a collector having overflow cells which are of lesser capillarity than the ink feed passage and which communicates with the ink feed and control passages below the reservoir element for receiving ink therefrom in excess of that required for writing purposes.

14. A pen according to any of claims 1 to 13, in which the reservoir element has ink storage spaces distributed throughout a wide transverse area and opening through to the front end thereof, in which a collector is mounted in engagement with the front end of the reservoir element, the collector having an axial bore at least a portion of which is tapered forwardly, and the collector having radial capillary feed passages communicating with the ink storage spaces of the reservoir and opening through to the tapered portion of the bore, and in which a feed bar is mounted in the collector to form a converging space between itself and the surface of the tapered bore portion, the feed bar including a longitudinal ink feed passage of capillary dimension communicating with the converging space and the nib.

15. A pen according to any of claims 1 to 14, in which the reservoir element comprises a plurality of laterally spaced thin perforated wall portions and a plurality of elongated spacers lying on the wall portions spacing them apart to define capillary ink storage spaces between the walls and extending longitudinally of the element, the spacers lying on the wall portions at acute angles to the longitudinal direction of the wall portions and laterally aligned to intersect, thereby providing lateral



st port for uniformly spacing the wall portions and providing ink paths for the effective flow of ink longitudinally and laterally of the element.

5 16. A pen according to claim 15 in which the reservoir element is generally cylindrical in form and the wall portions are radially spaced.

10 17. A pen according to claim 15 or claim 16 in which the reservoir element is a thin perforated sheet spirally rolled to form a plurality of convolutions as the wall portions.

15 18. A pen according to claim 17 in which the spacers are arranged in parallel rows in the direction of the convolutions of the element and so that the spacers on adjacent convolutions align intersectingly, the spacers increasing in length in each convolute row from the innermost convolution to the outermost convolution.

19. A fountain pen substantially as described with reference to Figs. 1 to 22 and 24 of the accompanying drawings.

20. A fountain pen substantially as described with reference to Figs. 1 to 22 and 24 of the accompanying drawings with the modification shown in Fig. 23. 25

21. A fountain pen substantially as described with reference to Figs. 1 to 22 and 24 of the accompanying drawings with the modification shown in Fig. 25. 30

22. A fountain pen substantially as described with reference to Figs. 1 to 22 and 24 of the accompanying drawings with the reservoir element formed as shown in Figs. 26 to 32. 35

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