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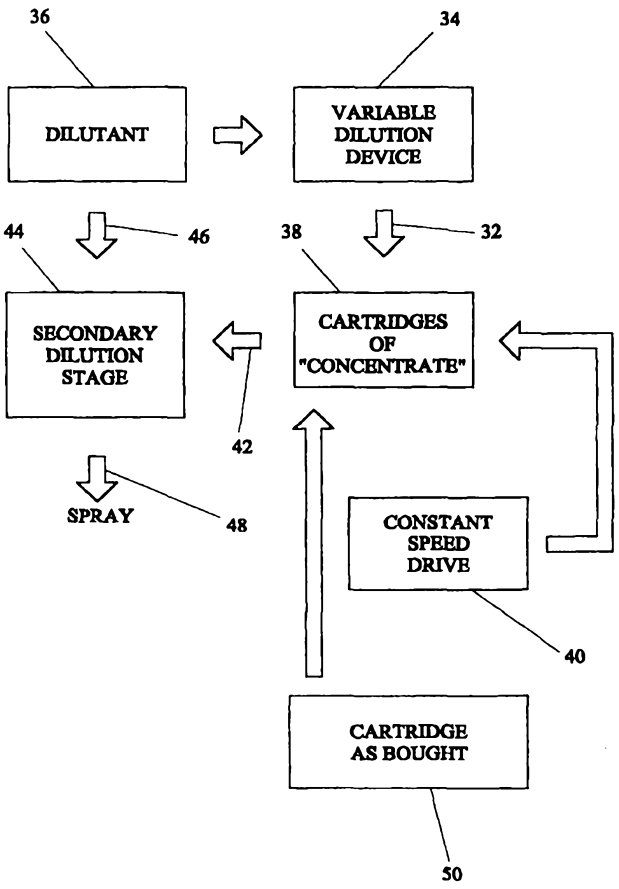
(54) Title: AGRICULTURAL AND HORTICULTURAL SPRAYING SYSTEMS

(57) Abstract

Method and apparatus for agricultural or horticultural spraying is based upon the cartridge system disclosed in GB 2304060A in which the concentrate medium is dispensed by a plunger into a flow of extender medium or dilutant at a rate controlled by a constant speed drive to the piston. This system is modified by eliminating the need for a supply of cartridges of differing cross-sectional sizes (to provide differing rates of application of medium to the crop) by using the cartridge/plunger assembly as a volumetric control means for at least one step in a preliminary or primary dilution or extension step in which the concentrate as supplied by the manufacturer is partially diluted or extended so that when the main dilution or extension step occurs, the required final concentration will be achieved.



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AGRICULTURAL AND HORTICULTURAL SPRAYING SYSTEMS

This invention relates to agricultural and horticultural spraying systems, methods of spraying, corresponding apparatus, and methods and apparatus for dealing with the technical questions arising from the need to provide in spraying methods and apparatus a diluted supply of a chemical or other treatment material which, in its concentrated form, is toxic and/or hazardous and/or environmentally potentially damaging, and therefore needs to be treated and handled with extreme caution. The previously used system of allowing operators of agricultural spray apparatus to effect the dilution process by conventional means involving the use of hose pipes and buckets and related dilution aids in an essentially manual dilution process is completely unacceptable having regard, specifically to Health and Safety at Work legislation.

Proposals have been made for avoiding the need to carry out a batch-type dilution process (with the above-indicated attendant risks) by utilising a dynamic process in which a supply of liquid concentrate is metered into a corresponding metered supply or flow of dilutant to produce the required concentration of spray liquid. Such an approach has the advantage that it enables the concentrate to be supplied in a tank or cartridge format which can be connected to the spray apparatus as a sealed package and without the need to handle the liquid (or even solid) concentrate in any direct way. Such a system is disclosed in WO92/11759 (Prolion) and elsewhere.

However, although this system deals with the problem of the safety implications of using concentrated treatment mediums there is a direct consequence of adopting that approach, namely that such concentrated treatment mediums need varying levels of concentration in order to be

correctly sprayed on varying crops at varying stages in their life etc. Hence the above-mentioned need for the concentrate to be "metered" into the supply of dilutant. This leads to the need to provide in an essentially agricultural or horticultural machine a metering mechanism capable of variable and accurate metering of very small quantities of concentrate (at very substantially varying rates), over the expected life of the equipment. Such a facility is not readily provided at an acceptable cost and with a degree of simplicity and robustness of operation which meets agricultural and horticultural needs.

In our own our prior-published application GB 23 04 060A (reference P53292GB) we have proposed a solution to this problem which enables the requirement for an accurate and variable speed (including substantial speed variations) drive in such metering mechanisms to be dispensed-with . This is achieved by means of a system of cartridges of concentrate in which the cartridge plunger or piston is driven at a constant speed and the required differences in dispensing rate are achieved by using cartridges of differing cross-sectional area. However, such a system inevitably requires the availability of cartridges of concentrate corresponding to the required dilution rates and at least for the time being such provision is not readily available.

Therefore, the present invention seeks to provide a system of dilution and spraying in which the previously-identified safety and accuracy advantages of the system of GB 060A are retained while providing improvements in relation to the provision of means for meeting the need for cartridges (of differing cross-sectional area) capable of producing the very substantially different dilution rates needed for agricultural/horticultural usage, while being actuated by a generally constant speed drive (to the

cartridge plunger).

With regard to the agricultural and horticultural aspects of the present invention including its exclusive application to the technical problems arising in relation to that field, we hereby make specific reference to and incorporate for disclosure purposes the entire technical content of our prior-published PCT applications as follows:-

A) WO 97/16257 our reference P52821WO

B) WO 94/11228 our reference P51958WO

C) WO 93/02552 our reference P51794WO.

According to the invention there is provided a method and an apparatus of agricultural and/or horticultural spraying as defined in the accompanying claims.

There is disclosed in US 5,409,310 (Semitool) a semiconductor processor liquid spray system with additive blending. The system is for diluting a concentrated liquid additive into an actively flowing primary liquid. The concentrated additive is stored in a reservoir and transferred to a drained mixing tank via a metering pump. A dilutant supply adds a measured amount of dilutant to the mixing tank to provide a diluted additive. Primary fluid flows through multiple aspirator injectors each having a suction port which draws from the mixing tank. This process provides a two-stage dilution which can easily achieve very dilute ratios of the additive.

The system described in the embodiments of the US 310 reference, while it provides a means for achieving accurate dilution in relation to semiconductor

manufacturing processes is not in itself suitable for use in relation to agricultural or horticultural spraying systems due to its use (instead of a constant speed piston/cartridge device) of multiple aspirator injectors (40) each energised by the primary fluid flow in order to produce the required dynamic dilution step. Such an arrangement is possibly entirely satisfactory for use in the comparatively "laboratory-like" conditions of a semi-conductor factory, but are entirely unsuited to the operating conditions of agricultural machines which require utter reliability and simplicity for verified effective operation under adverse conditions of (lack of) cleanliness, extraneous presence of water, physical abuse etc.

In the embodiments of the present invention, one important feature relates to the use of a piston-type dispenser for effecting the step of dynamically dispensing the (if necessary), partially diluted concentrate into the main liquid flow. Moreover, the piston-type dispenser also serves in its body portion to provide in one embodiment a chamber in which the preliminary partial dilution step may take place, together with any associated mixing which is required.

By utilising a cartridge-type dispenser having a piston-type actuator, or a mechanical equivalent of same, the embodiments of the invention provide that essential agricultural/horticultural robustness and simplicity which is required for the technical/commercial field in which the invention is required to operate. The cartridge system with its associated linearly-moving plunger is well adapted to operate with a simple drive for the plunger, so as to give the required accuracy of control of dispensing rate. Moreover, the plunger (or mechnical equivalent) system is able (likewise with the necessary agricultural/horticultural robustness and simplicity) to

provide multiple functions which may be required for the application. These include reverse-direction driving of the plunger to draw in dilutant and concentrate materials, whether in sequence or at least partially simultaneously, mixing of the dilutant and concentrate whether by means of the drawing-in process and/or a subsequent generation of mixing movement, and some degree of variation in the rate of drive of the piston or plunger for dispensing purposes in order to accommodate variations in tractor speed/ground speed, and occasional need to cease spraying from certain portions of the boom for example when dealing with field headlands and first and last passes in a field in which the full width of the sprayer is not to be used.

In this latter regard, it is to be understood that although the use of a cartridge-type plunger system cannot accommodate the enormous variations in concentration of spraying medium which are required in agricultural/ horticultural spraying operations, merely by variation of the speed of the plunger drive, since such would require accuracy of drive rate over an enormous range of speeds, nevertheless such a system can acceptably accurately accommodate the relatively modest speed variations required to deal with the variations in spraying ground speed due to tractor speed variations, and the other (boom width) factors discussed above.

Thus, in a preferred embodiment of the invention such as that shown in Fig 5, the spraying system of the invention is able to provide a method and apparatus capable of dealing with the inherent and long-recognised difficulties arising from the use of agricultural/ horticultural concentrate liquids in a thoroughly straightforward and robustly-simple agricultural way which insulates the user from any need to be exposed in any way to the dangers arising from such concentrate materials. Thus, the spraying machine or apparatus is provided with

a sealed tank of concentrate which is readily coupled using well-known coupling systems, to the conduits of the sprayer apparatus, without any requirement for external exposure of the user to the concentrate material. The concentrate tank may be for example a polypropylene keg of the kind well established in the brewing industry for delivery of beer and the like, and which (in this application) is provided with an additional feature in the feed conduits whereby a seal is ruptured during the connection process, and after sealed connection has been made. The dilutant tank is likewise connected to the cartridge or displacement device, and the latter is coupled to its plunger drive, which is capable of modest speed variations.

Valves in the conduits of the system enable a sequence of plunger movements of the cartridge to produce loading into the cartridge of a defined and required volume of liquid concentrate, subsequent addition to this of a defined volume of dilutant to achieve a corresponding slight reduction of concentrate concentration, and subsequent dispensing of the slightly diluted concentrate into the main flow of primary spraying fluid.

The embodiments of the invention preserve the practical simplicity and dispensing accuracy of the GB060A system, using a plunger-type or piston-type injector or dispenser for the core task of dispensing the concentrated treatment material into a flow of extender or dilutant medium. The embodiments additionally provide the means to offer the functional capabilities of the interchangeable cartridges of differing cross-sectional size (of the GB060A specification) in a manner which permits the user to take advantage of the presence of a plunger-type control system so that, for example, in the case where the user is merely utilising a liquid concentrate which is dynamically mixed with the usual liquid extender medium

or dilutant, then the process for producing the equivalent of a cartridge for effecting a chosen application rate merely requires a short sequence of drive operations to the plunger to effect a preliminary or primary step of dilution or extension whereby the subsequent or secondary step of dynamic dilution or extension (which achieves the desired application rate), can be achieved without the need to vary the rate of flow of the extender medium or dilutant (though such may be adopted where convenient or otherwise desirable).

Thus by controlling the main plunger so that it effects controlled primary volumetric batchwise dilution or extension of the treatment medium (but in some cases of course it may occasionally happen that the treatment medium and the rate of treatment desired for a given crop happen not to require any such extension or dilution at all), the user can achieve what hitherto has required a specialist supply of manufactured-to-size cartridge/plunger assemblies.

Of course, the batchwise extension or dilution process is adaptable to many variations apparent to the technically competent person. In principle, the system merely requires that control means is provided for the piston/plunger drive to be able to carry out controlled volumetric stroke movements not only in the main dispensing action but also in the preliminary batchwise extension/dilution step.

In some cases it may be desirable to use the plunger to provide controlled extraction of concentrate from a tank supply thereof so that a known volume is drawn into the cartridge or cylinder (or indeed into an intermediate chamber). Such a step could then be followed (or indeed preceded) by a step involving the controlled volumetric placement of a desired quantity of the extender or dilution medium in the system. The presence of the

plunger/piston and cartridge/cylinder assembly offers the user the function for volumetric control of the batchwise extension or dilution step, even though occasionally the volume of dilutant/extender needed may by chance be zero.

Amongst the options which the skilled person will consider for particular uses in addition to the relatively straightforward addition of concentrate to dilutant or (vice versa) under the control of the plunger or piston are the following. For example, a known and fixed volume of concentrate could be manually provided for the piston or plunger by means of a sealed container thereof which is manually placed by the user for controlled opening or rupture by the system under remote control, followed by the addition of extender/dilutant by use of the plunger/piston. The inverse of this arrangement might be applicable in certain cases in which the system would use a fixed volume of dilutant/extender to which the plunger would add a calculated volume of concentrate.

In the case where the user requires to apply the treatment medium on the basis of a solid (for example granular) formulation thereof, this can be done by means of the use a plunger system which permits manual or remote-controlled addition of a solid medium in granular or dispersion format, the system incorporating agitation means to maintain the solid material in extended dispersion form throughout the various stages in the application process.

The control system for the plunger/piston of the apparatus will preferably be provided with a data input and system option selection means together with data input means relating to the desired treatment rate and the actual (absolute) concentration of the available treatment medium, whether in liquid or solid form. Other data which the system will require include the fixed or selected volumetric flow rate for the main dilutant or extender

together with the dimensional data relating to the piston and its linear drive speed rate.

In connection with the dynamic and non-batchwise second dilution or extender stage, the skilled person will appreciate that the principles of the invention apply to the system regardless of its ultimate mode of effecting the second dilution stage. Accordingly, although liquid dilution may be the more usual approach for many applications, the use of non-liquid extension or dilution has definite merit for many other applications. We hereby incorporate into the present application for this purpose the entire disclosure of our own application published as WO 97/16257 (our ref: P52821WO) relating to the use of air as an extender medium for agricultural/horticultural spray systems. In such a case the delivery of the output from the cartridge or piston/cylinder assembly of the present invention may be either dynamically mixed with a liquid extender medium which is then delivered to the droplet-generation chambers as described in our above-mentioned WO specification or the admixture may be effected on a nozzle-by-nozzle basis just in advance of the droplet generation chambers (so as to minimise the volume of conduit and chamber requiring to be flushed when changing to a different treatment material). A further possibility is that the slightly diluted "concentrate" from the cartridge or piston/plunger assembly is supplied neat to the droplet generation chambers so that only air is then used as the secondary extender medium.

In an embodiment of the invention described below there is provided an agricultural and/or horticultural spraying method and apparatus and a system in which the requisite rate of application of medium to be sprayed is produced by a dynamic mixing step in which a liquid concentrate is added to a flow of a liquid extender medium

or dilutant. The rate of dispensing of the concentrate into the flow of dilutant is controlled by a (relatively) constant speed drive operating a piston or plunger of a cartridge or like mechanism for dispensing the concentrate at a constant rate. In order to accommodate the variations required in the rate of application of the concentrate treatment medium via the flow of liquid extender medium or dilutant there is provided a system for achieving the same (or similar) effect as the use of cartridges of different cross-sectional area in the GB 060A specification. This is done not (as in GB 060A) by an apparatus substitution step, but by a method approach utilising the piston or plunger as a means to vary the exact concentration of the concentrate accordingly, starting from the full strength concentrates supplied by the manufacturers. For this purpose there is provided a system for preliminary dilution of the concentrate prior to its dispensing by the plunger or cartridge mechanism having the constant rate drive for the plunger or piston.

By providing a two-stage dilution process of which the first stage is at a variable rate and the second stage is at a relatively fixed rate, there is offered the flexibility and simplicity required for agricultural and horticultural operations while retaining the necessary accuracy in this dynamic mixing process without the need for sophisticated variable speed drive arrangements and other systems likely to lead to unreliability, complication and cost.

For the purpose of the primary dilution process, there is provided a source of liquid extender medium or dilutant and a supply of concentrate, and an admixture vessel in which the one liquid is added to the other, and a volumetric control means (which may comprise the piston or plunger device) whereby the volumetric ratios in the primary dilution process are varied.

The volumetric variation mechanism (which may comprise the piston or plunger device) is arranged to be remotely controlled so as to be capable of effecting the necessary primary dilution steps without direct (in the sense of manual) intervention by the operator. Means is provided whereby, under remote control, a required degree of dilution is provided whereby at the second (relatively) fixed rate dilution step there is provided exactly the required final concentration of spraying medium.

By providing the fluid extension or dilution process in the above-mentioned two stages the (relatively) fixed rate second dilution step is able to be provided with the accuracy and simplicity of control while retaining the inherent safety advantages of the dynamic extension or dilution process.

In the first extension or dilution stage the advantage is provided of being able to carry out the requisite variable step in the dilution process (corresponding to selecting and installing the approach size of cartridge in GB 060A) in a batchwise and controlled manner utilising a supply of concentrate obtained, for example, from a tank. In this way, the approach can be adopted of utilising a defined or even fixed volume of original (fully concentrated) concentrate to which is added a variable (but relatively small) volume of dilutant. Thus, for example, the method and apparatus allow the utilisation of a freely available batch of concentrate (of fixed known volume) to which is added the requisite (relatively small) volume dilutant according to the ultimate volume of concentration required in the spraying medium. The exact volume required for the latter purpose may be determined quite readily from a simple look-up chart. The means for effecting such small scale dilution under remote control can be readily provided by a simple plunger-type mechanism (preferably the main

dispensing plunger) with a remotely (and automatically) operated change-over valve mechanism which can be caused to draw off the required volume of dilutant and then to deliver same to the tank or other receptacle containing the concentrate, whereupon agitator means effects thorough mixing.

The use of cartridge-type volumetric control means enables accurate control of the volumetric ratios adopted in the primary dilution step. Those skilled in the art will be able to devise alternative arrangements. However, this hardware system is practical and well adapted to the needs of the agricultural/horticultural user. Thus, a typical arrangement can consist of a main tank of dilution liquid, usually plain water, a secondary tank of spraying medium concentrate, obviously significantly smaller than the main tank, a cartridge and plunger-type volumetric dilution control device and a discharge chamber having an associated constant speed plunger drive into which the volumetric system places predetermined volumes of concentrate and dilutant in admixture, whereupon the constant speed drive can cause it to be dynamically mixed with the main flow of dilutants shortly before final discharge from the spray nozzles of the spraying apparatus.

In one particularly simple embodiment of the invention there is no need to provide separate containers for the main supply of liquid concentrate, nor for the mixing of same with the dilutant, nor for the constant rate dispensing of the (slightly) diluted concentrate into the main supply of dilutant. These functions are all provided by the cartridge of concentrate (of known volume) initially installed on the sprayer at the start of spraying operations. This has sufficient internal volume for the addition of the (relatively small) volume of dilutant, together with simple internal mixing means to

produce a homogenous slightly diluted concentrate. Moreover, the cartridge of concentrate is readily provided with its own constant speed plunger drive for dispensing purposes.

In the described embodiments below the primary and secondary dilution stages enable the required flexibility of dilution to be achieved without the technical complexities of a continuously variable and highly accurate system for continuously dispensing very small volumes of concentrate into relatively large volumes of dilutant. By adopting the simple expedient of utilising a constant speed drive in the secondary dilution stage, the construction and operation of that stage is thereby rendered simple and effective and accurate and reliable at a sensible level of cost.

By transferring the variable dilution or extension stage to a separate primary dilution step there is offered the means to vary the ultimate dilution of the spray medium in a simple and cost effective manner. This is because the batchwise dilution step can be effected, for example, by the addition to a relatively small volume of concentrate liquid to a similarly relatively small volume of dilutant by means of a simple relatively accurate plunger-type device and, due to the inherent simplicity and relative accuracy of such equipment, this primary dilution step meets the above-discussed performance criteria.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which :

Fig 1 shows a flow diagram representation of the disclosure in the above-discussed prior-published Prolion specification;

Fig 2 shows, likewise in flow-diagram form, the disclosure in the above-discussed prior Benest

specification GB 23 04 060; and

Fig 3 shows, also in flow-diagram form, an embodiment of the present invention.

Figs 3, 4 and 5 show, also in flow diagram form, three embodiments of the present invention;

Fig 6 shows a practical embodiment of the invention including the piston or plunger of a displacement device, the connection of the latter to a supply of concentrate and of a dilutant, and the connection of same likewise to a spray boom; and

Fig 7 shows the plunger device of fig 6 mounted in association with a complementary cartridge or cylinder having an associated mixer drive.

As shown in Fig 1, the prior Prolion specification WO92/11759 shows a variable speed motor driving the piston of a cartridge of concentrate which produces a variable outflow of concentrate which dynamically mixes with the dilutant to produce the required spray medium. Such an arrangement is, as discussed above, subject to the shortcoming that the accuracy of the variable speed motor drive leaves much to be desired, not to mention cost and related implications.

As shown in Fig 2, the system of the present applicants' prior GB specification overcomes the shortcomings of the Prolion system by utilising a constant speed piston drive but requires a supply of cartridges of differing cross sectional area and while such could be manufactured and offered at an economic cost in the event of utilisation at significant production volumes, such a system is inherently in need of such availability at cost-effective levels and this leads to an inherent time lag before significant commercial penetration can be achieved.

Turning now to the system forming an embodiment of the present invention and shown in Fig 3, the apparatus 10 comprises a constant speed piston drive 12 acting on

a cartridge 14 from which is dispensed at 16 a constant flow of "concentrate" which is dynamically mixed at 18 with a flow of dilutant to produce at 20 a diluted or extended liquid spray medium at the required strength for the spray 22.

Thus, the secondary dilution stage of the invention occurs at 18 above and the primary dilution stage has already been effected prior to the dispensing at 16 of the "concentrate" from cartridge 14.

Turning now to the primary dilution stage, in the embodiment of Fig 3 this is effected utilising a tank 22 of concentrate from which a predetermined volume 24 is withdrawn by a device 26 such as plunger-type apparatus which at 28 adds the concentrate to a fixed small volume of dilutant to produce concentrate of predetermined (variable) strength which is provided in cartridge 14. In one embodiment, the concentrate from tank 22 is simply added to a cartridge containing a fixed volume of dilutant.

In Fig 3, the transfer of (slightly diluted) concentrate to cartridge 14 is identified at 28 and the actual dilution step of the primary dilution stage is likewise identified at 30.

In the embodiment of Fig 4, the main difference from the embodiment of Fig 3 relates to the primary dilution step indicated at 32 in which variable dilution device 34 takes dilutant from the dilutant supply 36 and supplies a predetermined volume to cartridge 38 of concentrate which has a constant speed drive 40 and delivers slightly diluted "concentrate" at 42 to secondary dilution stage 44 at which the flow 46 of dilutant from supplies 36 to spray 48 is provided with the requisite volume rate to achieve the required ultimate spray concentration.

It is indicated at 50 that cartridge 38 is utilised "as bought", having sufficient free internal volume to

accommodate the necessary volume of dilutant.

In the above embodiments the apparatus employed for the secondary dilution stage is generally constructed as described and illustrated in the GB 060 prior specification of the present applicants. The apparatus employed for the primary dilution stage employs volumetric measurement and control apparatus of the kind which is familiar to the technically component person and therefore further technical data is deemed unnecessary at this stage.

Turning now to the embodiment of Fig 5, this comprises a simple combination of apparatus 100 comprising dilutant tank 102, concentrate tank 104, displacement device 106 and the latter's associated drive 108 which, as shown at 110 is capable of minor speed variations.

Conduits 112, 114, 116 and 118 interconnect the parts discussed above as shown in Fig 5, and variable flow-rate valves 120, 122, 124 and 126 control the rate of flow between the main elements of the apparatus.

Dilutant from tank 102 is delivered through conduit 112 to the spray nozzles of the sprayer boom (not shown) by a pump (not shown) in the usual way.

Displacement device 106 comprises a cartridge-type dispenser of which the plunger is driven by drive 108. Of course, mechanically equivalent devices may be used which are not strictly concentrate cartridges. There is a need, of course, for the cartridge to be of sufficient capacity to accommodate both the concentrate liquid and the added dilutant. A commercially available concentrate cartridge may be employed for this purpose or a purpose-designed plunger or syringe type unit.

In use, a chosen volume of concentrate is drawn in followed by a corresponding chosen volume of dilutant. These volumes are mixed. A retractable internal mixing element (not shown) may be provided within displacement

device 106. The slightly diluted concentrate is then dispensed at the required rate into the flow of dilutant in conduit 112 through conduit 116.

Valves 120 to 126 control the sequence of fluid flows. The volumetric requirements can be met in an accurate manner by monitoring the linear piston movements within displacement device 106.

Turning now to the embodiment of figs 6 and 7, apparatus 200 for carrying out a method of agricultural and/or horticultural spraying comprises supply means 202 for a concentrated treatment material, supply means 204 for a dilutant or extender medium for the concentrated treatment material, dilution or extension means 206 adapted to effect dilution or extension of the concentrated treatment material, and spraying means 208 adapted to cause the resultant diluted or extended liquid medium to be sprayed. The dilution or extension means 206 comprises a piston or plunger device 210 adapted to effect the dispensing of the treatment material into a flow of the dilutant or extender medium so as to provide the required level of dilution or extension for spraying purposes.

The dilution or extension means 206 is adapted to effect two stages of dilution or extension. The step of dispensing the treatment material into a flow of dilutant or extension medium constitutes a secondary stage of dilution or extension and is preceded by a primary stage of dilution or extension.

The primary stage of dilution or extension provided by the dilution or extension means 206 comprises the primary dilution or extension of the concentrated treatment material from supply means 202 therefor with the dilutant obtained from supply means 204 thereof. This primary stage of dilution or extension is effected in the piston or plunger device 210 whereby the ultimate level

of application of diluted or extended liquid for spraying purposes is controlled by varying this primary dilution or extension stage, which is a batchwise extension stage.

In both the primary and secondary dilution or extension stages the piston or plunger device operates to effect volumetric control of the process.

A drive 212 for piston or plunger 210 effects generally constant speed linear motion of the piston or plunger in the directions shown by double-headed arrow D to effect the requisite volumetric control of the inward or outward displacement process. A control 214 for the drive enables the user to exercise a modest degree of control of the drive speed in accordance with above-discussed requirements including variations in ground speed of the spraying equipment and variations in boom utilisation with respect to usage requirements including headlands and other factors which may require partial boom folding during use.

Turning now to the details of construction of the general features discussed above, the supply means 202 for the concentrated treatment material comprises a concentrate tank or reservoir 216 which may for example be in the form of a polypropylene keg as mentioned above. This is coupled through a flow meter 218 and a non return valve 220 to a dilutant and concentrate delivery line 222 having a dry coupling connector 224 comprising separable elements 226 and 228.

The supply means 204 for the extender medium is closely associated with the supply means for the concentrated treatment material, and comprises a dilutant supply line 230 having a shut-off valve 232 whereby dilutant, such as water, can be drawn from a suitable tank (not shown) into the dilution or extension means 206 via delivery line 222 and dry coupling 224.

The dilution or extension means 206 which comprises

piston or plunger device 220 and is adapted to effect the dispensing of the treatment material into a flow of dilutant, further comprises (as shown in fig 7) a cylinder or cartridge device 234 in which piston 236 is slidably received and controlled by a rod 238 connecting it to drive 212. A flexible conduit 240 couples a port 242 to coupling element 226 and includes a tapping for an air relief valve 244 to permit the venting of trapped air from within cylinder 234. For this purpose piston 236 has an internal concave portion 246 with port 242 at its apex to facilitate the venting of air via port 242 and relief valve 244. In the base of cylinder 244 there is provided a recess 248 accommodating a mixing impellor 250 driven by an electric motor 252 and which serves in use to establish and maintain uniformity of dispersion of undissolved treatment materials (whether liquid or solid) within their dispersion medium.

As clearly shown in fig 6, conduit 240 with its dry coupling element 228 at the end can be manually interchangeably coupled to dry coupling connector 224 in its concentrate and dilutant-receiving or receptor phase, in which the batchwise dilution of the concentrate is effected by controlled ingress of concentrate and dilutant into cylinder 234 followed by mixing for uniformity. Then, coupling element 228 can be uncoupled and re-coupled to a coupling element 254 through which the slightly diluted concentrate is discharged for admixture with the flow of dilutant or extender medium to produce the required final level of dilution or extension for spraying purposes. This latter step can be effected by tapping the output line 256 from coupling element 254 into a dilutant or extender medium delivery line 258 located on the spraying boom or spraying means 208. Instead of this simplest arrangement, the output from dilution or extension means 206 may be divided and taken to individual boom sections for

admixture with the liquid flowing extension medium there, or may be divided into multiple delivery lines, one for each spray head or nozzle for admixture at the nozzle or head or (in a preceding mixing chamber) with the extender medium, where the liquid or gas/air based. The technically competent person will be well able to deal with the design details of such delivery systems. It will be understood that in fig 6, the two positions of coupling element 228 which have been indicated correspond to its two functions. Of course, a bifurcated line may be used instead with appropriate control valve arrangements.

The flow meter 218 is not used for volumetric control of the dilution process, but only to monitor the volume of conentrate remaining within the tank 216.

In use, drive 212 causes piston 236 to draw concentrate from tank 216 into cylinder 234. Then, having regard to the intended use of the equipment 200, the appropriate volume of dilutant is drawn by piston 236 from the dilutant or extender medium supply means 204. The concentrate and extender are mixed by means of impellor 250 and motor drive 252. Then, piston 236 is caused to move inwards with respect to cylinder 234 and then after venting of any air through valve 244, the slightly diluted concentrate is delivered to the dilutant delivery line 258 after re-connecting coupling element 228 to coupling element 254.

In the case where the slightly diluted concentrate is to be extended with air, the volumes for delivery to individual spray heads or nozzles are relatively low and microbore delivery systems are employed. Such represent no technical difficulty for the competent person.

CLAIMS :

1 A method of agricultural and/or horticultural spraying comprising :

a) providing a supply of concentrated treatment material;

b) providing a supply of an extender medium for said concentrated treatment material;

c) effecting the step of extending said supply of concentrated treatment material by said dilutant medium therefor and causing the resultant extended treatment material to be sprayed;

d) said step of effecting extending comprising the step of causing a piston or plunger-type displacement device to dispense said treatment material into a flow of said extender medium to produce the required level of concentration of said treatment material for spraying purposes;

characterised by

e) said step of extending said concentrated treatment material by said extender medium comprising two stages, said step of dispensing said treatment material into a flow of extender medium constituting a secondary stage of extending and being preceeded by a primary extending stage;

f) said primary extending stage comprising the primary extension of said concentrated treatment material with an extender medium and being effected in a batchwise manner utilising said displacement device as volumetric control means in at least one step of said primary extension, whereby the ultimate level of application of said extended treatment material for spraying purposes may be controlled by varying said primary extension stage.

2 A method of agricultural or horticultural spraying

comprising effecting extension or dilution of a concentrated treatment material by a dilutant or extension medium therefor in primary and secondary dilution stages comprising a continuous or dynamic secondary extension or dilution stage preceded by a batchwise primary extension stage, said primary extension or dilution stage being effected in a drivable displacement device as volumetric control means in at least one step of said primary extension, which device also effects dispensing of the batch-diluted or extended concentrate in said secondary extension or dilution stage.

3 A method according to claim 1 or claim 2 characterised by the step of causing said secondary extension or dilution stage to be varied by varying the speed of a drive to said piston or plunger device in accordance with variations in sensed ground speed of the apparatus.

4 A method according to any one of the preceding claims characterised by effecting said primary dilution or extension step by causing said piston or plunger to cause in said primary step of dilution or extension, volumetric control of the addition in said cartridge or cylinder of concentrate medium to extend a medium or dilutant.

5 Apparatus for agricultural or horticultural spraying comprising :

a) supply means for a concentrated treatment material;

b) supply means for a dilutant or extender medium for said concentrated treatment material;

c) dilution or extension means adapted to effect dilution or extension of said concentrated treatment

material by said dilutant therefor; and

d) spraying means adapted to cause the resultant diluted or extended liquid medium to be sprayed;

e) said dilution or extension means comprising a piston or plunger device adapted to effect the dispensing of said treatment material into a flow of said dilutant or extender medium to produce the required level of dilution or extension for spraying purposes;

characterised by

f) said dilution or extension means being adapted to effect two stages of dilution or extension, said step of dispensing said treatment material into a flow of said dilutant or extension medium constituting a secondary stage of dilution or extension and being preceded by a primary stage of dilution or extension; and

g) said primary stage of dilution or extension provided by said dilution or extension means comprising the primary dilution or extension of said concentrated treatment material with a dilutant therefor and being effected utilising said piston or plunger type apparatus as volumetric control means whereby the ultimate level of application of diluted or extended liquid medium for spraying purposes may be controlled by varying said primary dilution or extension stage.

6 Apparatus for agricultural or horticultural spraying and adapted to effect dilution or extension of a supply of concentrated treatment material by a dilutant therefor in primary and secondary stages comprising a continuous or dynamic secondary dilution or extension stage and a batchwise primary extension or dilution stage, said apparatus comprising a drivable displacement device adapted to permit said primary and secondary stages to be effected with volumetric control by said displacement device.

7 Apparatus according to claim 5 or claim 6 characterised by said secondary dilution or extension stage of said dilution means comprising a variable speed drive for said displacement device, said variable speed drive being adapted to vary said drive speed in accordance with ground speed of the apparatus.

8. Apparatus according to claim 5 or 6 or 7 characterised by said dilution or extension means comprising a dilution or extension chamber connected to said piston or plunger device and into which said concentrated treatment material and said dilutant may be transferred by said piston or plunger device in a volumetrically controlled manner to effect said dilution or extension before being dispensed into said flow of dilutant or extender medium by said piston plunger device.

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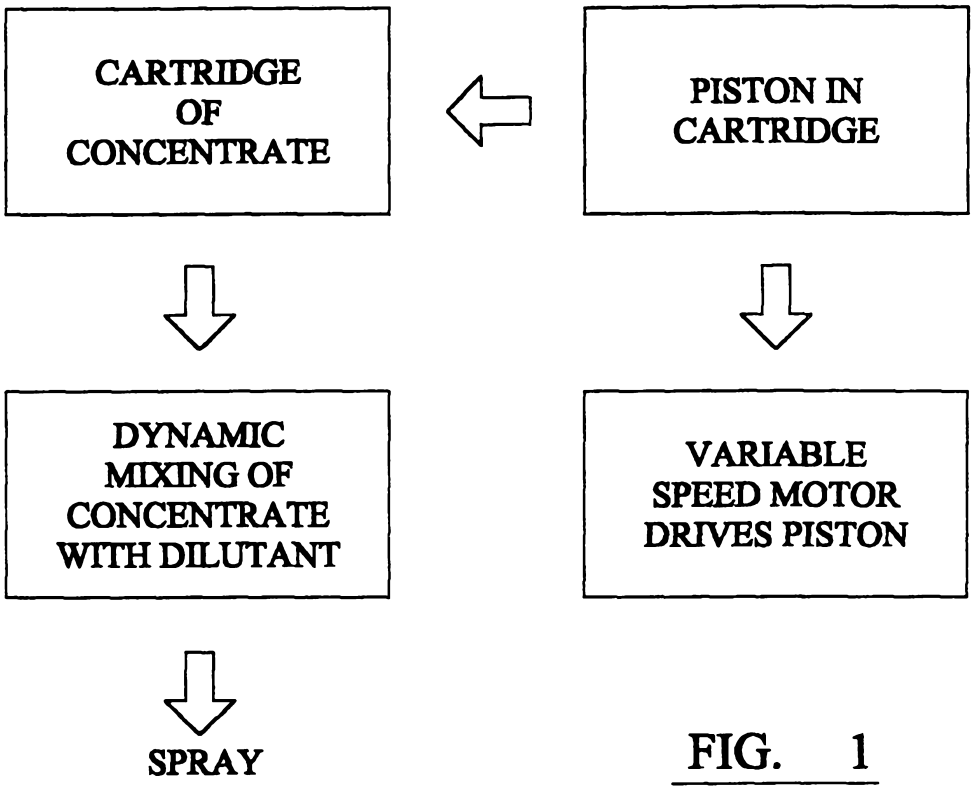

FIG. 1

GB 2304 060(BENEST):-

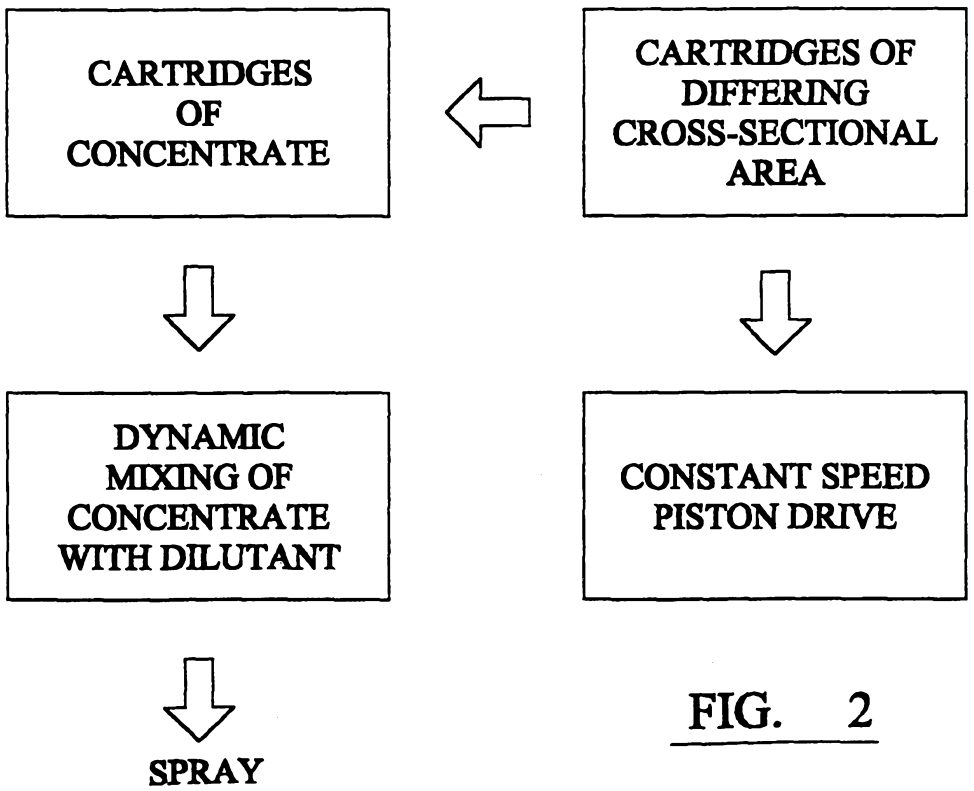

FIG. 2

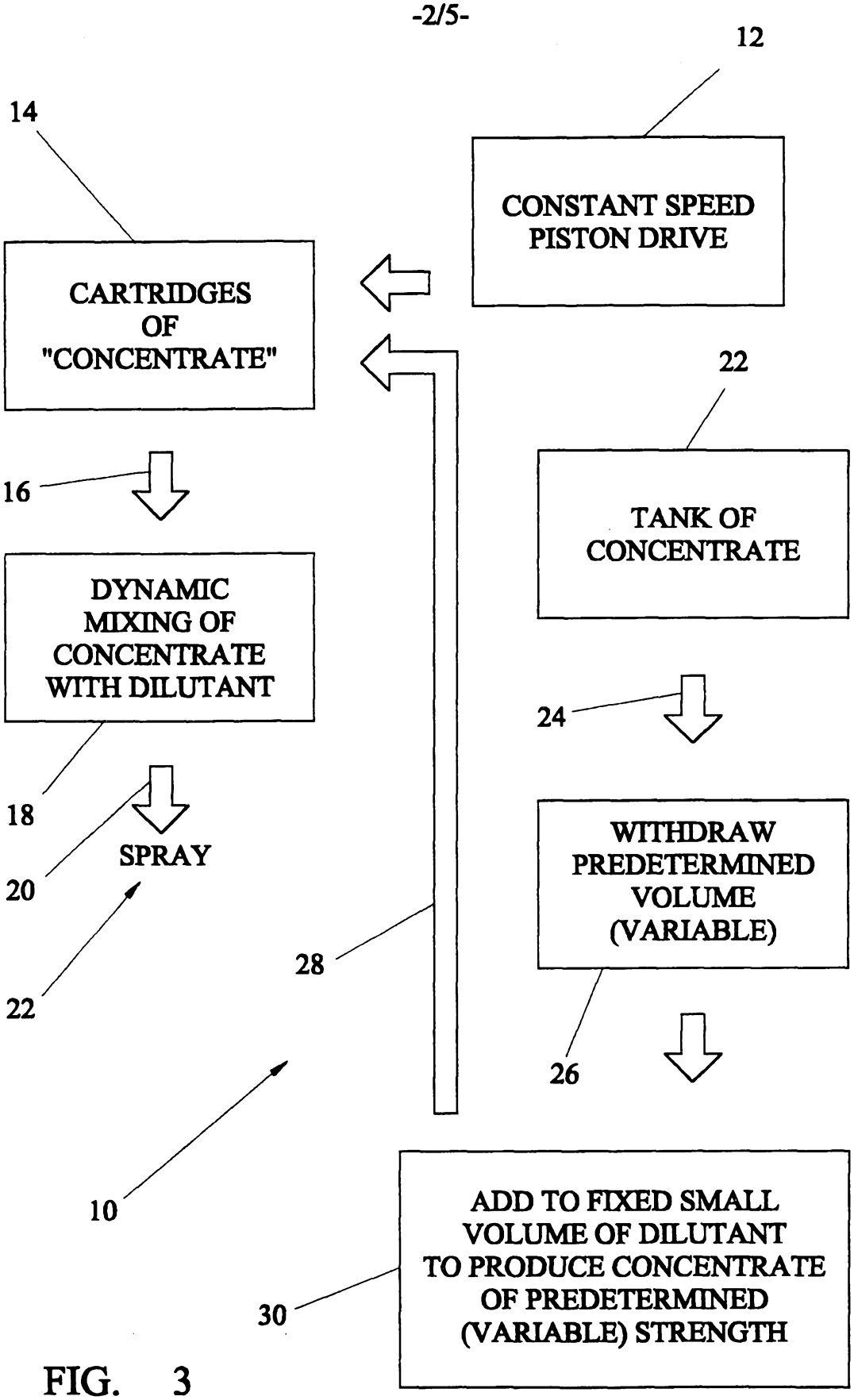
12
14
CONSTANT SPEED PISTON DRIVE
CARTRIDGES OF "CONCENTRATE"
22
16
TANK OF CONCENTRATE
DYNAMIC MIXING OF CONCENTRATE WITH DILUTANT
24
18
SPRAY
20
WITHDRAW PREDETERMINED VOLUME (VARIABLE)
28
22
26
10
ADD TO FIXED SMALL VOLUME OF DILUTANT TO PRODUCE CONCENTRATE OF PREDETERMINED (VARIABLE) STRENGTH
30

FIG. 3

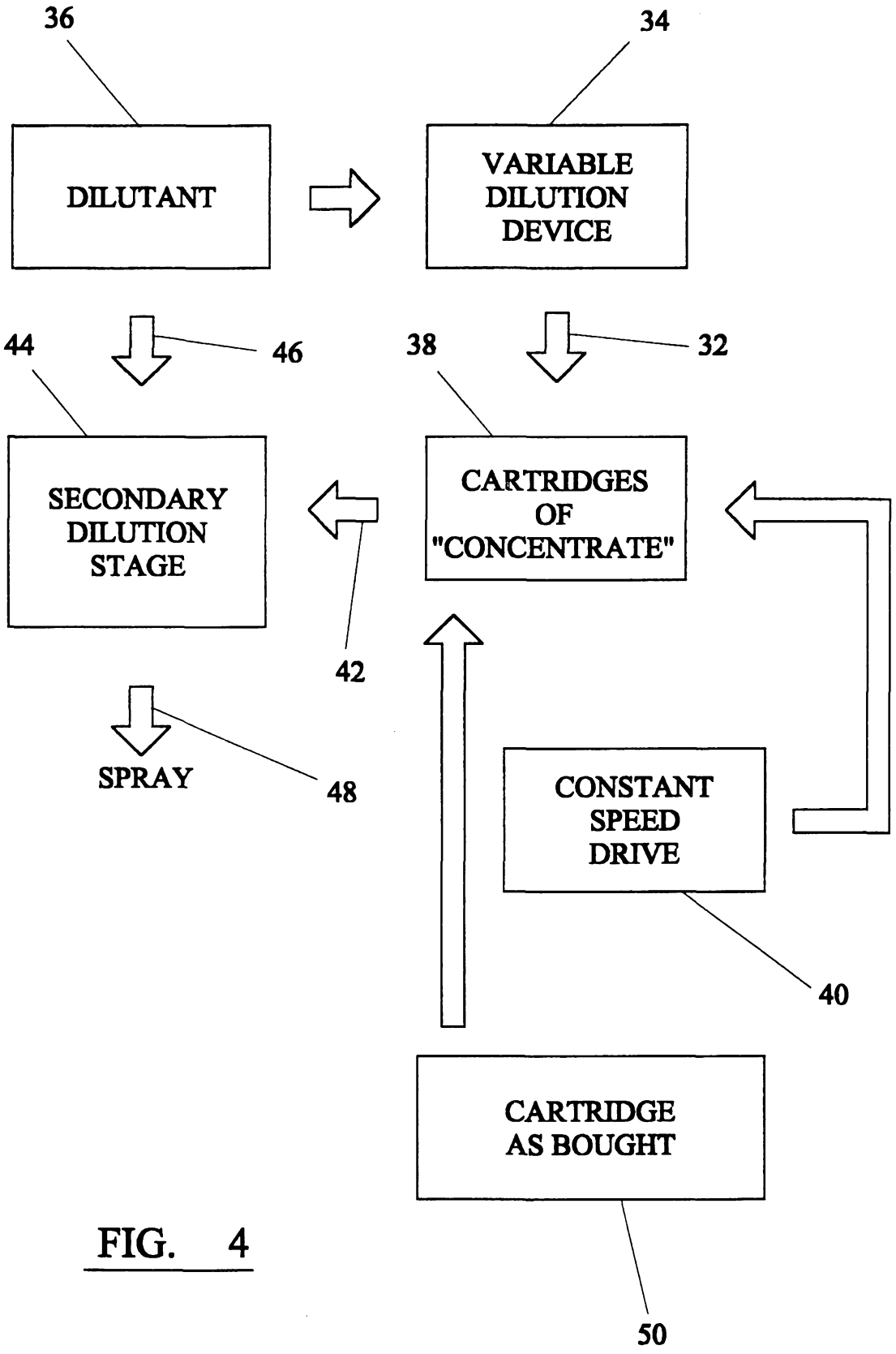
36
34
DILUTANT
VARIABLE DILUTION DEVICE
44
46
38
32
SECONDARY DILUTION STAGE
CARTRIDGES OF "CONCENTRATE"
42
SPRAY
48
CONSTANT SPEED DRIVE
40
CARTRIDGE AS BOUGHT
50

FIG. 4

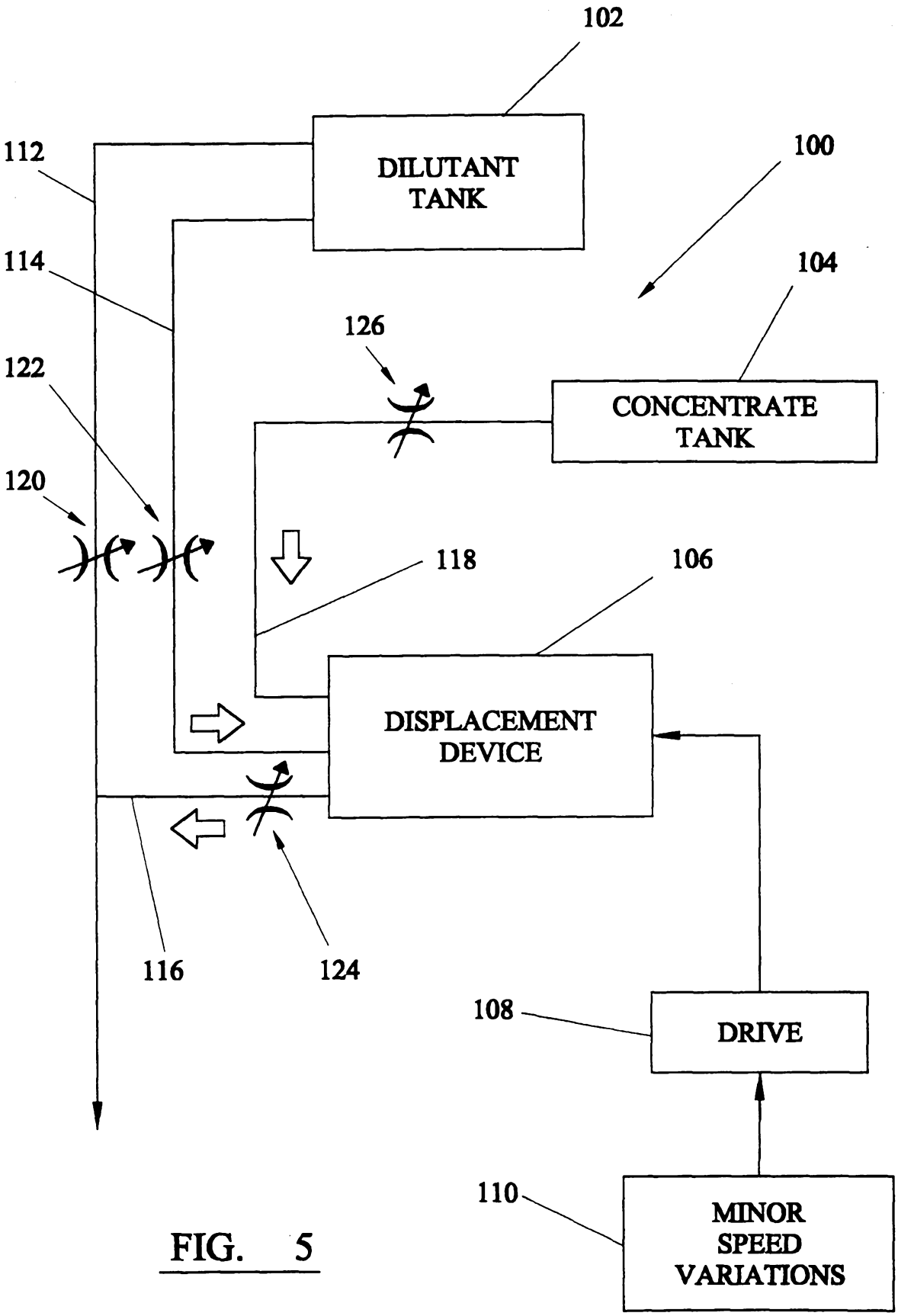
102
DILUTANT TANK
112
100
114
104
126
122
CONCENTRATE TANK
120
118
106
DISPLACEMENT DEVICE
116
124
108
DRIVE
110
MINOR SPEED VARIATIONS

FIG. 5

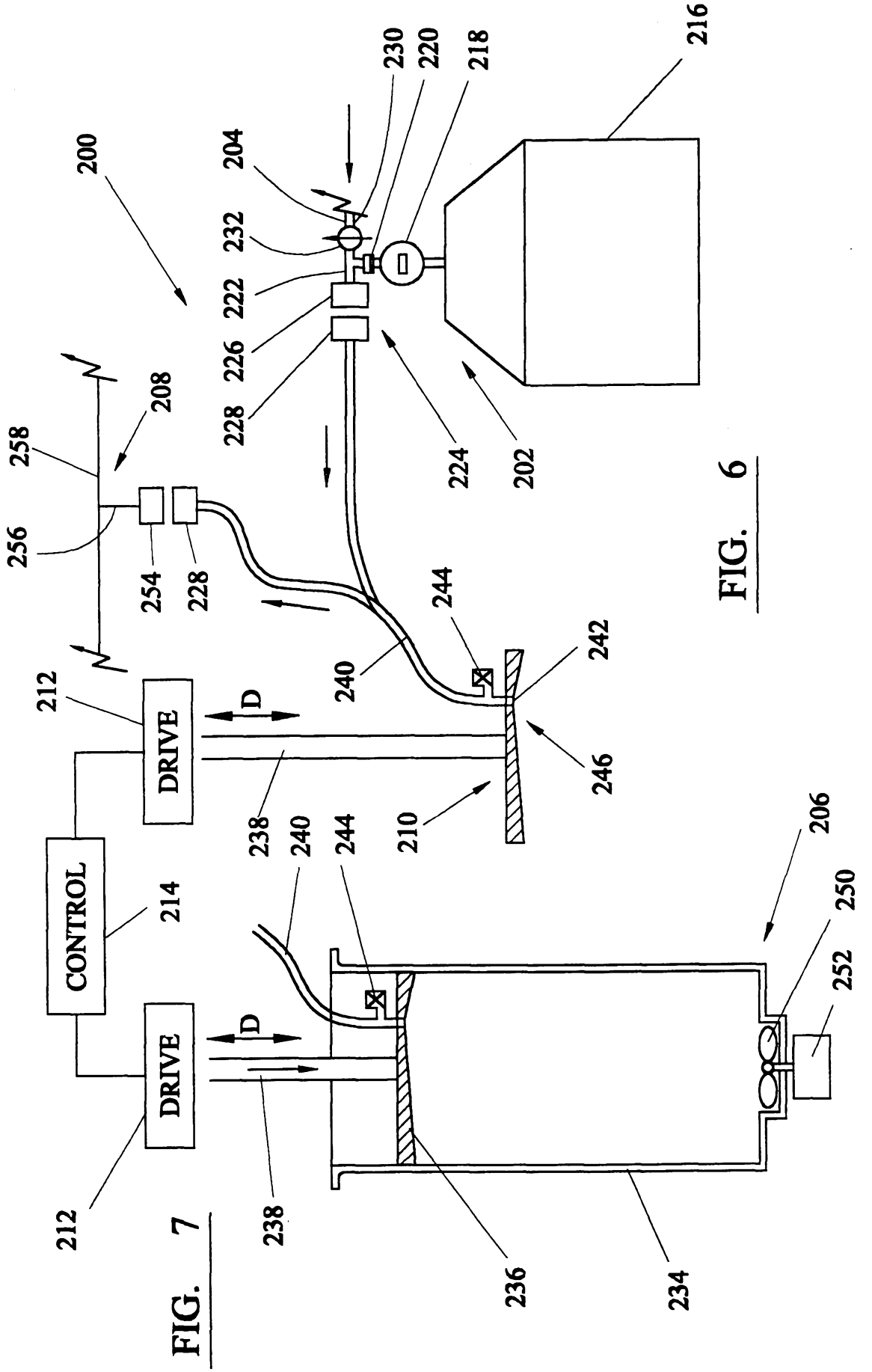
200
204
232
222
226
228
230
220
218
216
224
202
208
258
256
254
228
244
240
242
246
212
DRIVE
D
238
210
CONTROL
214
206
250
252
234
236

FIG. 6

FIG. 7