United States Patent [19]

Dickinson, III et al.

[11] **3,811,443**

[45] **May 21, 1974**

[54] **METHOD AND APPARATUS FOR ARTIFICIAL INSEMINATION**

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[21] Appl. No.: **108,891**

[52] **U.S. Cl.** **128/235**

[51] **Int. Cl.** **A61m 37/00**

[58] **Field of Search** 128/213, 235, 238, 130, 128/242–244, 271; 119/1

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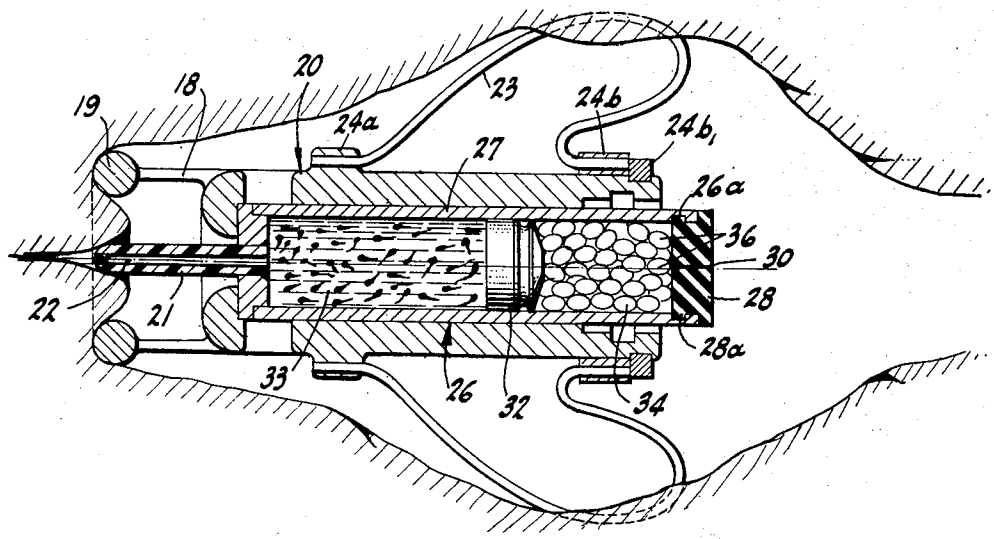
[57] **ABSTRACT**

A semen container carrying an anchor assembly adapted to engage the reproductive tract wall of an animal to prevent expulsion therefrom after insertion therein and including means to urge semen from the container into the tract toward the ovary a predetermined time after insertion of the container. In order to properly time the release of semen, the semen urging means may be actuated in response to means for sensing ovulation precursive fluid secretions including a soluble sensing element. Also, semen release may be delayed independent of any sensing means to begin until after a predetermined time selected to allow some semen flow during ovulation. In the latter case, the semen is capable of releasing semen over an extended period of time. Multiple semen containers adapted to release semen in sequence increase the duration of semen release.

19 Claims, 10 Drawing Figures



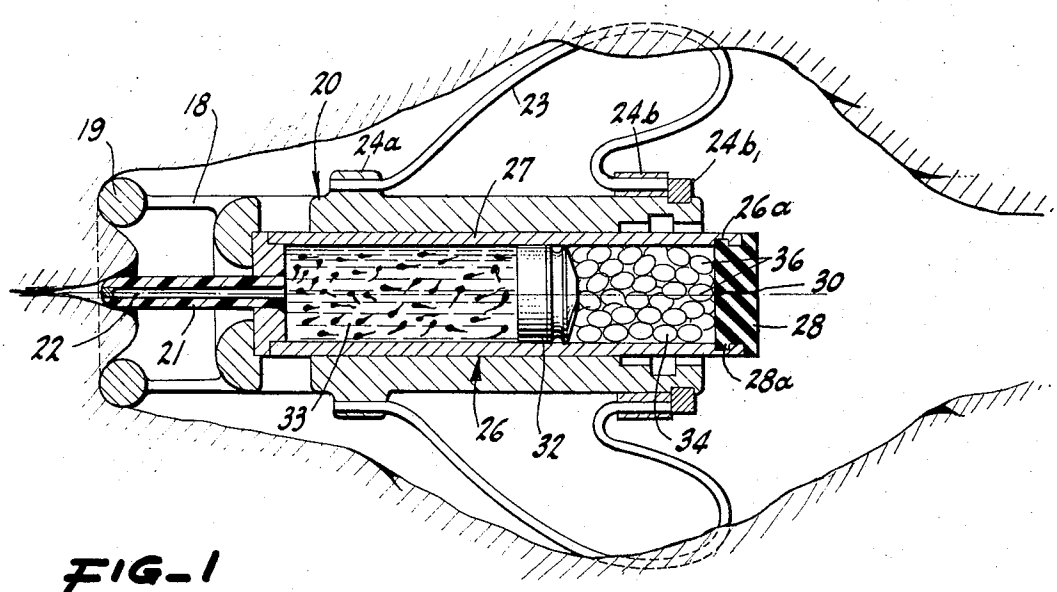


FIG-1

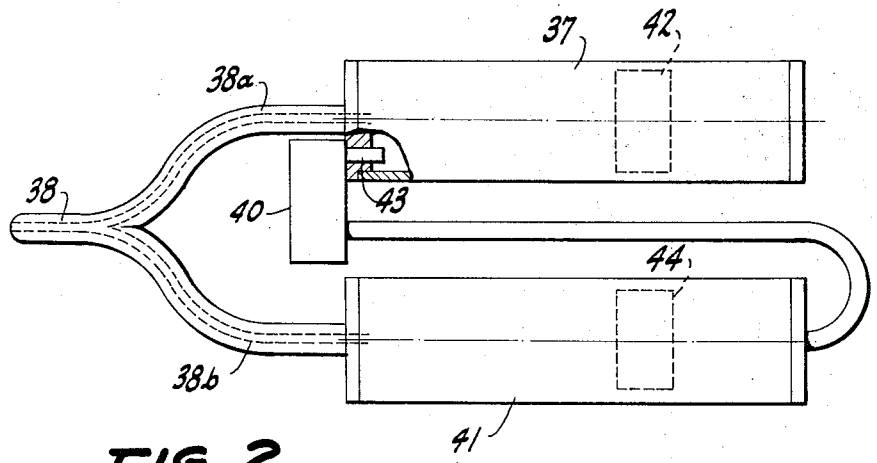


FIG-2

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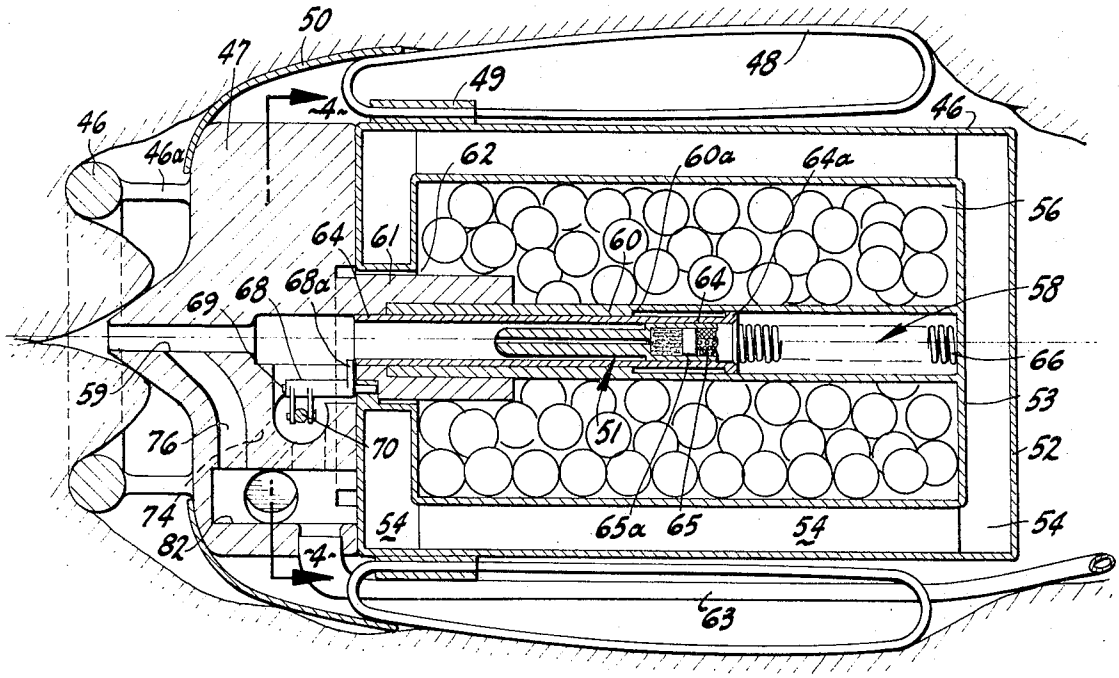
FIG_3



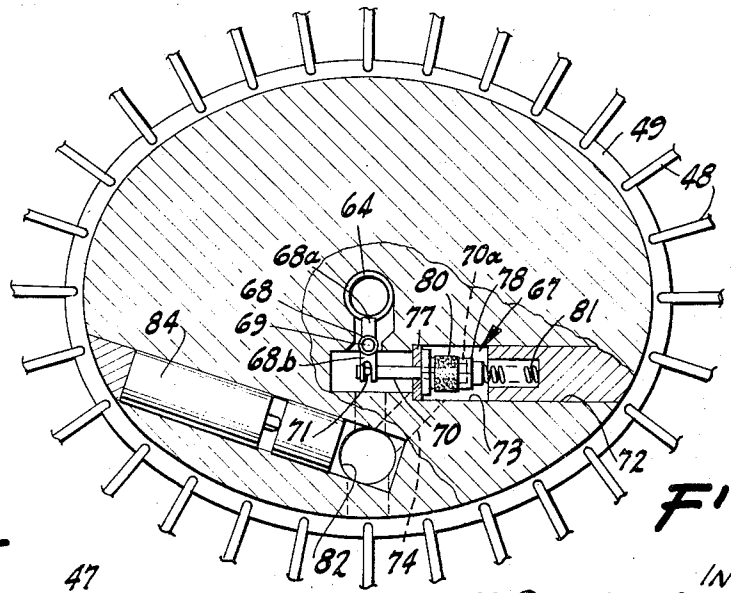


FIG_4

FIG_5

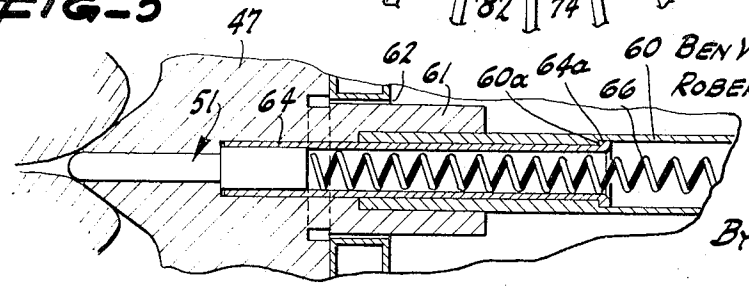


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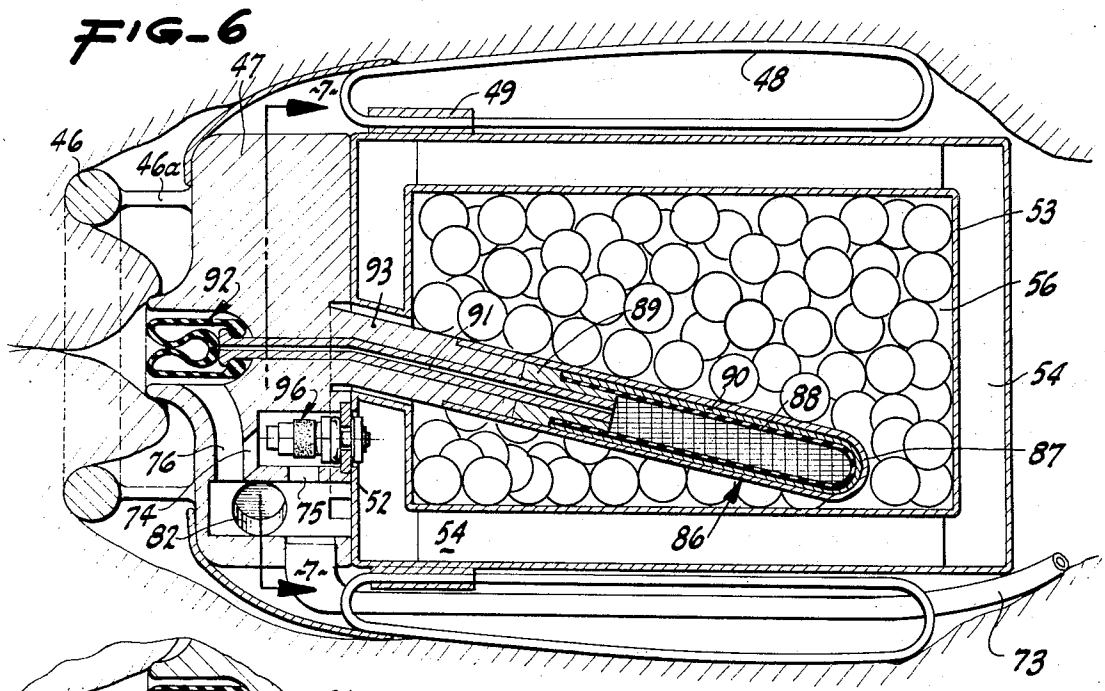
FIG-6



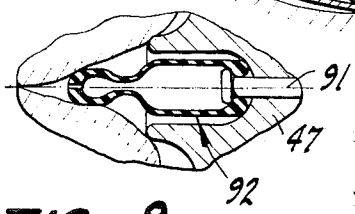


FIG-8

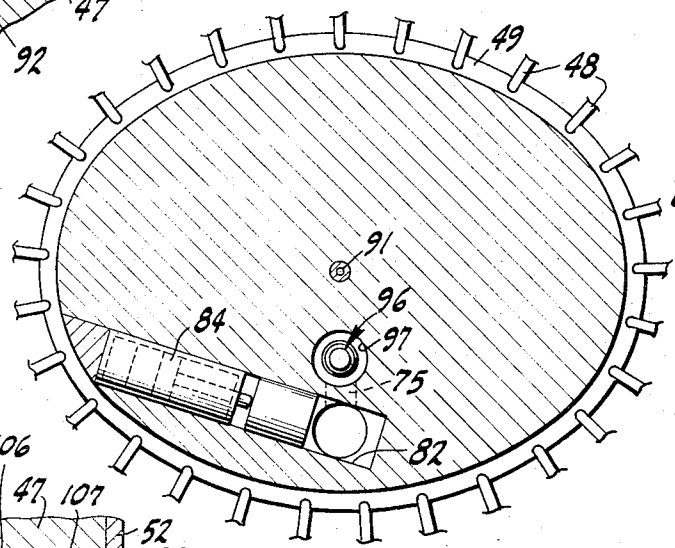


FIG-7

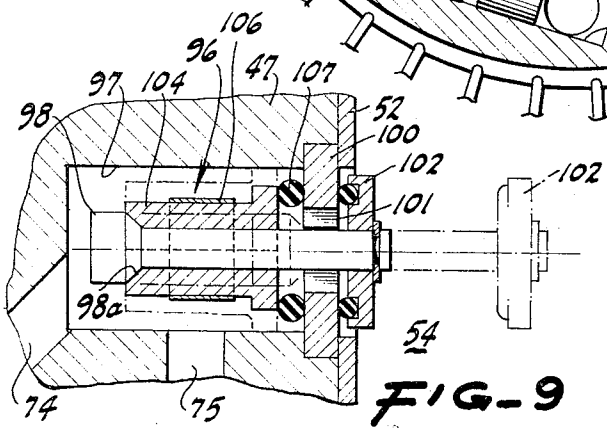


FIG-9

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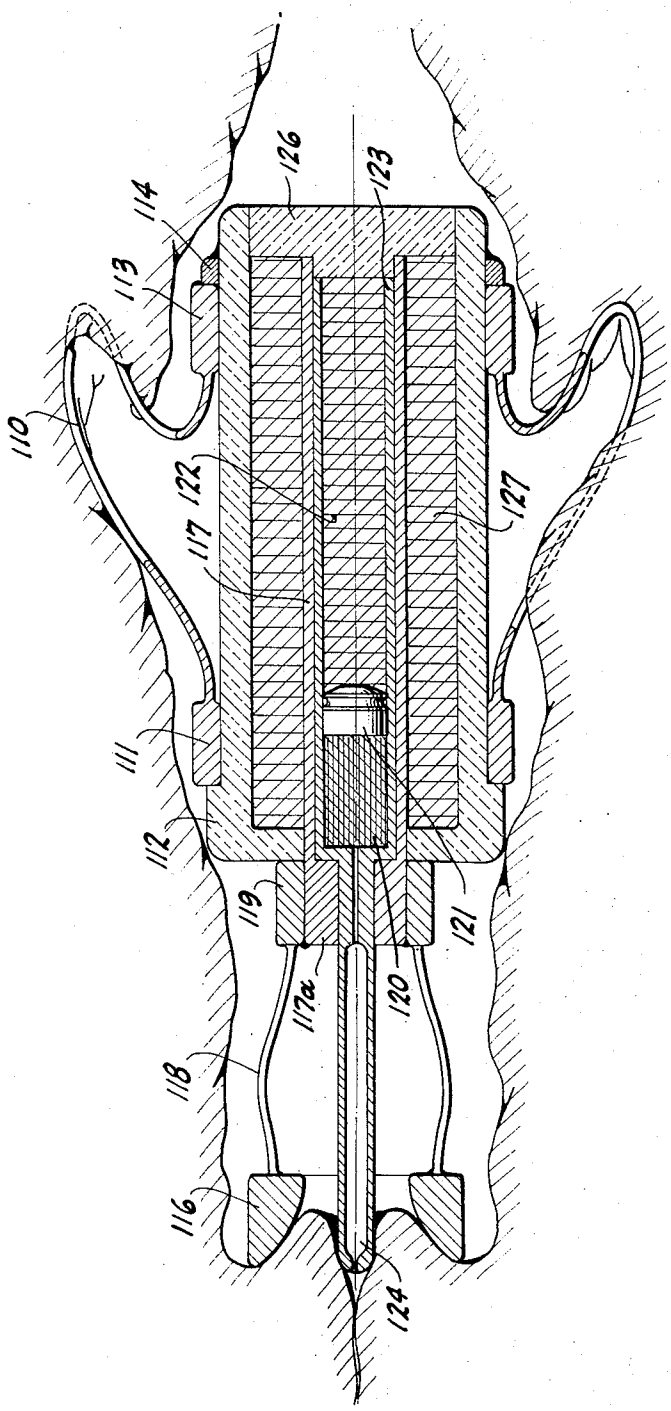

FIG. 10

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METHOD AND APPARATUS FOR ARTIFICIAL INSEMINATION

BACKGROUND OF THE INVENTION

Artificial insemination may be performed on animals of the type having a tubular reproductive tract including an ovary. Exemplary of such animals are the cow, hogs, sheep, dogs, chickens, horses, humans, and the like. For purposes of clarity, the following description will relate to a cow, which has a reproductive tract including a uterus opening through a cervix into a vagina. It should be understood that, unless otherwise specified, the description should be construed to generally relate to other animals of the above type. Of course, appropriate variations in the reproductive tract configuration and timing of the reproductive cycle should be taken into account.

The present conventional method for performing insemination of the cow is by first visually attempting to determine the period of peak fertility in terms of external behavioral estrus phenomena, and then manually injecting a supply of semen into the cow's vagina, cervix or uterus. The techniques presently employed for detecting peak fertility are not highly efficient. Ovulation or fertility in a cow is during the period of "estrus" or "standing heat," averaging about 15–18 hours, and of that short time period, the best results for artificial insemination occur in the peak fertility period of about 12 hours.

Even if the present methods for determining peak fertility were sufficiently accurate for practical purposes, overlapping this period during the relatively short manual insemination operation is unpredictable. It would be desirable to provide a prolonged release of semen to increase the probability of insemination during peak fertility. Even if a prolonged release mechanism were available, it would be employed in a two step process of first detecting peak fertility, as by a variety of visual observation techniques, followed by manual insertion of the device. It would be particularly advantageous to provide a device which is insertable into the animal's reproductive tract which is capable of automatic insemination of the animal at the proper time without the necessity of either visual detection of peak fertility or for subsequent manual insemination.

SUMMARY OF THE INVENTION AND OBJECTS

It is a general object of the present invention to provide a device and method for artificial insemination which overcomes the aforementioned disadvantages.

It is a particular object of the invention to provide a semen containing device capable of retention in the animal's reproductive tract and also capable of automatic semen release.

It is another object of the invention to provide a device of the aforementioned type capable of sensing the peak fertility period and of actuating the release of semen into the animal's reproductive tract in response to that sensing.

It is a further object of the invention to provide a device of the aforementioned type capable of preserving semen in the container within the reproductive tract over an extended period of time.

It is a particular object of the invention to provide a device capable of causing a substantially predictable time range or specific time for ovulation (synchronization of estrus) of the animal and for causing semen to be released in that time range.

Further objects and features of the present invention will be apparent from the following description in which the preferred embodiments are set forth in detail in conjunction with the accompanying drawings.

In accordance with the above objects, the device comprises a semen container carrying an anchor assembly adapted to engage the reproductive tract wall of an animal to prevent spontaneous expulsion therefrom. Means are provided to urge semen from the container into the tract towards the ovary a predetermined time after container insertion. This means may be actuated by response to means for sensing ovulation precursive fluid secretions. The semen is preserved at a temperature below cow ambient temperature within the container. With the anchor assembly formed to stimulate the reproductive tract wall to cause a predictable time or time range for ovulation, time delay means may be provided for preventing actuation of the semen urging means until after a time interval selected to allow at least some semen flow into the reproductive tract during ovulation. A number of methods may be practiced employing the above types of devices for artificial insemination. The basic method comprises inserting the container supply of semen into the reproductive tract, anchoring the container therein for a substantial period of time, and forcing the semen from the container toward the ovaries over a prolonged period of time. In order to determine the proper timing of semen release to correspond to ovulation, the release may be delayed to begin after secretion of ovulation precursive fluids and in response to the same. Another method of proper insemination timing is to artificially stimulate the reproductive tract wall by means of the anchor assembly placement and/or total or partial removal or change in contact pressure level to cause a predictable time range for ovulation and to delay semen release until that time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a device according to the invention anchored into the vagina of an animal capable of a prolonged release of semen into the cervix.

FIG. 2 is a schematic view of a device similar to that of FIG. 1 in which semen is supplied over two prolonged sequential periods of time.

FIG. 3 is a cross-sectional view of a vaginally inserted artificial insemination device of a type responsive to an ovulation precursive fluid detection mechanism.

FIG. 4 is a front view of FIG. 3 partially broken away.

FIG. 5 is a cross-sectional view detailing a device of FIG. 3 in a semen injecting position.

FIG. 6 is another embodiment of a device of the type illustrated in FIG. 3.

FIG. 7 is a cross-sectional view of the device of FIG. 6 taken along the line 7—7.

FIG. 8 is an enlarged view of the semen outlet port in an ejecting position.

FIG. 9 is an enlarged view of the sensing mechanism of FIG. 6.

FIG. 10 is a cross-sectional view of an artificial insemination device inserted in the vaginal lumen of an animal.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, one embodiment of an artificial insemination device is illustrated retained within the vagina with the semen release directed toward the cervix and includes an elongate housing **20** formed of a non-irritating material in a generally tubular configuration. The posterior end of the housing is interconnected, by means of a follower assembly comprising flexible spaced apart follower elements **18**, extending in a composite annulus, to a cervical ring **19** which slides over and is retained by the cervical lip of a cow. An elongated nozzle **21** projects from the housing to define a semen outlet duct **22** extending into the cervix. The follower assembly serves to maintain nozzle **21** in this position even though there is relative movement of the housing in the vagina. Housing **20** is primarily retained within the vaginal lumen by means of an anchor assembly of the type including a plurality of spaced apart resilient loop elements suitably formed of nylon **23** slideably received within slots of axially spaced fixed posterior ring **24a** and slideable anterior ring **24*b***, both mounted to housing **20.** A slowly disintegrable plug **24*b*$_1$** retains ring **24*b*** in the illustrated position until after semen release and then permits ring **24*a*** to slide anteriorly with a consequent anchor collapse. The housing and anchor assembly illustrated herein are of the general type and description of the application entitled "Device for Insertion into the Reproductive Tract and Method of Using Same" U.S. Ser. No. 108,889, filed Jan 22, 1971, filed simultaneously herewith. Housing **20** corresponds to the shell illustrated in FIG. **12** of that application which remains after removal of the internal working parts in the described manner.

Semen container **26** includes a tube **27** slideably received within the internal opening defined by annular housing **20** concentrically therewith. It is apparent that container **26** may be inserted into that opening of the device described in application U.S. Ser. No. 108,889 subsequent to the visual indication of estrus and removal of the indicating core of the device. According to this embodiment of the invention, the artificial insemination device serves to supply semen over a prolonged period of time subsequent to estrus indication to increase the probabilities that insemination would occur during the relatively short peak ovulation or estrus period. It should be understood that assuming that the insemination device is capable of storing semen either frozen or at a temperature below the animal's ambient temperature over a sufficiently long period of time to cover a substantial portion or all of the reproductive or estrus cycle of the animal, then the device could be inserted into the animal without the necessity for prior estrus determination. In that event, the device functions as an independent self-container device for artificial insemination. The ability of the anchor assembly to both change and reset the beginning of the reproductive cycle and to shorten the cycle, as described in the application entitled "Artificial Method for Modifying the Reproductive Cycle in Animals" filed simultaneously herewith U.S. Ser. No. 108,922, filed Jan 22, 1971, facilitates this latter development.

Referring again to FIG. 1, container **26** is sealed at its posterior end by plug **28** seating in an accommodating recess of the container wall. Nozzle **21** is formed of a resilient material such as natural and synthetic rubber or plastic so that the recess forms a tight fit. If it is desired to place the semen into the cervix rather than at its posterior os, the front portion of the nozzle may be formed into a nipple defining a semen outlet duct **22** having a diameter sufficiently small to retain uncompressed semen in the container and sufficiently large to pass semen therethrough under back pressures of the type described hereinafter without damage to the spermatozoa. By forming the nipple of an expandable material, it is capable of assisting the above dual function of duct **22** by expansion upon the application of force to assist the flow of semen. Alternatively a pressure breakage seal may be inserted into duct **22.** Plug **28** fits into the rear open portion of container **26** in fluid sealing engagement. The seal is assisted by providing a neck portion **28*a*** which fits into a corresponding annular groove **26*a*** of cylindrical portion **26.** For reasons that will be explained hereinafter, a liquid opening **30** is provided in plug **28.**

The semen urging assembly includes a piston **32** slideably received within tube **27** in fluid sealing engagement to divide container **26** into a semen chamber **33** and an expansive force chamber **34.** The material in chamber **34** is capable of expansion after a predetermined time to drive piston **32** anteriorly. Devices of this type capable of creating motion by expansion are fully described in our copending application entitled "Method and Apparatus for Creating Motion" filed simultaneously herewith U.S. Ser. No. 108,892, filed Jan. 22, 1971. It should be understood that the other embodiments of motion creating devices of that application may be employed for purpose of the present artificial insemination device. In the embodiment shown herein, a plurality of germinatable seeds **36** are enclosed within chamber **34.** By the injection of water into the chamber as by hypodermic syringe through opening **30,** the water wets the seeds which causes them to germinate with the consequent slow evolution of carbon dioxide which in turn creates a pressure head to drive piston **32** anteriorly in a time well in excess of 1 hour. As an alternative to inserting water through plug **30,** the water could be premixed with the seeds just prior to insertion into the animal to begin the germination process. In this manner, semen in chamber **33** is urged forward through outlet duct **22** and into the cervix at a predetermined prolonged rate dependent upon the number of seeds, the amount of water, the size of chamber **34,** and the frictional resistance of the system. Exemplary of the type of seeds which may be used for this purpose are radish.

The semen container **26** is adapted to be inserted into the shell illustrated in FIG. **12** of U.S. Ser. No. 108,889 which remains after the removal of the ovulation precursive (estrus) fluid assembly. When the above device is used for artificial insemination following the detection of estrus, a time span on the order of 12 to 24 hours for continuous insemination would be sufficient. It should be noted that properly extended sperm in a container is viable at cow vagina ambient temperature (approximately 102°F) with the necessity of preservative precautions for about 48 hours.

Referring to the schematic diagram of FIG. **2,** a device is shown for sequential artificial insemination in which a first semen supply assembly **37** forces semen through branch **38*a*** of duct **38** into the cervix until the supply is nearly exhausted. A trigger mechanism **40** responsive to that exhaustion then actuates the supply of

semen from supply assembly through branch 38*b* into duct 38. In this manner a continuous serial supply of semen from two separate sources is directed into the cervix. One means of accomplishing this sequential semen supply is described in the aforementioned application U.S. Ser. No. 108,892 in conjunction with FIG. 6. In FIG. 2 of the present application, a semen supply is disposed to the left of a piston 42 and a motion creating device to the right thereof. When piston 42 reaches sensing element 43, it causes the actuation of the motion creating device in assembly 41 to the right of piston 44 to urge semen to the left of the same piston through duct 38. It should be apparent that three or more semen supply assemblies could be sequentially linked in like manner.

A device of the above sequential type is capable of providing a continuous semen supply for an extended period of time sufficient to allow the device to be inserted during any time in the reproductive cycle so that at least some semen reaches the ovaries during ovulation even without prior estrus indication to determine the proper timing of insertion. Since semen is viable at the cow's ambient reproductive tract temperatures (approximately 102°F) for about 48 hours, that is the maximum time of effective operation in the absence of semen refrigeration. This time may be increased in successive semen sources of up to 48 hours by maintaining successive sources in a frozen or reduced temperature state until triggered or released.

Referring to FIGS. 3–5, an embodiment of an artificial insemination device is illustrated which is insertable into an animal's reproductive tract in, say, the vagina of a cow and which functions to detect the estrus period and to release semen toward the animal's ovaries as into the cow's cervix in response to detection. The device includes an elongated housing 46 affixed to a casing 47 so that as shown in FIG. 4 the overall device has a generally cylindrical configuration. As in the device of FIG. 1, housing 46 is engaged with the vaginal walls by a series of spaced apart resilient loop elements 48 retained within rings 49 about the circumference of the housing. A hood 50 extend between the front portion of casing 47 and each loop element 48 in order to provide a seal so that vaginal mucus does not either cause premature actuation of the sensing assembly or dilute semen if the semen is deposited at the fornix. A cervical ring 46 is connected through follower elements 46*a* to casing 47 of the foregoing type to slide over the cervical lip for alignment of the opening in the semen container with the cervix.

Housing 46 serves to provide insulation for semen in container 51 prior to movement of the same to a position projecting through casing 47 in response to estrus detection. For this purpose, housing 46 includes outer and inner walls 52 and 53 which define an annular vacuum chamber 54 to provide superior insulation. Walls 52 and 53 should be of a good insulating material such as a double walled vacuum insulated flask (thermos vacuum flask) or super insulation such as alternate layers of low thermal conductivity paper and aluminum foil or aluminized mylar. These are respectively available from Union Carbide Corp. or Norton Company. For proper functioning the layered insulation is held at a hard vacuum. To preserve the semen, it is maintained in a frozen or reduced temperature state in container 51 by cooling from refrigeration chamber 56. One means for cooling is to pack chamber 56 with dry ice (solid CO_2) or another cryogenic substance such as liquid nitrogen. A semen urging assembly 58 is provided including means for driving container 51 from chamber 56 through opening 59 of casing 47 so that the semen liquefies or reduces in viscosity and for thereafter urging the liquid semen from the container into the cervix over an extended period of time. Assembly 58 includes a tubular enclosure 60 maintained in axial alignment with housing 46 by annular plug 61 which fits between the front opening in housing 46 and enclosure 60 to form a seal therebetween. This seal is interrupted by small outlet ducts 62 which communicate via an annular groove into an opening in casing 47 and thence to an exhaust tube 63 through the vagina to the surroundings. Ducts 62 are small enough that they do not substantially interfere with the insulation in chamber 56 but are large enough that any change of state from solid to gaseous carbon dioxide due to small losses of insulation will enable the gas to be exhausted without any problem of excessive gaseous pressure buildup within the chamber. Container 51 is fixably carried by sleeve 64 which is, in turn, slideably received within tubular enclosure 60. Sleeve 64 includes a shoulder 64*a* which meets with an accommodating shoulder 60*a* of enclosure 60 to provide a means for stopping container 51 in a release position as shown in FIG. 5. Opening 59 includes a forward portion with a smaller diameter than the rear portion to provide a seat therebetween onto which sleeve 64 projects upon forward movement of container 51 which also serves to retain the container within the housing. The semen container is urged forward by spring 66 disposed within enclosure 60 which moves the container in a forward sliding manner upon release of the retaining means as explained hereinafter.

A prolonged semen release mechanism is provided of the type disclosed in application U.S. Ser. No. 108,892 and, in this instance, includes a compartment 65 for seeds, capable of producing CO_2 during germination, and refrigerant, said compartment having a slideable piston 65*a* forming a wall with the semen container. When compartment 65*a* is driven out of the refrigeration, the refrigerant melts and the seeds germinate to produce CO_2 which slowly builds up to push piston 65*a* slowly forward with a consequent slow release of semen.

Mechanically operated estrus fluids sensing assembly 67 retains container 51 within chamber 56 and, upon actuation, permits spring 66 to move the container into a forward semenreleasing position. The sensing assembly functions in a similar manner to that of the aforementioned application U.S. Ser. No. 108,889. Assembly 67 includes a retaining sear element 68 mounted to a support 69 journalled in an enlarged portion of housing 47. Element 68 includes an upright portion 68*a* which projects into the opening in housing 47 to retain sleeve 64 and thus container 51 in a semen storage position. Element 68 also includes downwardly projecting slide arms 68*b* which are coupled to bar 70 through cross pins 71 through slots in the side arms 68*b* so that portion 68*a* rotates away from sleeve 64 upon linear movement of bar 70. Sensing assembly 67 is retained within an enclosure 72 which defines a chamber 73 communicating through duct 74 to estrus fluid inlet passage 76. Referring to FIG. 4, the right portion of bar 70 projects through a plate 77 and includes a cammed surface portion 70*a* seated within an accommodating recessed portion body 78 as in the aforementioned co-

pending application. Body **78** is formed of mating cylinder halves which are retained in an abutting position by sensing element **80** formed of a material which has a relatively high tensile strength and which is soluble in water or in a solution (e.g., estrus) with a high aqueous concentration. As explained in application U.S. Ser. No. 108,889, polymers of the polyethylene oxide type are particularly suitable for this purpose. Referring to FIG. **4**, bar **70** is urged to the left position by a spring **81** carried by enclosure **72**.

In operation of the sensing assembly, estrus fluids flowing from the cervix through opening **59**, inlet passage **76** and duct **74** dissolve sensing element **80** causing the mating portions of body **78** to release and spring **81** moves bar **70** to the left to pivot element **68** away from sleeve **64**. In the initially inserted position of the device, fluids proceed from the cervix through opening **59** through passage **76** and directly therefrom into the vagina through bypass ports **82** without proceeding into enclosure **72** to contact sensing element **80**. This initial bypass position may be necessary since it has been found in some species that the insertion of a foreign object of a particular type into the vagina triggers a voluminous initial mucus flow which is not indicative of estrus. This phenomenon is fully discussed in application U.S. Ser. No. 108,889.

To channel the fluids from the cervix into contact sensing element after a predetermined period of time to allow the aforementioned initial mucus to bypass the same, a time delay mechanism, comprising a valve assembly **84** is provided which is capable of sealing bypass ports **82**. One embodiment of such a valve assembly is fully described in application U.S. Ser. No. 108,889, the structure and function of which is incorporated herein by reference. In brief, a motion creating mechanism releases a latch mechanism after a predetermined extended period of time (e.g., 12 hours) to urge a spring loaded piston into a bypass port closing position. Various types of motion creating devices may be used in the time delay mechanism of the present invention as described in application U.S. Ser. No. 108,892.

Another time delay mechanism (not shown) comprises a plug in the fluid channel to the sensing element disintegrable after a predetermined time as by slow vaporization or dissolution as described in application U.S. Ser. No. 108,889, incorporated herein by reference.

A device of the type illustrated in FIGS. **3–5** may be employed for both the detection of the peak fertility period and also for subsequent insemination of semen by insertion into the vagina of an animal of a type having a tubular reproductive tract including an ovary as exemplified by a cow. As previously discussed, this device may also be used in other animals of this type such as humans, horses, sheep, dogs and hogs. The device is inserted so that the front projecting portion of casing **47** abutts against the vaginal wall adjacent the cervix is generally fluid sealing engagement with port **59**. As discussed in application A-26130, the insertion of foreign objects of the general outer configuration described herein causes preliminary mucus fluid flow in certain animals (e.g., the cow) which is not indicative of estrus. In the initial bypass position, such preliminary fluids proceed through opening **59** through inlet passage **76** and out bypass ports **82**. After the aforementioned time delay to accommodate this initial mucus flow, valve assembly **84** closes ports **82** and the estrus fluids flowing through the duct **76** are channelled through duct **74** to contact sensing element **80** and thence to flow out of the device through duct **76** and out exhaust pipe **63**. After dissolution of element **80**, spring **81** urges bar **70** in a linear direction which in turn pivots upright portion **68a** out of engagement with sleeve **64**. Thereafter, container **51** is urged forward so that the front portion thereof projects into the cervical opening. While semen container **51** is within refrigeration chamber **56**, it is maintained in a frozen state so that it does not flow through the outlet opening. Where the semen is preserved at a cold temperature above the freezing point, a semen additive may be employed for semen flow behavior analogous to frozen semen. The additive is not deleterious to the sperm and is capable of providing high viscosity at low temperatures to inhibit flow and low viscosity at high temperatures for ready flow. When the container reaches a semen releasing position, it thaws or becomes less viscous to allow spring **66** to drive the same into the cervix.

Referring to FIGS. **6–9**, another embodiment of an artificial insemination device of the same general type as that of FIGS. **3–5** is illustrated. Like numbers will denote like portions of the two embodiments. According to this embodiment, the semen urging assembly **86** includes an outer tube projecting through the opening in housing **87** in a fixed manner and a semen container **88** slideably received therein. Semen is sealed within the container by means of plug **89** which also retains the container in a fixed position. The plug, outer tube, and container define a fluid sealed annular space **90** into which is inserted a cryogenic substance such as solid carbon dioxide which sublimes or liquid nitrogen which vaporizes upon subjection to heat. Container **88** is of a flexible material so that when a pressure is created in annular space **90** it compresses the container to urge the semen through tube **91** projecting through plug **90** into the container at one end and communicating with semen dispenser **92** at the other end. The opening in housing **53** is thermally sealed by insulation plug **93** formed of a suitable material such as polyurethane foam. Chamber **56** is cooled as by solid carbon dioxide and is insulated as by vacuum in annular vacuum compartment **54** of the aforementioned type. It should be noted that the semen container is illustrated at an angle to the horizontal so that upon thawing, the semen is urged over a prolonged period of time through passage **91** and out dispenser **92** to increase the chances for a proper timing of insemination. Thus, the device is oriented so that container **88** projects downwardly from forward to back rather than in the opposite direction. This orientation also assures continuing thermal contact between the solid CO_2 and a low temperature conduction liquid such as alcohol in all cases. An alternate design embodying axial orientation of container **88** permits the semen to be released in less time and the device may assume any radial position after insertion.

Dispenser **92** includes a closed sealed position as shown in FIG. **6** to avoid contamination of the semen and an open position actuated under the force of semen flow as illustrated in FIG. **8** to permit semen release. A droplet of wax or silicone grease may be placed at **92***a* to assure sealing. When **92** turns inside out from internal pressure by the pressurized semen, the seal material is projected to the outside of the extended semen injector for release of the seal.

The time delay of valve assembly **84** which functions to block bypass ports **82** after a predetermined time interval is structurally and functionally the same as that described in the embodiment of FIGS. **3–5.**

Sensing assembly **96** actuates the release of semen in response to estrus detection by releasing the vacuum in chamber **56** and consequently the insulation of the same to cause the expansion of the cryogenic substance in space **90** and the compression of flexible container **88** to urge the liquid semen through tube **91** and out dispenser **92** into the cervix. Assembly **96** is contained within a chamber **97** within casing **47** which communicates with inlet passage **76** through duct **74** and with exhaust pipe **63** through outlet duct **75.** Assembly **96** includes an element **98** having a cammed surface **98a** and projecting through a closure plate **100** affixed to wall **52.** The plate includes a series of open vanes **101** to provide passage of gas thereby when element **98** moves into compartment **54** as illustrated in phantom in FIG. **9.** Another plate **102** is fixably carried by element **98** to form a vacuum tight seal with plate **100** with the assistance of a resilient O-ring meeting with an accommodating groove in plate **102** and urged against plate **100.** Element **98** is retained in a vacuum sealing position by retaining body **104** formed of mating cylindrical halves having sloping surfaces to accommodate surface **98a.** The two portions of body **104** are retained in abutting position by adhesive sensing element **106,** of the aforementioned type, extending around the entire surface of the body. A vacuum seal between body **106** and plate **100** is provided by resilient O-ring **107.**

In operation of the device of FIGS. **6–9,** fluid initially secreted from the cervix flows through the annular opening between dispenser **92** and casing **47** and thence through duct **76** out bypass ports **82.** After actuation of the aforementioned time delay mechanism, ports **82** are blocked and the fluid proceeds through duct **74** to contact sensing element **106.** This releases the retaining effect of body **104** and the suction of the vacuum in chamber **54** draws element **94** into the same until cammed surface **98a** reaches plate **100.** Vanes **101** prevent the reclosure of the vacuum by the cammed surface. By releasing the vacuum, the insulation in compartment **54** is lost, the thermal conductivity of the insulation layer rises markedly, and the cryogenic material in chamber **56** becomes warm to simultaneously liquefy or reduce the viscosity of the semen in container **88** and to expand the cryogenic material in space **90** to slowly create a pressure head to compress flexible chamber **88.** Thereafter, the semen is urged through tube **91** to turn dispenser **92** inside out and to force semen into the cervix.

Referring to FIG. **10,** there is shown an embodiment of an artificial insemination device which is capable of self-actuation to release semen into an animal's reproductive tract toward the ovary at a time predictably close to that of peak fertility without the necessity for prior determination of this timing for the particular animal. This device is dependent upon the ability of an anchor assembly as of the foregoing type to apply sufficient pressure during retention of the device within the vaginal lumen to stimulate the tract wall and to thereby cause a substantially predictable time range or specific time for ovulation of the animal regardless of the natural timing for ovulation which would have occurred but for insertion of the device. This phenomenon is fully explained in the application entitled "Artificial Method for Modifying the Reproductive Cycle in Animals" in the names of the two inventors herein along with Cecil R. Miller, filed simultaneously herewith U.S. Ser. No. 108,922, filed Jan. 22, 1971. The vaginal anchor assembly illustrated in FIG. **10** includes a plurality of resilient strands **110** formed into a number of resilient hoops forming a posteriorly directed umbrella-like shape caused by a partial collapse of an initial rosette-like pattern which occurs during insertion into the vagina. The strands contact the folds of the vaginal wall in intermeshing fashion to thereby resist movement of the device. The anterior ends of strands **110** are fixably secured to a mounting ring **111** which, in turn, is carried by housing **112** as by forming the ring of a resilient material and sliding the same over the housing to form a tight fit. Posterior mounting ring **113** is slidably carried by housing **112** and is maintained in the illustrated position by abuttment against retaining plugs **114.**

A cervical anchor assembly is provided to align the semen outlet duct and also serves to axially stretch the vaginal lumen to provide additional stimulation of the tract, if desired. This anchor assembly includes a clamping ring **116** which is of a size large enough to be slideable over the projecting annulus of the cervix and small enough to be retained thereon. An annular sleeve **117** is carried by housing **112** and it includes a projecting portion **117***a*. Ring **116** is connected to portion **117***a* in a flexible manner by means of a series of spaced apart elongated strands **118** fixably secured at one end to the clamping ring and at the other end to mounting ring **119** which, in turn, is fixedly secured and carried by portion **117***a*.

As illustrated in FIG. **10,** the insemination device including container **120** may be inserted into the vagina of an animal of the type having a defined sphincter muscle so that the anchor formed of strands **110** is positioned to the anterior side of the sphincter muscle. In this manner, projection of the anchor into the sensitive vestibule to the posterior side of the sphincter muscle is avoided.

Plugs **114** are formed of a slowly disintegrable material as by dissolution or vaporization such as described in application A-26130. Plugs **114** are formed to disintegrate after completion of insemination by the device as explained hereinafter so that the spring-like compressions of strands **110** in a hoop-like configuration will urge slideably mounted ring **113** anteriorly to project into the sensitive vestibule on the posterior side of the sphincter-like constriction. Thereafter, the animal's natural muscular movement will urge the posterior end of the anchor assembly, now projecting into the sensitive vestibule, along with the remainder of the insemination device, for expulsion by the animal from the vagina.

Another embodiment of a device according to the present invention includes two axially spaced retaining or stopping elements such as of the aforementioned disintegrable plug type. The posterior element is selected to be disintegrable a predetermined time after the anterior element to provide a two stage collapse of the anchor. The first or partial anchor collapse timing is selected to be after a sufficient time for the exertion of pressure to stimulate the animal's reproductive regulatory mechanisms. The partial collapse position applies enough pressure on the reproductive tract for retention of the device but stimulation of the above type is generally eliminated to accomplish a simulated de-

vice withdrawal. As described in application U.S. Ser. No. 108,922, this increases the probability of ovulation a predictable time thereafter. The semen is dispensable during this predicted time. Thereafter, the posterior element disintegrates for removal of the device by the animal as above described.

The insemination device includes a semen container **120** positioned at the posterior end thereof against a semen urging assembly comprising a slideable piston **121** which, in turn, forms the anterior boundary for compartment **122** for a suitable expandable material such as solid carbon dioxide. Container **120** and compartment **122** are retained within a tubular housing **123** which includes an elongated semen duct **124** positioned into the cervical opening at its anterior end. A plug **126** is provided to close off the posterior end of housing **112** as well as to seal the expandable material in compartment **122.** it is noted that other materials capable of providing expansion may be employed in compartment **122** such as described in application U.S. Ser. No. 108,892. Means are provided for maintaining the expandable material in compartment **122** in a frozen unexpanded state and also for maintaining the semen in container **120** in a frozen or reduced temperature high viscosity state for preservation of the same. In this instance, such means includes a cryogenic substance such as liquid nitrogen or solid carbon dioxide disposed within the annular chamber defined by housings **112** and **123.** This means, which serves as a cooled insulator, may include walls such as of a thermos-type material or of vacuum super-insulation such as layers of paper and aluminized plastic film or aluminum foil. A combination of the insulation and the quantity of cryogenic materials in chamber **127** should be chosen to permit sufficient heat to be transmitted to container **120** and compartment **122** to thaw the refrigerant frozen semen and solid carbon dioxide so that expansion of the latter drives piston **121** anteriorly to force the semen through duct **124** into the cervix over a time interval overlapping that of ovulation.

In operation of the device of FIG. **10,** the inseminator is inserted into the reproductive tract with duct **124** facing the cervix and strands **110** forming the illustrated umbrella-like configuration. The cervical follower assembly assists duct **124** in remaining engaged with the cervical opening. Strands **110** exert sufficient pressure on the tract wall to cause the same to be stimulated with a consequent substantially predictable time range for ovulation of the animal as described in application Ser. No. 108,922. Initially, the solid carbon dioxide in compartment **122** and the semen in container **120** are frozen or reduced in temperature under the influence of the cryogenic substance in insulated chamber **127.** After a predetermined time interval selected to be during the time interval of ovulation, sufficient heat from the warm ambient cow's vagina is transmitted to the solid carbon dioxide and frozen semen to thaw each of them. Thereafter, the carbon dioxide slowly urges piston **121** anteriorly to drive the semen through duct **121** into the cervix. After insemination, plug **114** disintegrates so that ring **113** slides posteriorly to collapse strands **110** projecting the anchor into the sensitive vestibule. Thereafter, the animal may remove the entire device in one step or two as previously discussed.

It is apparent from the foregoing that three types of artificial insemination devices are provided according to the invention which function by anchoring the semen container within the reproductive tract of an animal over an extended period of time and then urging the semen toward the ovaries a predetermined time after container insertion. The first inseminator type is provided to be used in conjunction with another device for the detection of peak fertility of the animal and is capable of inseminating over an extended period of time. A second type incorporates a peak fertility detection device along with an insemination device in a single unit. The third type is capable of functioning to artificially inseminate the animal in the absence of prior detection of peak fertility in view of its inherent ability to cause a substantially predictable time range for ovulation of the animal.

I claim

1. In a fluid-dispensing device for use in animals of the type having a tubular reproductive tract including an ovary, a fluid container adapted to be inserted in the tract and anchoring means carried by the container for engaging and anchoring said container within the track to prevent expulsion for an extended period of time and including yieldable means comprising a plurality of spaced-apart resilient strands mounted to project outwardly from and circumferentially about said container to form a generally annular shape, said container including means for continuously dispensing fluid from said container over an extended period of time, said yieldable means frictionally engaging the tract so that the device can be readily inserted and removed without injury to the animal.

2. A device as in claim **1** in which said means for dispensing fluid includes means for gradually forcing the fluid from said container for a period of time in excess of one hour.

3. A device as in claim **1** wherein said means for continuously dispensing fluid includes an expandable material and means for causing expansion of said material.

4. A device as in claim **1** together with means carried by said container for preserving said fluid for a substantial period of time.

5. A device as in claim **4** in which said means for preserving includes refrigation means for maintaining said fluid in a reduced temperature state for a substantial period of time.

6. A device as in claim **1** together with time delay means operatively associated with said fluid dispensing means for preventing actuation of said fluid dispensing means until after a time selected to allow at least some fluid flow into the tract during ovulation.

7. A device as in claim **6** in which said means for dispensing fluid includes a material in the container capable of expansion upon the absorbance of a predetermined quantity of heat.

8. A device as in claim **1** in which said anchoring means includes means for causing said anchoring means to assume a collapsed position.

9. A device as in claim **1** in which said anchoring means includes self-collapsing means for compressing the yieldable strands to permit expulsion of the device by the animal.

10. A device as in claim **1** of a length no greater than the distance between the animal's cervix and vulva and so is adapted to be completely disposed in the vagina for long term retention.

11. In a method for dispensing a fluid into the reproductive tract of an animal, utilizing a fluid container in-

cluding an anchor formed of a plurality of spaced-apart yieldable strands mounted circumferentially of the container to project outwardly from the container, the steps of inserting the fluid container into the tract so that the strands are urged against the tract wall under sufficient pressure for retention within the tract over an extended period of time, and dispensing fluid from said fluid container into the reproductive tract.

12. A method as in claim **11** in which said fluid container is inserted into the vagina of an animal of the type having a defined sphincter muscle to position said anchor to the anterior side of the sphincter muscle.

13. A method as in claim **11** wherein said dispensing step includes dispensing fluid a predetermined time subsequent to insertion of the device.

14. A method as in claim **11** in which said fluid dispensing includes the steps of gradually dispensing the fluid over a prolonged period of time in excess of one hour after container insertion.

15. A method as in claim **11** in which said fluid dispensing includes the step of gradually dispensing the fluid over a prolonged period of time in excess of three days after insertion.

16. In a method for dispensing a fluid into the reproductive tract of an animal, utilizing a fluid container including an anchor formed of a plurality of spaced-apart yieldable strands mounted circumferentially of the container to project outwardly from the container, the steps of inserting the fluid container into the tract so that the strands are urged against the tract wall under sufficient pressure for retention within the tract over an extended period of time, and dispensing fluid from said fluid container into the reproductive tract.

17. A method as in claim **16** in which said fluid container is inserted into the vagina of an animal of the type having a defined sphincter muscle to position said anchor to the anterior side of the sphincter muscle.

18. In a fluid dispensing device for use in the reproductive tract of an animal in which the reproductive tract is characterized in that it is defined by a fold-containing wall forming an elongate sheath-like tubular passage with its anterior end leading from the cervix of the uterus and with its posterior end terminating in a normally closed vulva and which has an annular sphincter muscle between the anterior and posterior ends, said device comprising mounting means, said mounting means including an annular surface, yieldable means carried by said mounting means and extending circumferentially about said mounting means, said yieldable means being deformable from a normal outwardly extending condition into a compressed condition, said mounting means including fluid containing means, means forming a passage from said fluid-containing means adapted to be disposed adjacent to said cervix, and means carried by the mounting means coupled to said means containing fluid for causing fluid to be dispensed from said fluid containing means through said means forming a passage over an extended period of time, said device when said yieldable means is in said compressed condition being of a size so that it is adapted to be inserted through the vulva into the passage of the animal, said device being of a length so that it is adapted to be disposed between the cervix and the sphincter muscle, said device when disposed between the cervix and the sphincter muscle being adapted to expand into engagement with the fold-containing wall to expand the wall from its normal state so as to inhibit expulsion of the device by the animal, said yieldable means frictionally engaging the fold-like wall so that the device can be readily inserted and removed without injury to the animal.

19. In a method for placing a device for long-term retention in the reproductive tract of an animal in which the reproductive tract is characterized in that it is defined by a fold-containing wall forming an elongate sheath-like tubular passage with its anterior end leading from the cervix of the uterus and its posterior end terminating in a normally closed vulva and having an annular sphincter muscule between the anterior and posterior ends and in which the device is characterized in that it has mounting means with said mounting means including an annular surface, yieldable means carried by said mounting means and extending circumferentially about said mounting means, said yieldable means being deformable from a normal outwardly extending condition into a compressed condition, said device when said yieldable means is in a depressed condition being of a size so that it is insertable into the passage of the animal with the frontal portion in engagement with the cervix, said device being of a length so that it is adapted to be disposed between the cervix and the sphincter muscle so that the vulva can remain in its normally closed condition when the device is in place in the passage, said mounting means including fluid containing means, means forming a passage from said fluid containing means to said cervix and being in the vicinity of said cervix and being readily removable therefrom, and means carried by the mounting means coupled to said means containing fluid for causing fluid to be dispensed from said fluid-containing means through said means forming a passage to said cervix over an extended period of time, the method comprising the steps of compressing the yieldable means of the device and inserting the device into the passage while the yieldable means is compressed until the frontal portion is in the vicinity of the cervix with the yieldable means and extending between the cervix and the sphincter muscle and the rearwardly extending portion being forward of the vulva so that the vulva can assume its normally closed position, permitting the yieldable means to expand into engagement with the fold-containing wall to expand the fold-containing wall beyond its normal condition so as to inhibit expulsion of the device from the passage by the animal and introducing fluid from said fluid-containing means into said cervix over an extended period of time.

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