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Tyskland

This is in response to the Communication pursuant to Article 96(2) and Rule 51(2) EPC, dated 26.09.95, for which a two-month extension of time limit has been kindly granted.

A new set of claims 1 to 16 is hereby enclosed to replace the claims previously on file. In addition, new pages 2 and 3 of the description are enclosed to replace pages 2 and 3 of the description as filed.

It will be noted that the new set of claims includes independent claim 1 which is directed to the system as illustrated in Fig. 1 and independent method claim 9 directed to the method of operation of the system of Fig. 1. In addition, the set of claims includes independent claim 10 which is directed to the system as illustrated in Fig. 2 and an independent method claim 16 directed to the method of operation of the system of Fig. 2. It is respectfully submitted that, in the present case, it is fully appropriate to have a plurality of claims of the same category since, as evidenced by original claim 1, it is deemed impossible to claim the two embodiments of Figs. 1 and 2 in a clear and concise generic claim. Furthermore, and as will be explained in greater detail later, there can be no doubt that the independent claims meet the unity requirements of Article 82 EPC.

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The subject-matter of new claim 1 is based on previous claims 1 and 2, with the addition of the features which are disclosed i.a. on page 4, lines 22 to 25. In terms of the dependent claims, new claim 2 corresponds essentially to previous claim 3; new claim 3 to previous claim 4; new claim 4 to previous claim 6; new claim 5 to previous claim 5; new claim 6 to previous claim 7; new claim 7 to previous claim 8, and new claim 8 to previous claim 9.

New claim 9 is based on previous claim 14, with the addition of features which are disclosed i.a. on page 5, lines 21 to 24.

New claim 10 is essentially a combination of the features of previous claims 1 and 15. New claim 11 corresponds essentially to previous claim 7 or 22; new claim 12 corresponds to previous claim 8 or 23, and new claim 13 corresponds to previous claim 9 or 24. The features of new claim 14 can be found i.a. on page 8, line 13 to page 9, line 6, and those of new claim 15 on page 8, lines 11 to 13.

Finally, support for new claim 16 can be found in previous claim 14 as well as page 9, lines 1 to 6, of the description as filed.

Accordingly, it is respectfully submitted that the requirements of Article 123(2) EPC are met by these amendments.

It will be noted that the newly filed claims are in the one-part form. With reference to Rule 29(1) EPC, it is submitted that this form of claim is more appropriate than the two-part form since none of the systems (see below) in any of the documents cited in the search report provide a suitable starting point upon which to base a preamble of a claim. For this reason, and as suggested in the Guidelines for Examination, C-III, 2.3b, a comprehensive summary of the features common to the independently claimed subject-matter and references D1 and D2 has been provided in the newly file pages of the description.

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In terms of unity of invention between the embodiments of the independent claims, and with reference to Rule 30 EPC, it is respectfully submitted that "the same or corresponding technical features" common to the claimed embodiments are the aspect of comparing the conductivity of the mixture when flowing along a common path with the conductivity before the common path. Thus, in the embodiment of Fig. 1, the conductivity before the common path is determined from a mixture of the two fluids, whilst in the Fig. 2 embodiment the conductivity of the individual constituent fluids is measured. Although these features are of course different (that being why they are claimed separately), it is submitted that these features are "corresponding" within the meaning of Rule 30(1) EPC since the technical relationship between the embodiments is the comparison of conductivity upstream and downstream of the common path.

In view of the above, it is felt that the objection raised by the Examiner in section 1 of said Communication has now been successfully overcome.

In terms of the clarity objection raised in section 2 of the Communication, it is submitted that the expression "means for" does define technical features and therefore the newly filed system claims cannot be deemed to be replete with steps of a method or process.

With regard to the disclosures of D1 and D2, the following is submitted.

As the Examiner rightly points out in section 3 of his Communication, neither D1 nor D2 discloses the provision of comparing the conductivity of a mixture of fluids when flowing along a common path with a point upstream of the common path. As is apparent from the summary of these documents in the newly filed pages of the description, both documents disclose an automatic, electronically controlled foam proportioning system which mixes fire fighting foam liquid with water at a constant

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predetermined percentage ratio. The amount of foam injected into the water stream or streams is controlled by a valve in the foam line. Foam liquid injection percentage is intended to remain constant with variations in water flow or pressure over an anticipated range. Both documents utilize flow meters to measure the flow of foam and water. Based on these measurements, the electronic control makes changes by adjusting the foam injection flow rate by means of an automatic control valve placed in the foam injection feed line.

Such arrangements suffer from many drawbacks. Firstly, flow meters require a certain length of straight pipe (usually ten pipe diameters) to be installed upstream and downstream to assure proper operation and accuracy of measurement. Due to space restrictions encountered on many fire fighting vehicles, these flow meter installation requirements are often compromised, something which may lead to reduced accuracy. In addition, most flow meters require that a part of the meter be projected into the liquid stream to be measured. This means that they are subject to damage and wear.

Furthermore, flow meters generally suffer from accuracy loss as the flow is reduced from the maximum to minimum flow range. For example, a meter which can measure flow within 2% accuracy at its maximum allowable rate may only be accurate within 10% at its minimum recommended flow. This can naturally result in variations from the desired foam injection percentage. In addition, flow meters are generally slow to react to flow change rates and therefore not particularly well suited for e.g. airport crash rescue vehicle foam proportioning applications where speed is critical. It is for this reason that the systems of D1 and D2 use an initial default value to compensate for the lack of speed in flow measurement experienced at system start up.

Finally, and as identified on page 2, lines 1 to 11, of the application as filed, flow meters can be adversely affected by

changes in the physical properties of the fluids they are measuring.

It is therefore an object of the present invention to provide a system and method which overcome the above-identified drawbacks.

This object is achieved by the systems shown in Figs. 1 and 2 and claimed in the respective independent claims.

In the present invention, no attempt is made to measure the flows of e.g. foam or water. Instead, the invention involves measuring the electrochemical characteristics (i.e. electrical conductivity) of the foam solution stream after the foam injection point and compares this value against a desired conductivity level which is directly related to the percentage level of foam in the water stream. Means in the form of a microprocessor is provided for computing the conductivity level corresponding to the desired (selected) foam injection percentage using the incoming water and foam liquid conductivity measurements. Based on comparison of the foam solution stream conductivity against the desired (computed) conductivity, the microprocessor will make adjustments to the mixing means to thereby result in a conductivity change in the foam solution causing it to match the computed conductivity value held in the microcomputer.

Since the present invention does not require the use of flow measurement means, the invention overcomes the drawbacks associated with prior systems.

Given that none of the references relied upon by the Examiner teaches or suggests the use of a conductivity comparison between fluids to determine a mixing ratio, the solution proposed in the present invention to the above-stated object cannot be deemed to be obvious to a person skilled in the art. Accordingly, the claimed invention must be deemed to involve an inventive step (Article 56 EPC).

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Description, pages 2 and 3

Conventional direct injection systems make use of paddlewheel type flow meters to measure water and foam concentrate flow rates. The foam concentrate flow rate is then adjusted either manually or automatically to the desired percentage of the water flow rate. Paddlewheel flow meters are affected by the viscosity of the liquid being measured, thus making it necessary to recalibrate them for foam concentrates of differing viscosities, and making them impossible to use with foam concentrates which have non-Newtonian rheologies. Exemplary systems of this type are described in U.S. Patent Nos. 4,324,294 and 4,246,969, both issued to McLoughlin et al., relating to chemical injection systems.

EP-A-0 263 290 describes an automatic, electronically controlled foam proportioning system which mixes fire fighting foam liquid with water at a constant predetermined percentage ratio. The amount of foam injected into the water stream is controlled by a valve in the foam line. The system is based on measuring the flow of water and foam liquids using flow meters. Flow output signals from the water and foam flow meters are transmitted electronically to a microprocessor where they are compared to a preselected foam-water mix ratio. If the percentage ratio of foam to water flow rates is not as desired, the microprocessor outputs a signal to the foam control valve which adjusts to provide the correct foam injection percentage.

DE-A-3 817 852 describes a similar system, though in which the electronics have been expanded to include control of additional valves to enable better control of the foam injection process. Again, the principle of operation is to control the ratio of foam injection by measuring its flow relative to the water flow.

SUMMARY OF THE INVENTION

5 It is an object of the present invention to provide a proportioning system which is not dependent on flow rate or pressure measurements for producing proportionately constant mixtures of fluids.

This object is achieved by a system according to claim 1 and by a system according to claim 10.

10 It is a further object of the invention to provide a method of maintaining a predetermined proportionate mixture of first and second fluids, which method is not dependent on flow rate or pressure measurements.

15 This object is achieved by a method according to claim 9 and by a method according to claim 16.

Conductivity proportioning is not dependent on flow rate or pressure as is inherent with conventional ratio
20 controllers. Conductivity will solve the problem of accurate proportioning over a wide range of flows. Currently available equipment operates with a turn-down range of approximately 8:1. Thus, the maximum flow of the device is about eight times greater than the minimum flow.
25 For example, an exemplary flow range through a three-inch ratio controller is 150 GPM to 1200 GPM. Many systems need to operate over a wider range, such as 30 GPM to 1200 GPM or higher. The prior art necessitates a compromise in proportioning accuracy. Some systems will proportion
30 less-than-desired percentages (lean) at low flows (less than standard flow range), while others will operate at greater than the desired percentage (rich).

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CLAIMS:

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1. A system (10) for maintaining a predetermined proportionate mixture of first (12) and second (14) fluids, said system comprising:

10 first mixing means (30) for mixing said first and second fluids to continuously produce a proportionate discharge mixture (32);

15 second mixing means (16,18,20) for mixing said first and second fluids to produce a sample mixture (24) at a ratio corresponding to said predetermined proportionate mixture;

means for measuring and comparing (34,36,38) the conductivity of the discharge mixture with the conductivity of said sample mixture, and for generating a control signal representative of any difference therebetween; and

20 means (26,28) responsive to said control signal for adjusting said first mixing means in order to minimize the difference between the measured conductivities of said sample mixture and said discharge mixture.

25 2. The system of claim 1, wherein said means for measuring and comparing the conductivity includes first means (36) for measuring the conductivity characteristics of said sample mixture of said first and second fluids.

30 3. The system of claim 2, wherein said means for measuring and comparing the conductivity further comprises second means (38) for measuring the conductivity characteristics of said discharge mixture.

4. The system of claim 3, wherein said first and second measuring means (36,38) comprise at least one conductivity probe.

5 5. The system of claim 1, wherein said second mixing means comprises a low capacity duplex metering pump (20) and adjustable injectors (a,b) associated with each of said fluids.

10 6. The system of claim 1, wherein said adjusting means comprises an adjustable control valve (26).

7. The system of claim 1, wherein said measuring and comparing means comprises a microprocessor (34).

15 8. The system of claim 1, wherein said first and second fluids comprise water (14) and foam concentrate (12).

20 9. A method of maintaining a predetermined proportionate mixture of first and second fluids (12,14), said method comprising the steps of:

mixing said first and second fluids to produce a proportionate discharge mixture;

25 mixing said first and second fluids to produce a sample, mixture at a ratio corresponding to a predetermined proportionate mixture;

30 measuring and comparing the conductivity of the discharge mixture with the conductivity of said sample mixture, and generating a control signal representative of any difference therebetween; and

adjusting, in response to said control signal, said first mixing means in order to minimize the difference between the measured conductivities of said sample mixture and said discharge mixture.

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10. A system (10) for maintaining a predetermined proportionate mixture of first (12) and second (14) fluids, said system comprising:

5 mixing means (30) for mixing said first and second fluids to continuously produce a proportionate discharge mixture (32);

10 means (42,44,46) for establishing a set point representative of a desired conductivity characteristic of said first and second fluids which corresponds to said predetermined proportionate mixture;

means (38,34) for measuring and comparing the conductivity of the discharge mixture with the set point, and for generating a control signal representative of any difference therebetween; and

15 means (26,28) responsive to said control signal for adjusting said mixing means in order to minimize the difference between the measured conductivity of said discharge mixture and said set point.

20 11. The system of claim 10, wherein said adjusting means comprises an adjustable control valve (26).

25 12. The system of claim 10, wherein said measuring and comparing means comprises a microprocessor (34).

13. The system of claim 10, wherein said first and second fluids comprise water (14) and foam concentrate (12).

30 14. The system of claim 10, wherein said establishing means comprises first measuring means (44) for measuring the conductivity characteristics of each of the fluids flowing along said separate paths, second measuring means (46) for measuring the conductivity characteristics of the
35 predetermined proportionate mixture flowing along said common path, and means (34) for calculating a conductivity

value representative of the desired proportionate mixture.

15. The system of claim 10, wherein said establishing means comprises a ratio selector device (42).

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16. A method of maintaining a predetermined proportionate mixture of first and second fluids (12,14), said method comprising the steps of:

10 mixing said first and second fluids to continuously produce a proportionate discharge mixture;

establishing a set point representative of a desired conductivity characteristic of said first and second fluids which corresponds to said predetermined proportionate mixture;

15 measuring and comparing the conductivity of the discharge mixture with the set point, and for generating a control signal representative of any difference therebetween; and

20 adjusting said mixing in response to said control signal in order to minimize the difference between the measured conductivity of said discharge mixture and said set point.