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(54) **FUEL INJECTOR FOR AN INTERNAL COMBUSTION ENGINE**

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(51) **Int. Cl.**
F02M 51/00 (2006.01)

(52) **U.S. Cl.** **123/549**; 123/557

(58) **Field of Classification Search** 123/543-557,
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431/11-13, 121, 208-209

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,716,416 A 2/1973 Aldhart et al.

3,868,939 A * 3/1975 Friese et al. 123/179.15

3,933,135 A * 1/1976 Zillman et al. 123/557

3,999,525 A * 12/1976 Stumpp et al. 123/557

4,013,396 A 3/1977 Tenney

4,344,404 A 8/1982 Child et al.

(Continued)

OTHER PUBLICATIONS

Boyle et al., "Cold Start Performance of an Automobile Engine Using Prevaporized Gasoline" SAE Technical Paper Series Society of Automotive Engineers, vol. 102, No. 3, pp. 949-9.

(Continued)

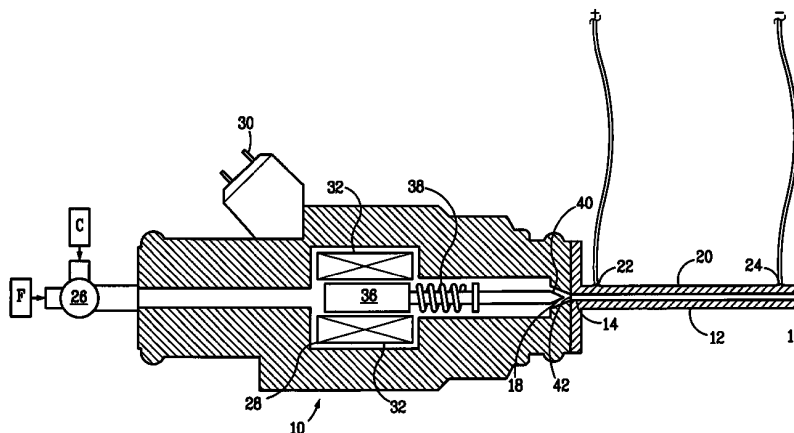
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(57) **ABSTRACT**

A fuel injector for vaporizing a liquid fuel for use in an internal combustion engine. The fuel injector includes at least one capillary flow passage, the at least one capillary flow passage having an inlet end and an outlet end, a fluid control valve for placing the inlet end of the at least one capillary flow passage in fluid communication with the liquid fuel source and introducing the liquid fuel in a substantially liquid state, a heat source arranged along the at least one capillary flow passage, the heat source operable to heat the liquid fuel in the at least one capillary flow passage to a level sufficient to change at least a portion thereof from the liquid state to a vapor state and deliver a stream of substantially vaporized fuel from the outlet end of the at least one capillary flow passage and means for cleaning deposits formed during operation of the apparatus. The fuel injector is effective in reducing cold-start and warm-up emissions of an internal combustion engine. Efficient combustion is promoted by forming an aerosol of fine droplet size when the substantially vaporized fuel condenses in air.

23 Claims, 21 Drawing Sheets



U.S. PATENT DOCUMENTS

4,472,133	A	9/1984	Petersen et al.	6,192,596	B1	2/2001	Bennett et al.
4,986,248	A	1/1991	Kobayashi et al.	6,195,504	B1	2/2001	Horie et al.
5,127,822	A	7/1992	Nakayama et al.	6,200,536	B1	3/2001	Tonkovich et al.
5,472,645	A	12/1995	Rock et al.	6,234,167	B1	5/2001	Cox et al.
5,482,023	A	1/1996	Hunt et al.	6,276,347	B1	8/2001	Hunt
5,692,095	A	11/1997	Young	6,293,333	B1	9/2001	Ponnappan et al.
5,694,906	A	12/1997	Lange et al.	6,315,217	B1	11/2001	Park
5,743,251	A	4/1998	Howell et al.	6,390,076	B1	5/2002	Hunt
5,813,388	A	9/1998	Cikanek et al.	6,779,513	B1	8/2004	Pellizzari et al. 123/549
5,870,525	A	2/1999	Young	6,871,792	B1	3/2005	Pellizzari 239/5
5,894,832	A	* 4/1999	Nogi et al. 123/491				
6,095,436	A	8/2000	Seegers et al.				
6,102,687	A	8/2000	Butcher et al.				
6,155,268	A	12/2000	Takeuchi				
6,162,046	A	12/2000	Young et al.				
6,169,852	B1	1/2001	Liao et al.				
6,189,803	B1	2/2001	Ganan-Calvo				

OTHER PUBLICATIONS

English abstract of JP 2000 110666.
 English abstract of DE 19546851.
 English abstract of EP 0,915,248.
 English translation of EP 0,915,248.

* cited by examiner

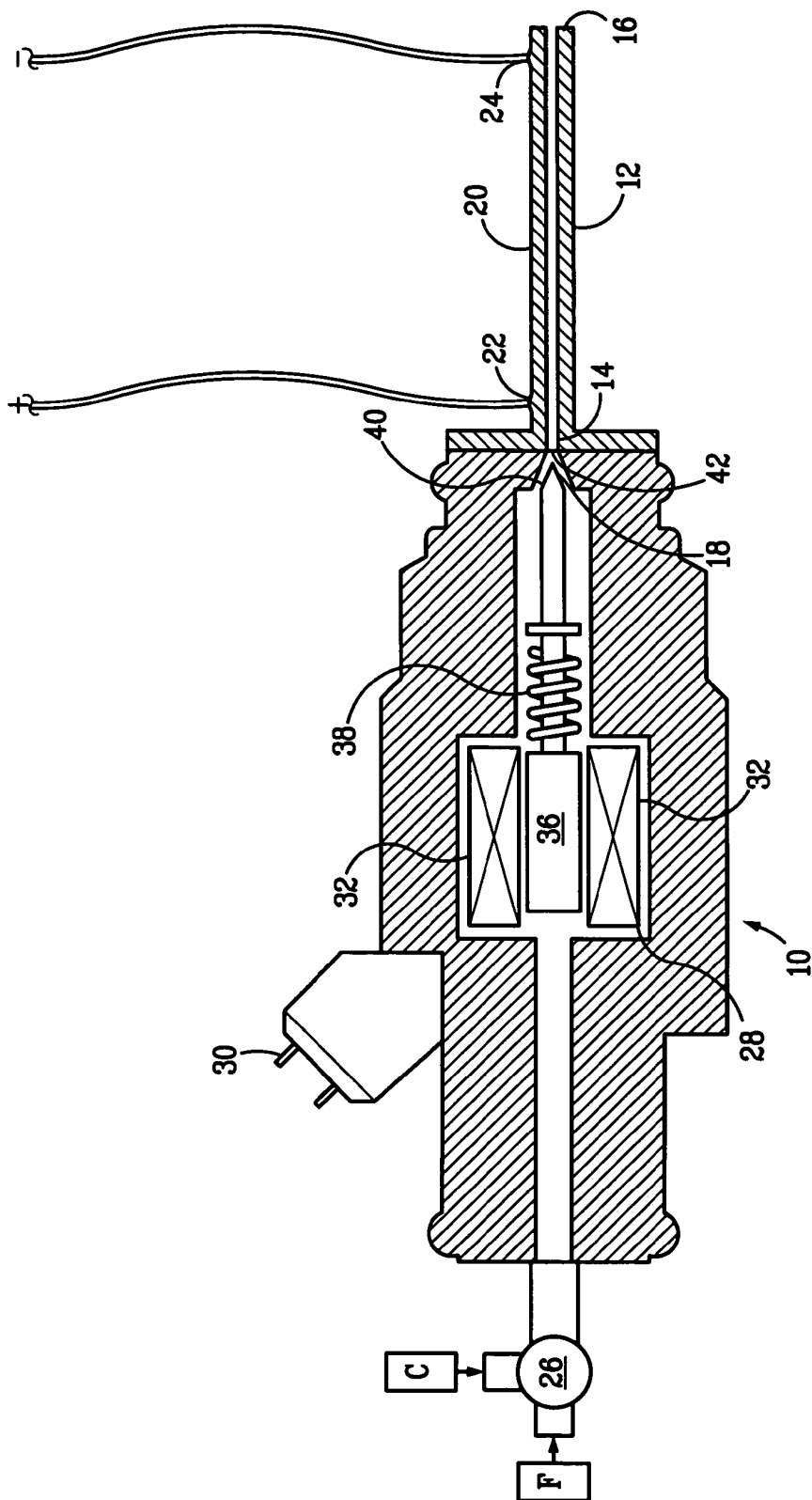
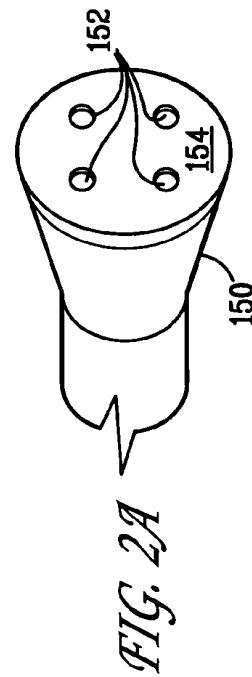
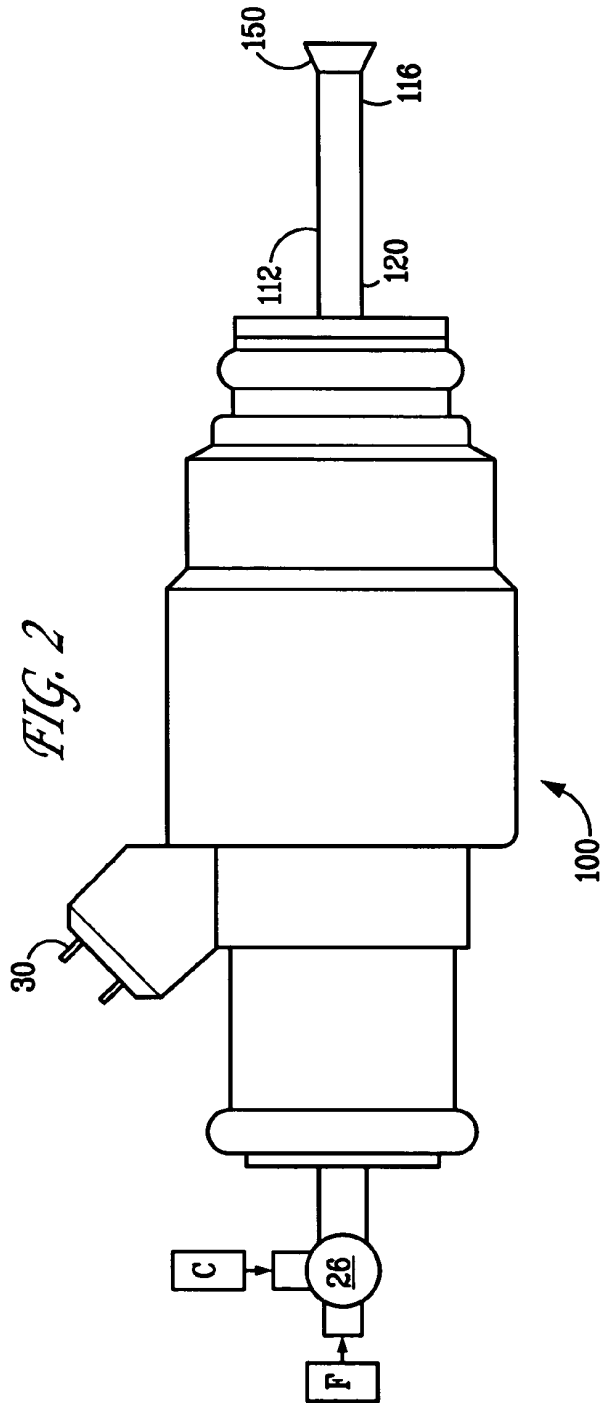
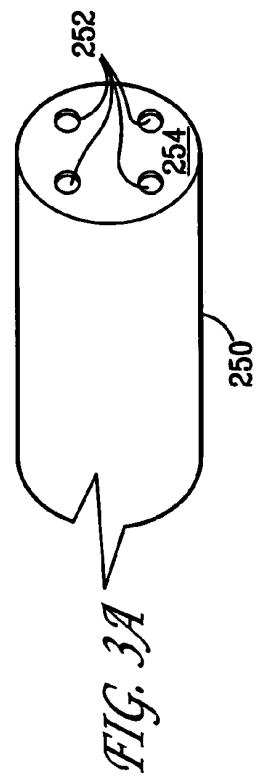
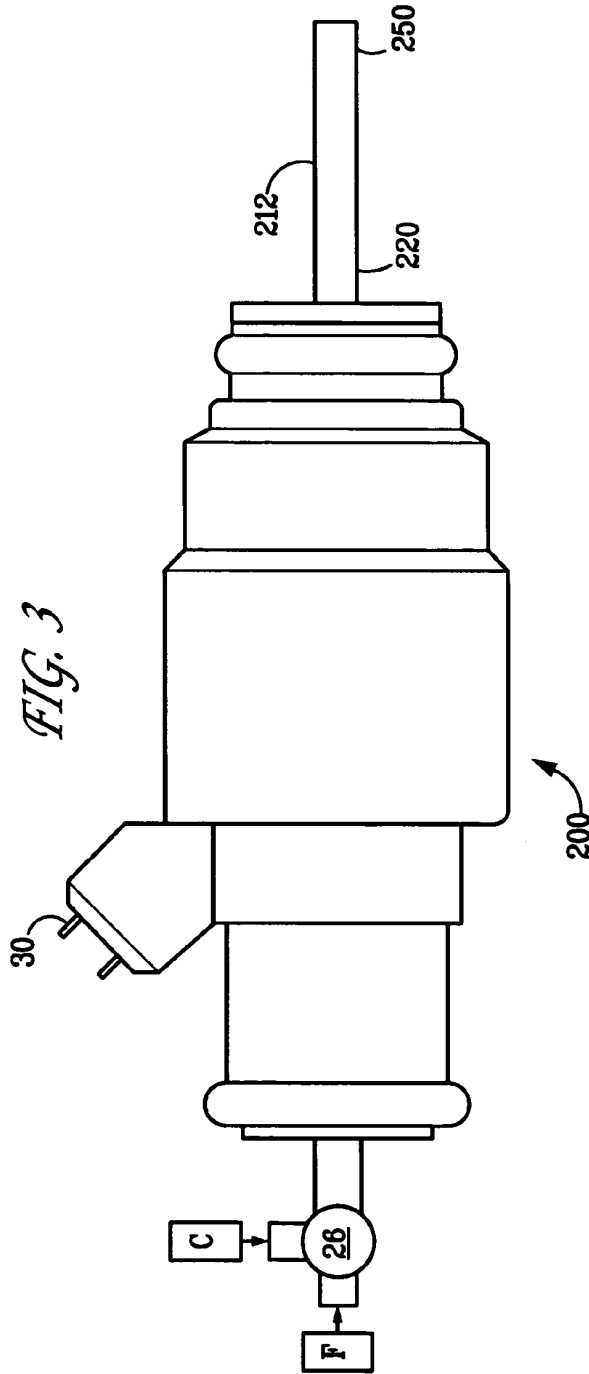


FIG. 1





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