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(54) **AUTOMATED CONTROL OF IRRIGATION AND ASPIRATION IN A SINGLE-USE ENDOSCOPE**


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**Related U.S. Patent Documents**

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(58) **Field of Classification Search**
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See application file for complete search history.



(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 3,266,059 | A | 8/1966 | Stelle |
| 3,470,876 | A | 10/1969 | Barchilon |
| 3,572,325 | A | 3/1971 | Bazell |
| 3,581,738 | A | 6/1971 | Moore |
| 4,108,211 | A | 8/1978 | Tanaka |
| 4,286,585 | A | 9/1981 | Ogawa |
| 4,294,162 | A | 10/1981 | Fowler |

(Continued)

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| DE | 198 00 765 | A1 | 4/1999 |
| EP | 0 075 153 | B1 | 3/1983 |

(Continued)


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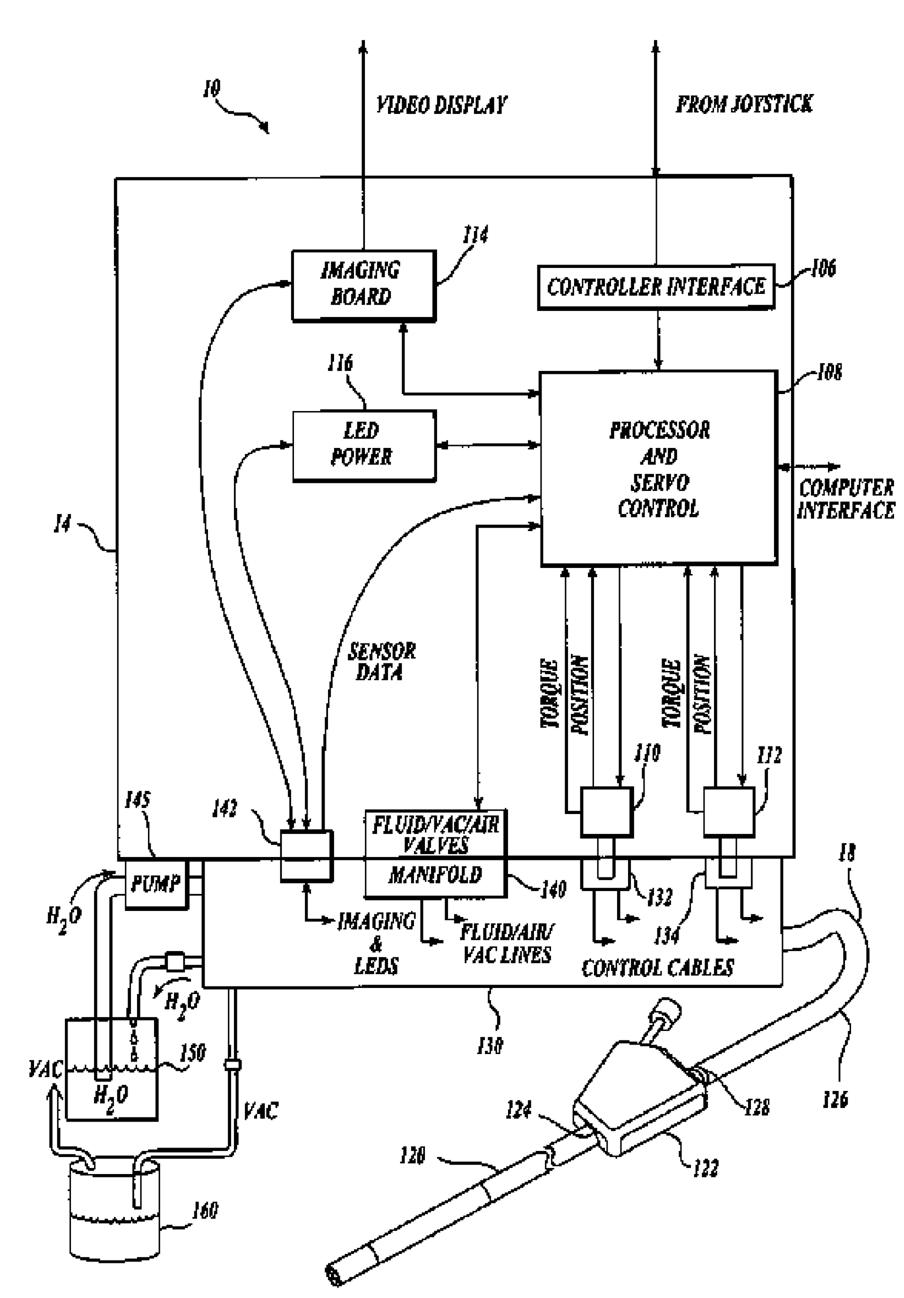
(57) **ABSTRACT**


The present invention is an integrated and automated irrigation and aspiration system for use in an endoscopic imaging system. The system provides for the automated cleaning of poorly prepared patients during a colonoscopy procedure as well as automated cleaning of an imaging system of an endoscope. The invention analyzes images obtained from an image sensor to detect the presence of an obstructed field of view, whereupon a wash routine is initiated to remove the obstruction. The wash routine may be adjusted in accordance with environmental conditions within the patient that are sensed by one or more sensors within the endoscope. In another embodiment, insufflation is automatically controlled to inflate a patient's colon as a function of one or more sensor readings obtained from one or more environmental sensor(s) on the endoscope.


**20 Claims, 4 Drawing Sheets**



(56) **References Cited**

U.S. PATENT DOCUMENTS


| | | | | |
|---|---|---|---|---|
| 4,311,134 | A | | 1/1982 | Mitsui |
| 4,315,309 | A | | 2/1982 | Coli |
| 4,351,323 | A | | 9/1982 | Ouchi |
| 4,425,113 | A | | 1/1984 | Bilstad |
| 4,432,349 | A | | 2/1984 | Oshiro |
| 4,471,766 | A | | 9/1984 | Terayama |
| 4,473,841 | A | | 9/1984 | Murakoshi |
| 4,488,039 | A | | 12/1984 | Sato |
| 4,491,865 | A | | 1/1985 | Danna |
| 4,493,537 | A | | 1/1985 | Nakahashi |
| 4,495,134 | A | | 1/1985 | Ouchi |
| 4,499,895 | A | | 2/1985 | Takayama |
| 4,503,842 | A | | 3/1985 | Takayama |
| 4,513,235 | A | | 4/1985 | Acklam |
| 4,515,444 | A | | 5/1985 | Prescott |
| 4,516,063 | A | | 5/1985 | Kaye |
| 4,519,391 | A | | 5/1985 | Murakoshi |
| 4,552,130 | A | | 11/1985 | Kinoshita |
| 4,559,928 | A | | 12/1985 | Takayama |
| 4,566,437 | A | | 1/1986 | Yamaguchi |
| 4,573,450 | A | | 3/1986 | Arakawa |
| 4,580,210 | A | | 4/1986 | Nordstrom |
| 4,586,923 | A | | 5/1986 | Gould |
| 4,615,330 | A | | 10/1986 | Nagasaki |
| 4,616,630 | A | | 10/1986 | Arakawa |
| 4,617,915 | A | | 10/1986 | Arakawa |
| 4,618,884 | A | | 10/1986 | Nagasaki |
| 4,621,618 | A | | 11/1986 | Omagari |
| 4,622,584 | A | | 11/1986 | Nagasaki |
| 4,625,714 | A | | 12/1986 | Toyota |
| 4,631,582 | A | | 12/1986 | Nagasaki |
| 4,633,303 | A | | 12/1986 | Nagasaki |
| 4,633,304 | A | | 12/1986 | Nagasaki |
| 4,643,170 | A | | 2/1987 | Miyazaki |
| 4,646,723 | A | | 3/1987 | Arakawa |
| 4,649,904 | A | | 3/1987 | Krauter |
| 4,651,202 | A | | 3/1987 | Arakawa |
| 4,652,093 | A | | 3/1987 | Stephen |
| 4,652,916 | A | | 3/1987 | Suzaki |
| 4,654,701 | A | | 3/1987 | Yabe |
| RE32,421 | E | | 5/1987 | Hattori |
| 4,662,725 | A | | 5/1987 | Nisioka |
| 4,663,657 | A | | 5/1987 | Nagasaki |
| 4,667,655 | A | | 5/1987 | Ogiu |
| 4,674,844 | A | | 6/1987 | Nishioka |
| 4,686,963 | A | | 8/1987 | Cohen |
| 4,697,210 | A | | 9/1987 | Toyota |
| 4,700,693 | A | | 10/1987 | Lia |
| 4,714,075 | A | | 12/1987 | Krauter |
| 4,716,457 | A | | 12/1987 | Matsuo |
| 4,719,508 | A | | 1/1988 | Sasaki |
| 4,727,417 | A | | 2/1988 | Kanno |
| 4,727,418 | A | | 2/1988 | Kato |
| 4,745,470 | A | | 5/1988 | Yabe |
| 4,745,471 | A | | 5/1988 | Takamura |
| 4,746,974 | A | | 5/1988 | Matsuo |
| 4,748,970 | A | | 6/1988 | Nakajima |
| 4,755,029 | A | | 7/1988 | Okabe |
| 4,762,119 | A | | 8/1988 | Allred, III |
| 4,765,312 | A | | 8/1988 | Sasa |
| 4,766,489 | A | | 8/1988 | Kato |
| 4,787,369 | A | | 11/1988 | Allred, III |
| 4,790,294 | A | | 12/1988 | Allred, III |
| 4,794,913 | A | | 1/1989 | Shimonaka |
| 4,796,607 | A | | 1/1989 | Allred, III |
| 4,800,869 | A | | 1/1989 | Nakajima |
| 4,805,596 | A | | 2/1989 | Hatori |
| 4,806,011 | A | | 2/1989 | Bettinger |
| 4,819,065 | A | | 4/1989 | Eino |
| 4,819,077 | A | | 4/1989 | Kikuchi |
| 4,821,116 | A | | 4/1989 | Nagasaki |
| 4,824,225 | A | | 4/1989 | Nishioka |
| 4,831,437 | A | | 5/1989 | Nishioka |
| 4,836,187 | A | * | 6/1989 | Iwakoshi et al. .............. 600/157 |
| 4,844,052 | A | | 7/1989 | Iwakoshi |
| 4,844,071 | A | | 7/1989 | Chen |
| 4,845,553 | A | | 7/1989 | Konomura |
| 4,845,555 | A | | 7/1989 | Yabe |
| 4,847,694 | A | | 7/1989 | Nishihara |
| 4,853,772 | A | | 8/1989 | Kikuchi |
| 4,860,731 | A | | 8/1989 | Matsuura |
| 4,867,546 | A | | 9/1989 | Nishioka |
| 4,868,647 | A | | 9/1989 | Uehara |
| 4,869,237 | A | | 9/1989 | Eino |
| 4,873,965 | A | | 10/1989 | Danieli |
| 4,875,468 | A | | 10/1989 | Krauter |
| 4,877,314 | A | | 10/1989 | Kanamori |
| 4,882,623 | A | | 11/1989 | Uchikubo |
| 4,884,134 | A | | 11/1989 | Tsuji |
| 4,885,634 | A | | 12/1989 | Yabe |
| 4,890,159 | A | | 12/1989 | Ogiu |
| 4,894,715 | A | | 1/1990 | Uchikubo |
| 4,895,431 | A | | 1/1990 | Tsujiuchi |
| 4,897,789 | A | | 1/1990 | King |
| 4,899,731 | A | | 2/1990 | Takayama |
| 4,899,732 | A | | 2/1990 | Cohen |
| 4,899,787 | A | | 2/1990 | Ouchi |
| 4,905,666 | A | | 3/1990 | Fukuda |
| 4,916,533 | A | | 4/1990 | Gillies |
| 4,918,521 | A | | 4/1990 | Yabe |
| 4,919,112 | A | | 4/1990 | Siegmund |
| 4,919,114 | A | | 4/1990 | Miyazaki |
| 4,920,980 | A | | 5/1990 | Jackowski |
| 4,928,172 | A | | 5/1990 | Uehara |
| 4,931,867 | A | | 6/1990 | Kikuchi |
| 4,941,454 | A | | 7/1990 | Wood |
| 4,941,456 | A | | 7/1990 | Wood |
| 4,951,134 | A | | 8/1990 | Nakasima |
| 4,951,135 | A | | 8/1990 | Sasagawa |
| 4,952,040 | A | | 8/1990 | Igarashi |
| 4,960,127 | A | | 10/1990 | Noce |
| 4,961,110 | A | | 10/1990 | Nakamura |
| 4,967,269 | A | | 10/1990 | Sasagawa |
| 4,971,034 | A | | 11/1990 | Doi |
| 4,973,311 | A | | 11/1990 | Iwakoshi |
| 4,979,497 | A | | 12/1990 | Matsuura |
| 4,982,725 | A | | 1/1991 | Hibino |
| 4,984,878 | A | | 1/1991 | Miyano |
| 4,986,642 | A | | 1/1991 | Yokota |
| 4,987,884 | A | | 1/1991 | Nishioka |
| 4,989,075 | A | | 1/1991 | Ito |
| 4,989,581 | A | | 2/1991 | Tamburrino |
| 4,996,974 | A | | 3/1991 | Ciarlei |
| 4,996,975 | A | | 3/1991 | Nakamura |
| 5,001,556 | A | | 3/1991 | Nakamura |
| 5,005,558 | A | | 4/1991 | Aomori |
| 5,005,957 | A | | 4/1991 | Kanamori |
| 5,007,408 | A | | 4/1991 | Ieoka |
| 5,018,509 | A | | 5/1991 | Suzuki |
| 5,019,056 | A | | 5/1991 | Lee |
| 5,022,382 | A | | 6/1991 | Ohshoji |
| 5,029,016 | A | | 7/1991 | Hiyama |
| 5,034,888 | A | | 7/1991 | Uehara |
| 5,040,069 | A | | 8/1991 | Matsumoto |
| RE33,689 | E | | 9/1991 | Nishioka |
| 5,045,935 | A | | 9/1991 | Kikuchi |
| 5,049,989 | A | | 9/1991 | Tsuji |
| 5,050,584 | A | | 9/1991 | Matsuura |
| 5,050,974 | A | | 9/1991 | Takasugi |
| 5,056,503 | A | | 10/1991 | Nagasaki |
| 5,061,994 | A | | 10/1991 | Takahashi |
| 5,068,719 | A | | 11/1991 | Tsuji |
| 5,074,861 | A | | 12/1991 | Schneider |
| 5,081,524 | A | | 1/1992 | Tsuruoka |
| 5,087,989 | A | | 2/1992 | Igarashi |
| 5,110,645 | A | | 5/1992 | Matsumoto |
| 5,111,281 | A | | 5/1992 | Sekiguchi |
| 5,111,306 | A | | 5/1992 | Kanno |
| 5,111,804 | A | | 5/1992 | Funakoshi |
| 5,113,254 | A | | 5/1992 | Kanno |
| 5,119,238 | A | | 6/1992 | Igarashi |
| 5,131,393 | A | | 7/1992 | Ishiguro |
| 5,137,013 | A | | 8/1992 | Chiba |
| 5,140,265 | A | | 8/1992 | Sakiyama |

(56) **References Cited**

U.S. PATENT DOCUMENTS


| | | | | |
|---|---|---|---|---|
| 5,159,446 | A | | 10/1992 | Hibino |
| 5,170,774 | A | | 12/1992 | Heckele |
| 5,170,775 | A | | 12/1992 | Tagami |
| 5,172,225 | A | | 12/1992 | Takahashi |
| 5,174,293 | A | | 12/1992 | Hagiwara |
| 5,176,629 | A | | 1/1993 | Kullas |
| 5,188,111 | A | | 2/1993 | Yates |
| 5,191,878 | A | | 3/1993 | Iida |
| 5,198,931 | A | | 3/1993 | Igarashi |
| 5,201,908 | A | | 4/1993 | Jones |
| 5,208,702 | A | | 5/1993 | Shiraiwa |
| 5,209,220 | A | | 5/1993 | Hiyama |
| 5,225,958 | A | | 7/1993 | Nakamura |
| 5,228,356 | A | | 7/1993 | Chuang |
| 5,243,416 | A | | 9/1993 | Nakazawa |
| 5,243,967 | A | | 9/1993 | Hibino |
| 5,257,628 | A | | 11/1993 | Ishiguro |
| 5,271,381 | A | | 12/1993 | Ailinger |
| RE34,504 | E | | 1/1994 | Uehara |
| 5,279,542 | A | | 1/1994 | Wilk |
| 5,291,010 | A | | 3/1994 | Tsuji |
| 5,299,559 | A | | 4/1994 | Bruce |
| 5,311,858 | A | | 5/1994 | Adair |
| 5,325,845 | A | | 7/1994 | Adair |
| 5,331,551 | A | | 7/1994 | Tsuruoka |
| 5,342,299 | A | | 8/1994 | Snoke |
| 5,347,987 | A | | 9/1994 | Feldstein |
| 5,347,989 | A | | 9/1994 | Monroe |
| 5,374,953 | A | | 12/1994 | Sasaki |
| 5,379,757 | A | | 1/1995 | Hiyama |
| 5,381,782 | A | | 1/1995 | DeLaRama |
| 5,390,662 | A | | 2/1995 | Okada |
| 5,400,769 | A | | 3/1995 | Tanii |
| 5,402,768 | A | | 4/1995 | Adair |
| 5,402,769 | A | | 4/1995 | Tsuji |
| 5,409,485 | A | | 4/1995 | Suda |
| 5,412,478 | A | | 5/1995 | Ishihara |
| 5,418,649 | A | | 5/1995 | Igarashi |
| 5,420,644 | A | | 5/1995 | Watanabe |
| 5,429,596 | A | | 7/1995 | Arias |
| 5,431,645 | A | | 7/1995 | Smith |
| 5,434,615 | A | | 7/1995 | Matumoto |
| 5,436,640 | A | | 7/1995 | Reeves |
| 5,436,767 | A | | 7/1995 | Suzuki |
| 5,440,341 | A | | 8/1995 | Suzuki |
| 5,464,007 | A | | 11/1995 | Krauter |
| 5,469,840 | A | | 11/1995 | Tanii |
| 5,473,235 | A | | 12/1995 | Lance |
| 5,482,029 | A | | 1/1996 | Sekiguchi |
| 5,484,407 | A | | 1/1996 | Osypka |
| 5,485,316 | A | | 1/1996 | Mori |
| 5,492,131 | A | | 2/1996 | Galel |
| 5,496,260 | A | | 3/1996 | Krauter |
| 5,515,449 | A | | 5/1996 | Tsuruoka |
| 5,518,501 | A | | 5/1996 | Oneda |
| 5,518,502 | A | | 5/1996 | Kaplan |
| 5,543,831 | A | | 8/1996 | Tsuji |
| 5,549,546 | A | * | 8/1996 | Schneider et al. .............. 604/26 |
| 5,569,158 | A | | 10/1996 | Suzuki |
| 5,569,159 | A | | 10/1996 | Anderson |
| 5,586,262 | A | | 12/1996 | Komatsu |
| 5,589,854 | A | | 12/1996 | Tsai |
| 5,591,202 | A | | 1/1997 | Slater |
| 5,608,451 | A | | 3/1997 | Konno |
| 5,609,563 | A | | 3/1997 | Suzuki |
| 5,619,380 | A | | 4/1997 | Ogasawara |
| 5,622,528 | A | | 4/1997 | Hamano |
| 5,631,695 | A | | 5/1997 | Nakamura |
| 5,633,203 | A | | 5/1997 | Adair |
| 5,643,203 | A | | 7/1997 | Beiser |
| 5,643,302 | A | | 7/1997 | Beiser |
| 5,645,075 | A | | 7/1997 | Palmer |
| 5,647,840 | A | | 7/1997 | D'Amelio |
| 5,658,238 | A | | 8/1997 | Suzuki |
| 5,667,477 | A | | 9/1997 | Segawa |
| 5,674,182 | A | | 10/1997 | Suzuki |
| 5,674,197 | A | | 10/1997 | van Muiden |
| 5,685,823 | A | | 11/1997 | Ito |
| 5,685,825 | A | | 11/1997 | Takase |
| 5,691,853 | A | | 11/1997 | Miyano |
| 5,695,450 | A | | 12/1997 | Yabe |
| 5,698,866 | A | | 12/1997 | Doiron |
| 5,702,349 | A | | 12/1997 | Morizumi |
| 5,702,754 | A | | 12/1997 | Zhong |
| 5,703,724 | A | | 12/1997 | Miyano |
| 5,704,371 | A | | 1/1998 | Shepard |
| 5,704,896 | A | | 1/1998 | Fukunishi |
| 5,708,482 | A | | 1/1998 | Takahashi |
| 5,721,566 | A | | 2/1998 | Rosenberg |
| 5,724,068 | A | | 3/1998 | Sanchez |
| 5,728,045 | A | | 3/1998 | Komi |
| 5,730,702 | A | | 3/1998 | Tanaka |
| 5,739,811 | A | | 4/1998 | Rosenberg |
| 5,740,801 | A | | 4/1998 | Branson |
| 5,746,696 | A | | 5/1998 | Kondo |
| 5,764,809 | A | | 6/1998 | Nomami |
| 5,767,839 | A | | 6/1998 | Rosenberg |
| 5,779,686 | A | | 7/1998 | Sato |
| 5,781,172 | A | | 7/1998 | Engel |
| 5,788,714 | A | | 8/1998 | Ouchi |
| 5,789,047 | A | | 8/1998 | Sasaki |
| 5,793,539 | A | | 8/1998 | Konno |
| 5,805,140 | A | | 9/1998 | Rosenberg |
| 5,810,715 | A | | 9/1998 | Moriyama |
| 5,812,983 | A | | 9/1998 | Kumagai |
| 5,819,736 | A | | 10/1998 | Avny |
| 5,820,591 | A | | 10/1998 | Thompson |
| 5,821,466 | A | | 10/1998 | Clark |
| 5,821,920 | A | | 10/1998 | Rosenberg |
| 5,823,948 | A | | 10/1998 | Ross, Jr. |
| 5,827,176 | A | | 10/1998 | Tanaka |
| 5,827,186 | A | | 10/1998 | Chen |
| 5,827,190 | A | | 10/1998 | Palcic |
| 5,828,197 | A | | 10/1998 | Martin |
| 5,828,363 | A | | 10/1998 | Yaniger |
| 5,830,124 | A | | 11/1998 | Suzuki |
| 5,830,128 | A | | 11/1998 | Tanaka |
| 5,836,869 | A | | 11/1998 | Kudo |
| 5,837,023 | A | | 11/1998 | Koike |
| 5,840,014 | A | | 11/1998 | Miyano |
| 5,841,126 | A | | 11/1998 | Fossum |
| 5,842,971 | A | | 12/1998 | Yoon |
| 5,843,000 | A | | 12/1998 | Nishioka |
| 5,846,183 | A | | 12/1998 | Chilcoat |
| 5,855,560 | A | | 1/1999 | Idaomi |
| 5,857,963 | A | | 1/1999 | Pelchy |
| 5,865,724 | A | | 2/1999 | Palmer |
| 5,868,664 | A | | 2/1999 | Speier |
| 5,868,666 | A | | 2/1999 | Okada |
| 5,873,816 | A | | 2/1999 | Kagawa |
| 5,873,866 | A | | 2/1999 | Kondo |
| 5,876,326 | A | | 3/1999 | Takamura |
| 5,876,331 | A | | 3/1999 | Wu |
| 5,876,373 | A | | 3/1999 | Giba |
| 5,876,427 | A | | 3/1999 | Chen |
| 5,877,819 | A | | 3/1999 | Branson |
| 5,879,284 | A | | 3/1999 | Tsujita |
| 5,880,714 | A | | 3/1999 | Rosenberg |
| 5,882,293 | A | | 3/1999 | Ouchi |
| 5,882,339 | A | | 3/1999 | Beiser |
| 5,889,670 | A | | 3/1999 | Schuler |
| 5,889,672 | A | | 3/1999 | Schuler |
| 5,892,630 | A | | 4/1999 | Broome |
| 5,895,350 | A | | 4/1999 | Hori |
| 5,897,507 | A | | 4/1999 | Kortenbach |
| 5,897,525 | A | | 4/1999 | Dey |
| 5,907,487 | A | | 5/1999 | Rosenberg |
| 5,923,018 | A | | 7/1999 | Kameda |
| 5,928,136 | A | | 7/1999 | Barry |
| 5,929,607 | A | | 7/1999 | Rosenberg |
| 5,929,846 | A | | 7/1999 | Rosenberg |
| 5,929,900 | A | | 7/1999 | Yamanaka |
| 5,929,901 | A | | 7/1999 | Adair |
| 5,931,833 | A | | 8/1999 | Silverstein |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 5,933,809 | A | 8/1999 | Hunt |
| 5,935,085 | A | 8/1999 | Welsh |
| 5,936,778 | A | 8/1999 | Miyano |
| 5,941,817 | A | 8/1999 | Crawford |
| 5,950,168 | A | 9/1999 | Simborg |
| 5,951,462 | A | 9/1999 | Yamanaka |
| 5,956,416 | A | 9/1999 | Tsuruoka |
| 5,956,689 | A | 9/1999 | Everhart, III |
| 5,956,690 | A | 9/1999 | Haggerson |
| 5,959,613 | A | 9/1999 | Rosenberg |
| 5,976,070 | A | 11/1999 | Ono |
| 5,976,074 | A | 11/1999 | Moriyama |
| 5,980,454 | A | 11/1999 | Broome |
| 5,980,468 | A | 11/1999 | Zimmon |
| 5,986,693 | A | 11/1999 | Adair |
| 5,991,729 | A | 11/1999 | Barry |
| 5,991,730 | A | 11/1999 | Lubin |
| 5,999,168 | A | 12/1999 | Rosenberg |
| 6,002,425 | A | 12/1999 | Yamanaka |
| 6,007,482 | A | 12/1999 | Madni |
| 6,007,531 | A | 12/1999 | Snoke |
| 6,014,630 | A | 1/2000 | Jeacock |
| 6,015,088 | A | 1/2000 | Parker |
| 6,017,322 | A | 1/2000 | Snoke |
| 6,020,875 | A | 2/2000 | Moore |
| 6,020,876 | A | 2/2000 | Rosenberg |
| 6,026,363 | A | 2/2000 | Shepard |
| 6,030,360 | A | 2/2000 | Biggs |
| 6,032,120 | A | 2/2000 | Rock |
| 6,039,728 | A | 3/2000 | Berlien |
| 6,043,839 | A | 3/2000 | Adair |
| 6,050,718 | A | 4/2000 | Schena |
| 6,057,828 | A | 5/2000 | Rosenberg |
| 6,059,719 | A | 5/2000 | Yamamoto |
| 6,061,004 | A | 5/2000 | Rosenberg |
| 6,066,090 | A | 5/2000 | Yoon |
| 6,067,077 | A | 5/2000 | Martin |
| 6,071,248 | A | 6/2000 | Zimmon |
| 6,075,555 | A | 6/2000 | Street |
| 6,078,308 | A | 6/2000 | Rosenberg |
| 6,078,353 | A | 6/2000 | Yamanaka |
| 6,078,876 | A | 6/2000 | Rosenberg |
| 6,080,104 | A | 6/2000 | Ozawa |
| 6,081,809 | A | 6/2000 | Kumagai |
| 6,083,152 | A | 7/2000 | Strong |
| 6,083,170 | A | 7/2000 | Ben-Haim |
| 6,095,971 | A | 8/2000 | Takahashi |
| 6,099,465 | A | 8/2000 | Inoue |
| 6,100,874 | A | 8/2000 | Schena |
| 6,104,382 | A | 8/2000 | Martin |
| 6,120,435 | A | 9/2000 | Eino |
| 6,125,337 | A | 9/2000 | Rosenberg |
| 6,128,006 | A | 10/2000 | Rosenberg |
| 6,132,369 | A | 10/2000 | Takahashi |
| 6,134,056 | A | 10/2000 | Nakamuka |
| 6,134,506 | A | 10/2000 | Rosenberg |
| 6,135,946 | A | 10/2000 | Konen |
| 6,139,508 | A | 10/2000 | Simpson |
| 6,141,037 | A | 10/2000 | Upton |
| 6,142,956 | A | 11/2000 | Kortenbach |
| 6,146,355 | A | 11/2000 | Biggs |
| 6,149,607 | A | 11/2000 | Simpson |
| 6,152,877 | A | 11/2000 | Masters |
| 6,154,198 | A | 11/2000 | Rosenberg |
| 6,154,248 | A | 11/2000 | Ozawa |
| 6,155,988 | A | 12/2000 | Peters |
| 6,181,481 | B1 | 1/2001 | Yamamoto |
| 6,184,922 | B1 | 2/2001 | Saito |
| 6,193,714 | B1 | 2/2001 | McGaffigan |
| 6,195,592 | B1 | 2/2001 | Schuler et al. |
| 6,203,493 | B1 | 3/2001 | Ben-Haim |
| 6,206,824 | B1 | 3/2001 | Ohara |
| 6,211,904 | B1 | 4/2001 | Adair |
| 6,216,104 | B1 | 4/2001 | Moshfeghi |
| 6,219,091 | B1 | 4/2001 | Yamanaka |
| 6,221,070 | B1 | 4/2001 | Tu |
| 6,238,799 | B1 | 5/2001 | Opolski |
| 6,241,668 | B1 | 6/2001 | Herzog |
| 6,260,994 | B1 | 7/2001 | Matsumoto |
| 6,261,226 | B1 | 7/2001 | McKenna |
| 6,272,470 | B1 | 8/2001 | Teshima |
| 6,275,255 | B1 | 8/2001 | Adair |
| 6,282,442 | B1 | 8/2001 | DeStefano |
| 6,283,960 | B1 | 9/2001 | Ashley |
| 6,295,082 | B1 | 9/2001 | Dowdy |
| 6,299,625 | B1 | 10/2001 | Bacher |
| 6,309,347 | B1 | 10/2001 | Takahashi |
| 6,310,642 | B1 | 10/2001 | Adair |
| 6,319,196 | B1 | 11/2001 | Minami |
| 6,319,197 | B1 | 11/2001 | Tsuji |
| 6,334,844 | B1 | 1/2002 | Akiba |
| 6,346,075 | B1 | 2/2002 | Arai |
| 6,354,992 | B1 | 3/2002 | Kato |
| 6,366,799 | B1 | 4/2002 | Acker |
| 6,381,029 | B1 | 4/2002 | Tipirneni |
| 6,398,724 | B1 | 6/2002 | May |
| 6,413,207 | B1 | 7/2002 | Minami |
| 6,421,078 | B1 | 7/2002 | Akai |
| 6,425,535 | B1 | 7/2002 | Akiba |
| 6,425,858 | B1 | 7/2002 | Minami |
| 6,436,032 | B1 | 8/2002 | Eto |
| 6,441,845 | B1 | 8/2002 | Matsumoto |
| 6,447,444 | B1 | 9/2002 | Avni |
| 6,449,006 | B1 | 9/2002 | Shipp |
| 6,453,190 | B1 | 9/2002 | Acker |
| 6,454,162 | B1 | 9/2002 | Teller |
| 6,459,447 | B1 | 10/2002 | Okada |
| 6,468,204 | B2 | 10/2002 | Sendai |
| 6,475,141 | B2 | 11/2002 | Abe |
| 6,478,730 | B1 | 11/2002 | Bala |
| 6,489,987 | B1 | 12/2002 | Higuchi |
| 6,496,827 | B2 | 12/2002 | Kozam |
| 6,498,948 | B1 | 12/2002 | Ozawa |
| 6,503,193 | B1 | 1/2003 | Iwasaki |
| 6,520,908 | B1 | 2/2003 | Ikeda |
| 6,524,234 | B2 | 2/2003 | Ouchi |
| 6,530,882 | B1 | 3/2003 | Farkas |
| 6,533,722 | B2 | 3/2003 | Nakashima |
| 6,540,669 | B2 | 4/2003 | Abe |
| 6,544,194 | B1 | 4/2003 | Kortenbach |
| 6,545,703 | B1 | 4/2003 | Takahashi |
| 6,551,239 | B2 | 4/2003 | Renner |
| 6,558,317 | B2 | 5/2003 | Takahashi |
| 6,561,971 | B1 | 5/2003 | Akiba |
| 6,565,507 | B2 | 5/2003 | Kamata |
| 6,574,629 | B1 | 6/2003 | Cooke, Jr. et al. |
| 6,589,162 | B2 | 7/2003 | Nakashima |
| 6,595,913 | B2 | 7/2003 | Takahashi |
| 6,597,390 | B1 | 7/2003 | Higuchi |
| 6,599,239 | B2 | 7/2003 | Hayakawa |
| 6,602,186 | B1 | 8/2003 | Sugimoto |
| 6,605,035 | B2 | 8/2003 | Ando |
| 6,609,135 | B1 | 8/2003 | Omori |
| 6,611,846 | B1 | 8/2003 | Stoodley |
| 6,614,969 | B2 | 9/2003 | Eichelberger |
| 6,616,601 | B2 | 9/2003 | Hayakawa |
| 6,623,424 | B2 | 9/2003 | Hayakawa |
| 6,638,214 | B2 | 10/2003 | Akiba |
| 6,638,215 | B2 | 10/2003 | Kobayashi |
| 6,641,528 | B2 | 11/2003 | Torii |
| 6,641,553 | B1 * | 11/2003 | Chee et al. ...................... 604/68 |
| 6,651,669 | B1 | 11/2003 | Burnside |
| 6,656,110 | B1 | 12/2003 | Irion |
| 6,656,112 | B2 | 12/2003 | Miyanaga |
| 6,659,940 | B2 | 12/2003 | Adler |
| 6,663,561 | B2 | 12/2003 | Sugimoto |
| 6,669,629 | B2 | 12/2003 | Matsui |
| 6,673,012 | B2 | 1/2004 | Fujii |
| 6,677,984 | B2 | 1/2004 | Kobayashi |
| 6,678,397 | B1 | 1/2004 | Ohmori |
| 6,682,479 | B1 | 1/2004 | Takahashi |
| 6,685,631 | B2 | 2/2004 | Minami |
| 6,686,949 | B2 | 2/2004 | Kobayashi |
| 6,690,409 | B1 | 2/2004 | Takahashi |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 6,690,963 | B2 | 2/2004 | Ben-Haim |
| 6,692,431 | B2 | 2/2004 | Kazakevich |
| 6,697,101 | B1 | 2/2004 | Takahashi |
| 6,699,181 | B2 | 3/2004 | Wako |
| 6,702,737 | B2 | 3/2004 | Hino |
| 6,711,426 | B2 | 3/2004 | Benaron |
| 6,715,068 | B1 | 3/2004 | Abe |
| 6,716,162 | B2 | 4/2004 | Hakamata |
| 6,728,599 | B2 | 4/2004 | Wright |
| 6,730,018 | B2 | 5/2004 | Takase |
| 6,736,773 | B2 | 5/2004 | Wendlandt |
| 6,743,240 | B2 | 6/2004 | Smith |
| 6,749,559 | B1 | 6/2004 | Kraas |
| 6,749,560 | B1 | 6/2004 | Konstorum |
| 6,749,561 | B2 | 6/2004 | Kazakevich |
| 6,753,905 | B1 | 6/2004 | Okada |
| 6,758,806 | B2 | 7/2004 | Kamrava |
| 6,758,807 | B2 | 7/2004 | Minami |
| 6,758,842 | B2 | 7/2004 | Irion |
| 6,774,947 | B2 | 8/2004 | Muto |
| 6,778,208 | B2 | 8/2004 | Takeshige |
| 6,780,151 | B2 | 8/2004 | Grabover |
| 6,785,410 | B2 | 8/2004 | Vining |
| 6,785,414 | B1 | 8/2004 | McStravick, III |
| 6,785,593 | B2 | 8/2004 | Wang |
| 6,796,938 | B2 | 9/2004 | Sendai |
| 6,796,939 | B1 | 9/2004 | Konomura |
| 6,798,533 | B2 | 9/2004 | Tipirneni |
| 6,800,056 | B2 | 10/2004 | Tartaglia |
| 6,800,057 | B2 | 10/2004 | Tsujita |
| 6,808,491 | B2 | 10/2004 | Kortenbach |
| 6,824,539 | B2 | 11/2004 | Novak |
| 6,824,548 | B2 | 11/2004 | Smith |
| 6,829,003 | B2 | 12/2004 | Takami |
| 6,830,545 | B2 | 12/2004 | Bendall |
| 6,832,990 | B2 | 12/2004 | Kortenbach |
| 6,840,932 | B2 | 1/2005 | Lang |
| 6,842,196 | B1 | 1/2005 | Swift |
| 6,846,286 | B2 | 1/2005 | Hashiyama |
| 6,847,933 | B1 | 1/2005 | Hastings |
| 6,849,043 | B2 | 2/2005 | Kondo |
| 6,850,794 | B2 | 2/2005 | Shahidi |
| 6,855,109 | B2 | 2/2005 | Obata |
| 6,858,004 | B1 | 2/2005 | Ozawa |
| 6,858,014 | B2 | 2/2005 | Damarati |
| 6,860,849 | B2 | 3/2005 | Matsushita |
| 6,863,650 | B1 | 3/2005 | Irion |
| 6,863,661 | B2 | 3/2005 | Carrillo, Jr. |
| 6,868,195 | B2 | 3/2005 | Fujita |
| 6,871,086 | B2 | 3/2005 | Nevo |
| 6,873,352 | B2 | 3/2005 | Mochida |
| 6,876,380 | B2 | 4/2005 | Abe |
| 6,879,339 | B2 | 4/2005 | Ozawa |
| 6,881,188 | B2 | 4/2005 | Furuya |
| 6,882,785 | B2 | 4/2005 | Eichelberger |
| 6,887,195 | B1 | 5/2005 | Pilvisto |
| 6,890,294 | B2 | 5/2005 | Niwa |
| 6,892,090 | B2 | 5/2005 | Verard |
| 6,892,112 | B2 | 5/2005 | Wang |
| 6,895,268 | B1 | 5/2005 | Rahn |
| 6,898,086 | B2 | 5/2005 | Takami |
| 6,899,673 | B2 | 5/2005 | Ogura |
| 6,899,674 | B2 | 5/2005 | Viebach |
| 6,899,705 | B2 | 5/2005 | Niemeyer |
| 6,900,829 | B1 | 5/2005 | Ozawa |
| 6,902,527 | B1 | 6/2005 | Doguchi |
| 6,902,529 | B2 | 6/2005 | Onishi |
| 6,903,761 | B1 | 6/2005 | Abe |
| 6,903,883 | B2 | 6/2005 | Amanai |
| 6,905,057 | B2 | 6/2005 | Swayze |
| 6,905,462 | B1 | 6/2005 | Homma |
| 6,908,427 | B2 | 6/2005 | Fleener |
| 6,908,429 | B2 | 6/2005 | Heimberger |
| 6,911,916 | B1 | 6/2005 | Wang |
| 6,916,286 | B2 | 7/2005 | Kazakevich |
| 6,923,818 | B2 | 8/2005 | Muramatsu |
| 6,928,490 | B1 | 8/2005 | Bucholz |
| 6,930,706 | B2 | 8/2005 | Kobayashi |
| 6,932,761 | B2 | 8/2005 | Maeda |
| 6,934,093 | B2 | 8/2005 | Kislev |
| 6,934,575 | B2 | 8/2005 | Ferre |
| 6,943,663 | B2 | 9/2005 | Wang |
| 6,943,821 | B2 | 9/2005 | Abe |
| 6,943,822 | B2 | 9/2005 | Iida |
| 6,943,946 | B2 | 9/2005 | Fiete |
| 6,943,959 | B2 | 9/2005 | Homma |
| 6,943,966 | B2 | 9/2005 | Konno |
| 6,944,031 | B2 | 9/2005 | Takami |
| 6,949,068 | B2 | 9/2005 | Taniguchi |
| 6,950,248 | B2 | 9/2005 | Rudischhauser |
| 6,950,691 | B2 | 9/2005 | Uchikubo |
| 6,954,311 | B2 | 10/2005 | Amanai |
| 6,955,671 | B2 | 10/2005 | Uchikubo |
| 6,956,703 | B2 | 10/2005 | Saito |
| 6,961,187 | B2 | 11/2005 | Amanai |
| 6,962,564 | B2 | 11/2005 | Hickle |
| 6,963,175 | B2 | 11/2005 | Archenhold |
| 6,964,662 | B2 | 11/2005 | Kidooka |
| 6,967,673 | B2 | 11/2005 | Ozawa |
| 6,974,466 | B2 | 12/2005 | Ahmed |
| 6,975,968 | B2 | 12/2005 | Nakamitsu |
| 6,976,954 | B2 | 12/2005 | Takahashi |
| 6,977,053 | B2 | 12/2005 | Mukasa |
| 6,977,670 | B2 | 12/2005 | Takahashi |
| 6,980,227 | B2 | 12/2005 | Iida |
| 6,980,921 | B2 | 12/2005 | Anderson |
| 6,981,945 | B1 | 1/2006 | Sarvazyan |
| 6,982,740 | B2 | 1/2006 | Adair |
| 6,984,206 | B2 | 1/2006 | Kumei |
| 6,985,183 | B2 | 1/2006 | Jan |
| 6,986,686 | B2 | 1/2006 | Shibata |
| 6,994,668 | B2 | 2/2006 | Miyano |
| 6,994,704 | B2 | 2/2006 | Qin |
| 7,001,330 | B2 | 2/2006 | Kobayashi |
| 7,008,376 | B2 | 3/2006 | Ikeda |
| 7,335,159 | B2 * | 2/2008 | Banik et al. .................. 600/156 |
| 2001/0039370 | A1 | 11/2001 | Takahashi |
| 2001/0049491 | A1 | 12/2001 | Shimada |
| 2002/0017515 | A1 | 2/2002 | Obata |
| 2002/0028984 | A1 | 3/2002 | Hayakawa |
| 2002/0055669 | A1 | 5/2002 | Konno |
| 2002/0080248 | A1 | 6/2002 | Adair |
| 2002/0087048 | A1 | 7/2002 | Brock |
| 2002/0087166 | A1 | 7/2002 | Brock |
| 2002/0095175 | A1 | 7/2002 | Brock |
| 2002/0128633 | A1 | 9/2002 | Brock |
| 2002/0193662 | A1 | 12/2002 | Belson |
| 2002/0193664 | A1 | 12/2002 | Ross |
| 2003/0032863 | A1 | 2/2003 | Kazakevich |
| 2003/0065250 | A1 | 4/2003 | Chiel |
| 2003/0069474 | A1 | 4/2003 | Couvillon, Jr. |
| 2003/0069897 | A1 | 4/2003 | Roy |
| 2003/0149338 | A1 | 8/2003 | Francois |
| 2003/0181905 | A1 | 9/2003 | Long |
| 2003/0216617 | A1 | 11/2003 | Hirakui |
| 2004/0049097 | A1 | 3/2004 | Miyake |
| 2004/0054258 | A1 | 3/2004 | Maeda |
| 2004/0073083 | A1 | 4/2004 | Ikeda |
| 2004/0073084 | A1 | 4/2004 | Maeda |
| 2004/0073085 | A1 | 4/2004 | Ikeda |
| 2004/0143159 | A1 | 7/2004 | Wendlandt |
| 2004/0147809 | A1 | 7/2004 | Kazakevich |
| 2004/0167379 | A1 | 8/2004 | Akiba |
| 2004/0204671 | A1 | 10/2004 | Stubbs |
| 2004/0220452 | A1 | 11/2004 | Shalman |
| 2004/0249247 | A1 | 12/2004 | Iddan |
| 2004/0257608 | A1 | 12/2004 | Tipirneni |
| 2005/0192476 | A1 | 9/2005 | Homan |
| 2005/0197861 | A1 | 9/2005 | Omori |
| 2005/0200698 | A1 | 9/2005 | Amling |
| 2005/0203341 | A1 | 9/2005 | Welker |
| 2005/0203418 | A1 | 9/2005 | Yamada |
| 2005/0205958 | A1 | 9/2005 | Taniguchi |
| 2005/0207645 | A1 | 9/2005 | Nishimura |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2005/0209509 | A1 | 9/2005 | Belson |
| 2005/0225872 | A1 | 10/2005 | Uzawa |
| 2005/0226508 | A1 | 10/2005 | Gotohda |
| 2005/0228221 | A1 | 10/2005 | Hirakawa |
| 2005/0228222 | A1 | 10/2005 | Furumi |
| 2005/0228227 | A1 | 10/2005 | Weber |
| 2005/0228697 | A1 | 10/2005 | Funahashi |
| 2005/0231591 | A1 | 10/2005 | Abe |
| 2005/0234507 | A1 | 10/2005 | Geske |
| 2005/0243169 | A1 | 11/2005 | Ono |
| 2005/0247081 | A1 | 11/2005 | Sakata |
| 2005/0250983 | A1 | 11/2005 | Tremaglio |
| 2005/0251112 | A1 | 11/2005 | Danitz |
| 2005/0251998 | A1 | 11/2005 | Bar-Or |
| 2005/0253044 | A1 | 11/2005 | Kuriyama |
| 2005/0256370 | A1 | 11/2005 | Fujita |
| 2005/0256373 | A1 | 11/2005 | Bar-Or |
| 2005/0256377 | A1 | 11/2005 | Deppmeier |
| 2005/0256424 | A1 | 11/2005 | Zimmon |
| 2005/0264687 | A1 | 12/2005 | Murayama |
| 2005/0267417 | A1 | 12/2005 | Secrest |
| 2005/0271340 | A1 | 12/2005 | Weisberg |
| 2005/0272978 | A1 | 12/2005 | Brunnen |
| 2005/0273085 | A1 | 12/2005 | Hinman |
| 2005/0288545 | A1 | 12/2005 | Matsumoto |
| 2005/0288553 | A1 | 12/2005 | Sugimoto |
| 2006/0015008 | A1 | 1/2006 | Kennedy |

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| EP | 0 278 217 | A1 | 8/1988 |
| EP | 0 437 229 | A1 | 7/1991 |
| EP | 0 689 851 | A1 | 1/1996 |
| EP | 0 728 487 | B1 | 8/1996 |
| EP | 1 300 883 | A2 | 4/2003 |
| JP | 58-78635 | A | 5/1983 |
| JP | 05-31071 | A | 2/1993 |
| JP | 05-091972 | A | 4/1993 |
| JP | 06-105800 | | 4/1994 |
| JP | 06-254048 | A | 9/1994 |
| JP | 07-008441 | A | 1/1995 |
| JP | 10-113330 | A | 5/1998 |
| JP | 10-286221 | A | 10/1998 |
| JP | 11-216113 | A | 8/1999 |
| JP | 2001 128933 | A | 5/2001 |
| JP | 3219521 | B2 | 8/2001 |
| JP | 2002 078675 | A | 3/2002 |
| JP | 2002-102152 | A | 4/2002 |
| JP | 2002-177197 | A | 6/2002 |
| JP | 2002-185873 | A | 6/2002 |
| JP | 2002-253481 | A | 9/2002 |
| JP | 3372273 | B2 | 11/2002 |
| JP | 2003-075113 | A | 3/2003 |
| JP | 2002 007134 | | 7/2003 |
| JP | 2002 007134 | A | 7/2003 |
| JP | 3482238 | B2 | 10/2003 |
| WO | 93/13704 | A1 | 7/1993 |
| WO | 2004/016310 | A2 | 2/2004 |
| WO | 2005/023082 | A2 | 3/2005 |

* cited by examiner

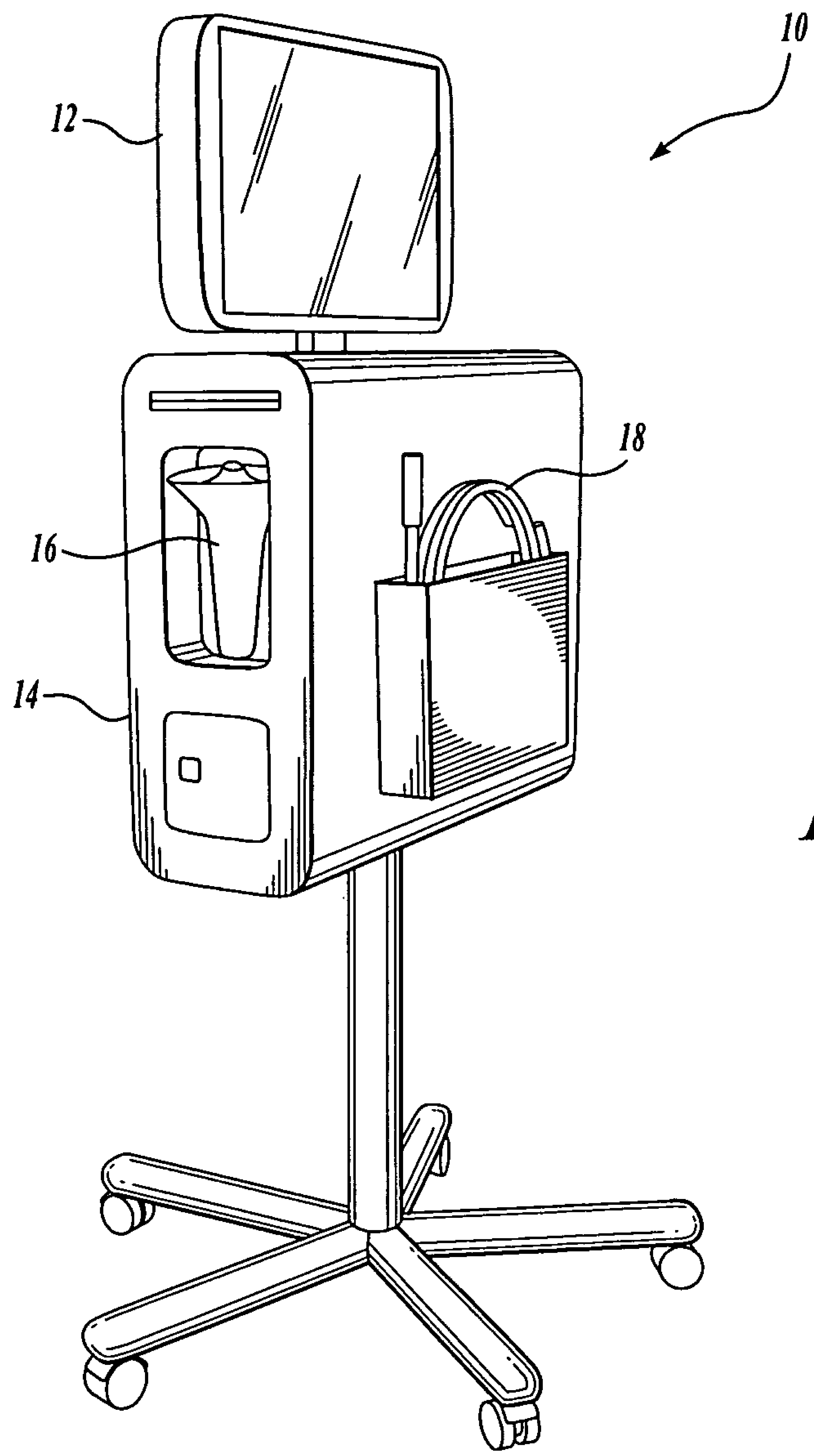
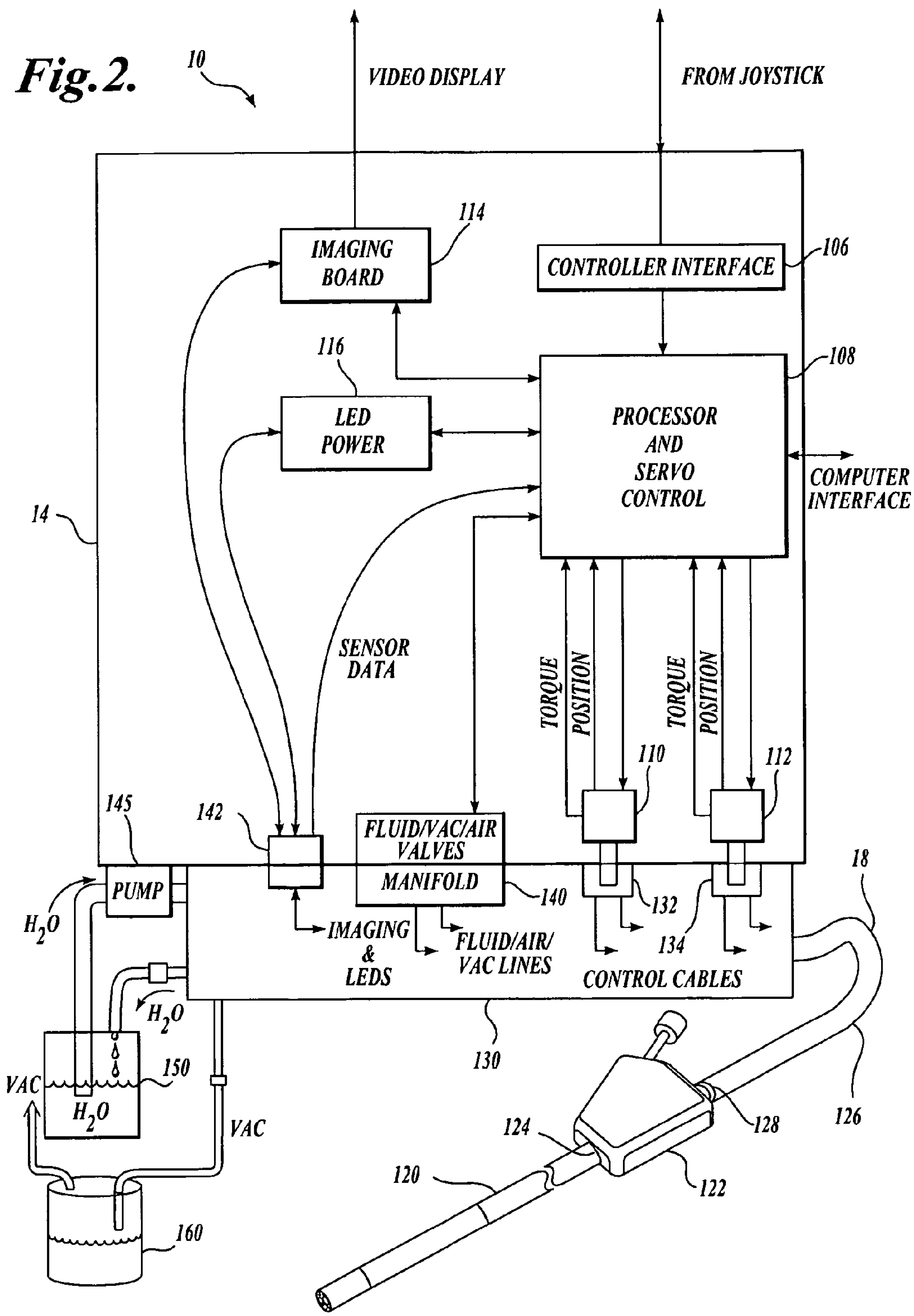



*Fig.1.*


10
VIDEO DISPLAY
FROM JOYSTICK
IMAGING BOARD
114
CONTROLLER INTERFACE
106
116
LED POWER
PROCESSOR AND SERVO CONTROL
108
COMPUTER INTERFACE
14
SENSOR DATA
TORQUE
POSITION
TORQUE
POSITION
110
112
145
142
FLUID/VAC/AIR VALVES
MANIFOLD
140
PUMP
132
134
18
$H_2O$
IMAGING & LEDS
FLUID/AIR/ VAC LINES
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160

Fig. 2.

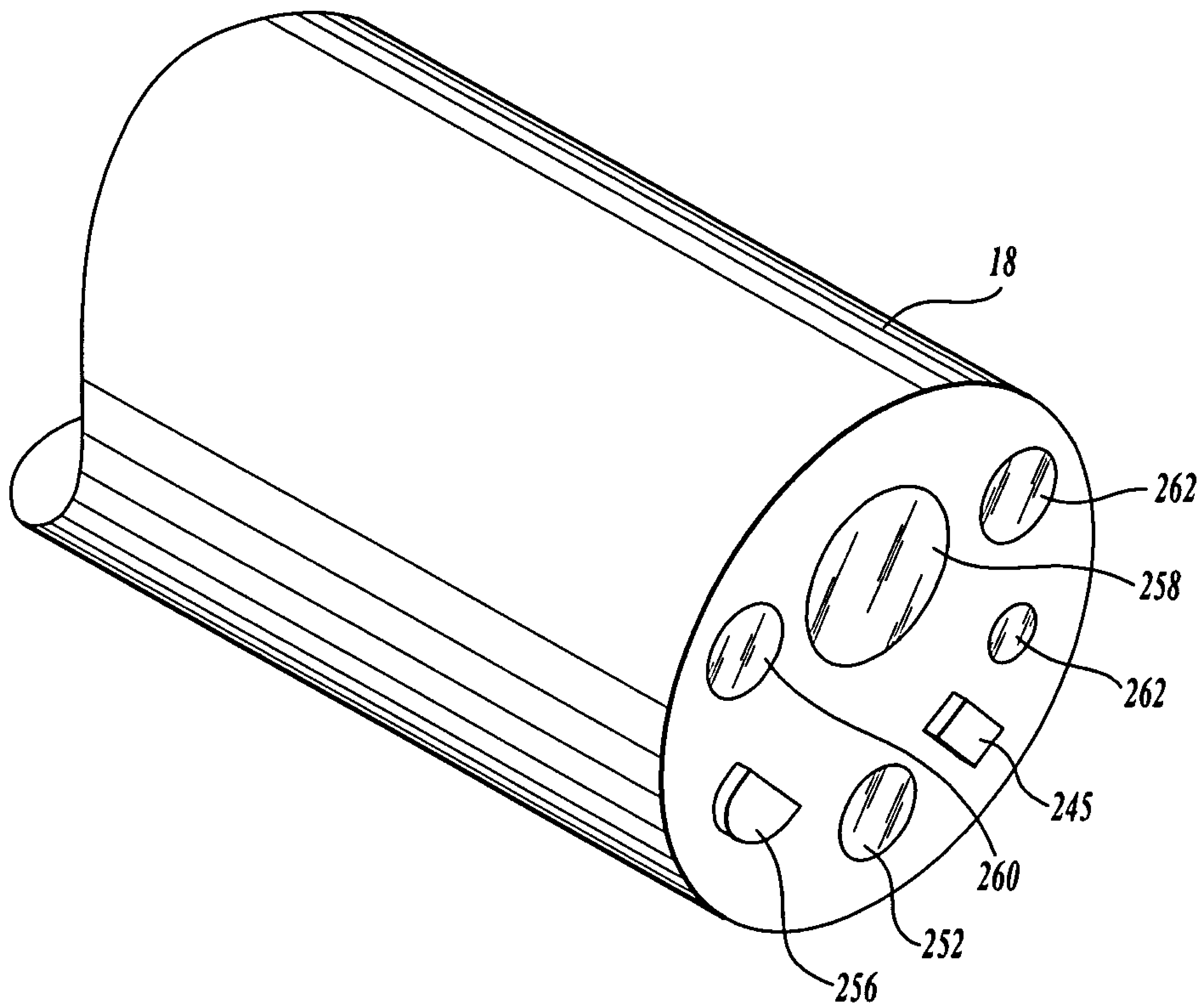


*Fig.3.*

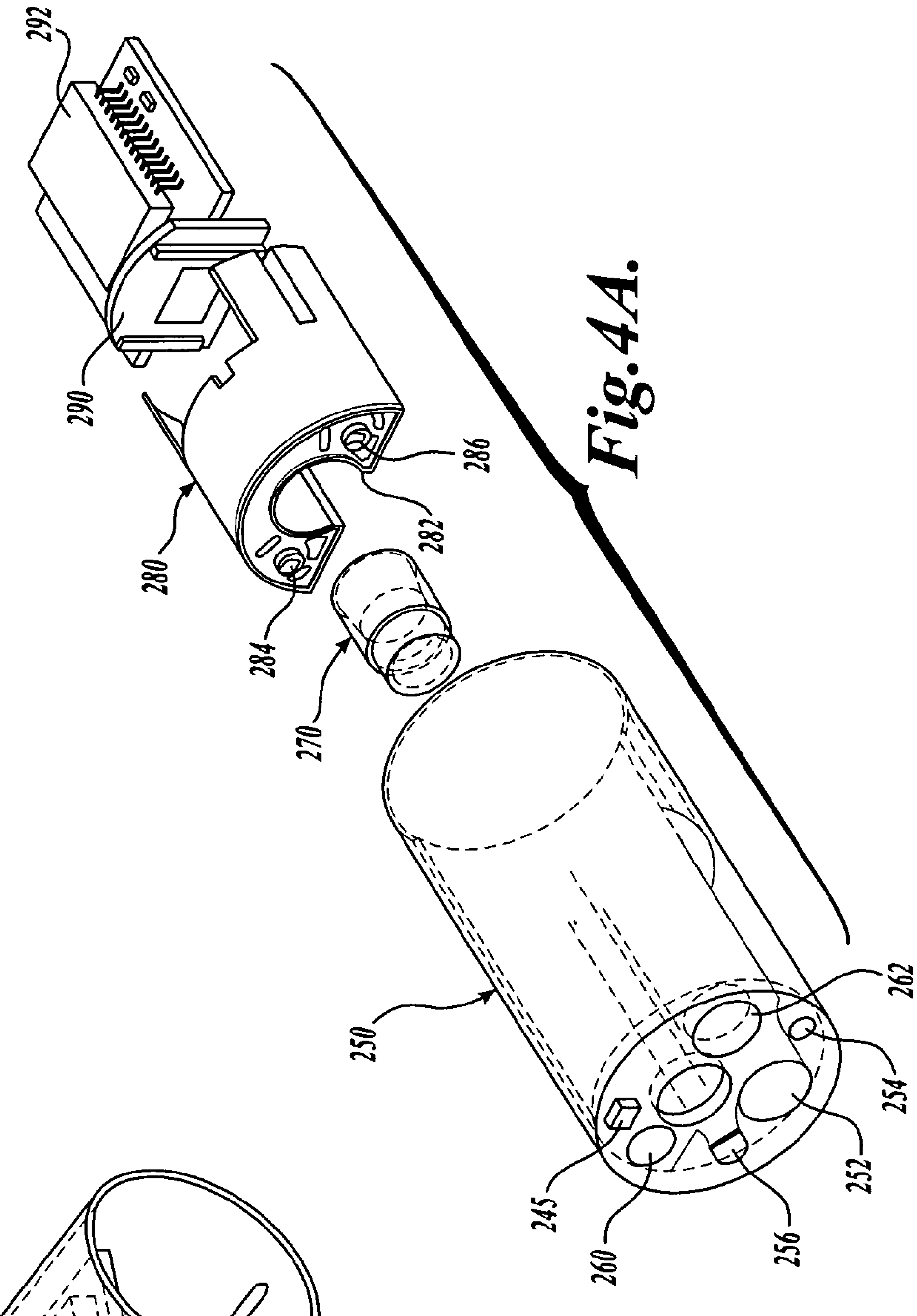


Fig.4A.

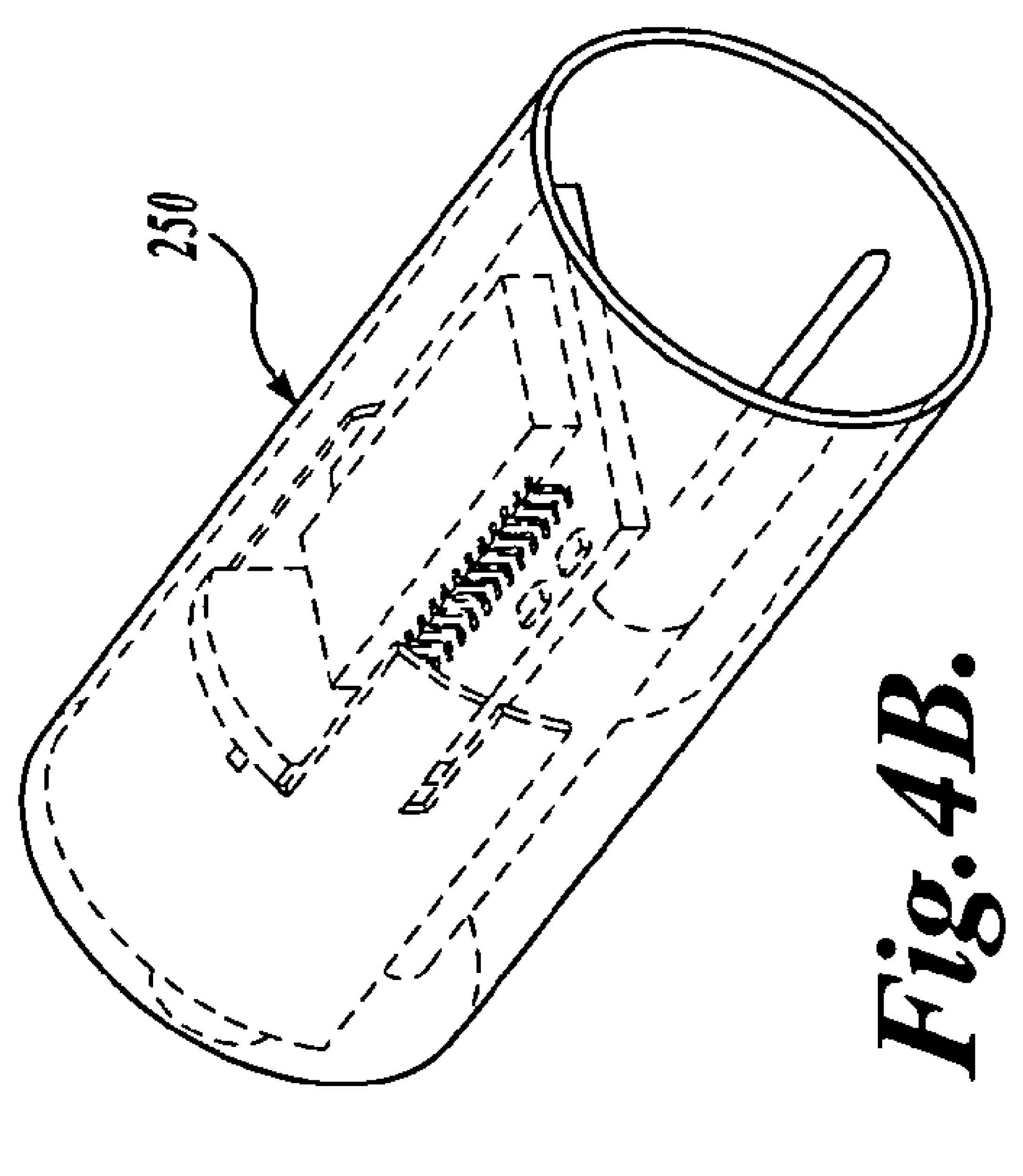


Fig.4B.

# AUTOMATED CONTROL OF IRRIGATION AND ASPIRATION IN A SINGLE-USE ENDOSCOPE

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.**

## CROSS-REFERENCE TO RELATED APPLICATION

This application *is a reissue application of U.S. Pat. No. 8,435,172, which issued from U.S. patent application Ser. No. 12/330,470, filed Dec. 8, 2008, which* is a continuation of U.S. patent application Ser. No. 10/955,901, filed Sep. 30, 2004, *now U.S. Pat. No. 7,479,106,* the disclosure of which is expressly incorporated herein by reference.

## FIELD OF THE INVENTION

The present invention relates to an endoscope system. In particular, it relates to an integrated and automated irrigation and aspiration system for use in an endoscope system.

## BACKGROUND OF THE INVENTION

Endoscopes have been used for many years in the medical field to look within a selected region of a patient's body or to perform surgical, therapeutic, diagnostic, or other medical procedures under direct visualization. A conventional endoscope generally contains several components including illuminating means such as light-emitting diodes or fiber optic light guides connected to a proximal source of light, an imaging means such as a miniature video camera or a fiber optic image guide, and a working channel. These components are positioned within an endoscope sheathing tube. Flexible or steerable endoscopes also incorporate an elongated flexible shaft and an articulating distal tip to facilitate navigation through the internal curvature of a body cavity or channel.

Colonoscopy is a medical procedure in which a flexible endoscope, or colonoscope, is inserted into a patient's colon for diagnostic examination and/or surgical treatment of the colon. A standard colonoscope is typically 135-185 cm in length and 12-13 mm in diameter. Colonoscopes generally include a fiber optic imaging bundle, illumination fibers, one or two instrument channels that may also be used for insufflation or irrigation, and a suction channel that extends the length of the colonoscope to facilitate removal of occlusions such as mucus, plaque, fecal matter, or other material that can obstruct the physician's view or interfere with the endoscopic procedure. The colonoscope is inserted via the patient's anus and is advanced through the colon, allowing direct visual examination of the colon, the ileocecal valve, and portions of the terminal ileum. Approximately six million colonoscopies are performed each year.

In order to examine a patient's anatomy during a colonoscopy, it is essential to have a clear field of view. Currently, about 20% of colon polyps are undetected due to low visibility, which can arise from inadequate lens cleaning. Poor colon preparation is also a cause of reduced visibility in the colon. Presently, about 10% of all patients are non-compliant with preparatory procedures and approximately 4% of all patients are unable to complete the exam due to an excess of stool in



the colon. The remaining 6% of all cases are considered marginal, and the colonoscopy may still be performed if the colon is evacuated as a part of the procedure. Conventionally, the colons of marginal cases are cleared by repeatedly administering several small (60 cc) fluid flushes through an endoscope's working channel by means of an ancillary apparatus that employs a low-volume wash and suction. The waste is then removed through the suction channel in the endoscope. However, this tedious and inefficient process is limited by the amount of stool that can be removed with each flush. The process also causes a loss of productivity due to the added time required to evacuate the colon. Therefore, there is a need for a system and method of efficiently cleaning poorly prepared colons.

One example of a colon irrigation method for colonoscopy is described in U.S. Pat. No. 5,279,542, entitled "Colon Irrigation Method." The '542 patent describes an irrigation instrument for use in evacuating the colon prior to endoscopic surgery. The instrument consists of an elongate tube with a plurality of longitudinally and circumferentially spaced apertures along its entire length. A pressurized source of irrigation fluid is connected to the tube for feeding fluid through the channel and out through the apertures with an essentially uniform radial distribution. The tube is thin enough to fit down the biopsy channel of an endoscope. The invention essentially provides an improved method for providing irrigating fluid to a distal end of an endoscope or to a surgical site.

Although the apparatus and method of the colon irrigation method described in the '542 patent provides a means of irrigation for colonoscopy and other endoscopic procedures, the device is an accessory to standard endoscopes that uses the working channel of the endoscope. As such, the apparatus requires labor-intensive assembly on an as-needed basis. Furthermore, it is up to the physician to determine the amount of cleaning that is required and to control the apparatus such that the patient is sufficiently prepped for an examination. This reduces the time that the physician has to perform the actual examination.

Given these problems, there is a need for a system that can automatically prepare poorly prepped patients for an endoscopic examination with minimal physician supervision. In addition, the system should operate based on the patient's individual physical anatomy and detected level of cleanliness so that a desired field of view is created in which an examination is conducted.

## SUMMARY OF THE INVENTION

To address the foregoing deficiencies in the prior art, the present invention is an endoscopic system that provides automated irrigation and aspiration of patients undergoing colonoscopy. The endoscopic examination system according to the present invention includes an endoscope with a source of illuminative light and an image sensor to produce images of a patient's colon. An image processor is coupled to receive image signals from the image sensor. The image processor or a computer automatically analyzes the images obtained from the image sensor to determine if irrigation and aspiration is required to provide a clear field of view. If so, the computer operates one or more control valves that supply the insufflation, irrigation, and aspiration to the patient.

In one embodiment, the endoscope may include one or more sensors that sense environmental conditions within the patient's colon such that the amount, rate, or composition of the cleaning solution delivered can be adjusted to the patient's individual anatomy and level of preparation. In one embodiment, the level of insufflation and aspiration are automatically adjusted to provide a desired field of view in the region of the distal tip of the endoscope.

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** illustrates a single-use endoscopic imaging system in accordance with one embodiment of the present invention;

FIG. **2** is a functional block diagram that shows the interrelationship of the major components of a single-use endoscopic imaging system shown in FIG. **1**;

FIG. **3** illustrates a distal end of a single-use imaging endoscope in accordance with an embodiment of the present invention; and

FIGS. **4**A and **4**B illustrate an imaging sensor and heat exchanger positioned at the distal end of the endoscope in accordance with an embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As indicated above, the present invention is an endoscopic examination system that provides integrated and automated irrigation and aspiration for prepping poorly prepared patients for examination. The system is integral to the overall endoscope architecture. Further, the physical hardware implementation of the endoscope improves upon previous means of irrigation by the use of an automated mechanism that administers one or more colon irrigation modalities depending on an analysis of the patient's anatomy or level of preparation. Although the present invention is described with respect to its use within the colon, it will be appreciated that the invention can be used in any body cavity that can be expanded and/or prepared for examination or surgery.

FIG. **1** illustrates the major components of an exemplary single-use endoscopic imaging system **10**. The components of the system **10** include a display **12**, a user input device **16**, and a single-use imaging endoscope **18**, all of which are functionally connected to a control cabinet **14** that executes application software (not shown) residing therein. Display **12** is any special-purpose or conventional computer display device, such as a computer monitor, that outputs graphical images and/or text to a user. Single-use imaging endoscope **18** is a single-use flexible tube that contains one or more lumens for the purpose of performing endoscopic procedures and facilitating the insertion and extraction of fluids, gases, and/or medical devices into and out of the body. Single-use endoscope **18** further contains a digital imaging system (not shown) comprised of, in one example, an image sensor such as a CMOS imager, optical lenses such as plastic optics, a light source such as a number of LEDs, and an articulating tip that enables steering of the endoscope in a desired direction.

Control cabinet **14** is a special-purpose electronic and electromechanical apparatus that processes and manages all system functions, and includes a network-enabled image-processing CPU, a physical connection to the single-use endoscope **18**, an optional dock for the user interface **16**, and valves that control the delivery of gas/water to the endoscope and a vacuum line that removes the air/gas and debris, etc., from the patient. User input device **16** is a hand-held device, either wired to the control cabinet **14** or wireless, that accepts inputs from a human operator via standard push buttons, joysticks, or other activation devices either singularly or in combination to control the operation of single-use endoscopic imaging system **10**.



Operation of single-use endoscopic imaging system **10** is as follows: the system is initiated and operated upon command by means of user input device **16**, causing the application software executed by a processor within the control cabinet **14** to activate the appropriate hardware to perform surgical, therapeutic, diagnostic, or other medical procedures and to deliver insufflation and/or suction to the lumen(s) of single-use endoscope **18**. Display **12** provides live endoscopic video images and visual feedback of control parameters to the physician or operator so that an examination of the patient can be completed. Upon termination of the examination, the endoscope **18** is disconnected from the control cabinet and disposed of.

FIG. **2** is a functional block diagram of single-use endoscopic imaging system **10** that shows the operational interrelationship of the major hardware and software elements of the system. A complete description of the control cabinet **14** and other components is set forth in U.S. patent application Ser. No. 10/811,781, filed Mar. 29, 2004, and U.S. patent application Ser. No. 10/956.007, entitled VIDEO ENDOSCOPE, filed concurrently herewith) and herein incorporated by reference. The single-use endoscopic imaging system **10** includes the control cabinet **14** that operates to control the orientation and functions of a single-use imaging endoscope **18**. The control cabinet **14** includes a controller interface **106** that receives commands from the user input device **16** such as a joystick, that is used by a physician or their assistant to control the operation of the single-use endoscope **18**. Commands from the joystick are supplied to a programmable processor such as a digital signal processor that controls the overall operation of the imaging system and a servo control unit **108**. The processor and servo control unit **108** control the operation of a pair of servo motors **110**, **112** that in turn drive control cables within the single-use endoscope **18**. The orientation of the distal tip is controlled in response to directional signals received from the user input device as well as feedback signals obtained from sensors that measure the position and torque of each of the servo motors **110**, **112**.

In one embodiment of the invention, the processor and servo control unit **108** implement a position-to-rate control that varies the speed at which the distal tip is moved as a function of the position of the directional switch on the user input device **16**. However, other control algorithms such as position-to-position or position-to-force (i.e., acceleration) could also be implemented.

The control cabinet **14** also includes an imaging board **114** that produces images from the signals that are received from the image sensor at the distal end of the single-use endoscope **18**. The imaging board **114** deserializes the digital video signals from the CMOS imager sensor and performs the necessary algorithms such as demosaicing, gain control and white balance to produce a quality color image. The gain control of the system is implemented by adjusting the intensity of the illumination (current supplied to a number of LEDs) and adjusting the RGB gains of the CMOS imager. The imaging board **114** also includes isolation circuitry to prevent a patient from becoming shocked in the event of an electrical failure on the imaging board **114** or within the control cabinet **14** as well as circuitry for transmitting control signals to the image sensor and for receiving image signals from the image sensor. In one embodiment of the invention, the imaging board **114** is provided on a standard PC circuit board to allow individual endoscopes to be tested with a personal computer and without the need for an additional control cabinet **14**.

In the embodiment shown in FIG. **2**, the single-use endoscope **18** has a distal shaft portion **120** that is connected to a breakout box **122** with a swivel connection **124**. The breakout box **122** provides access to a working channel in the distal portion of the endoscope. In addition, the proximal portion **126** of the shaft is connected to the breakout box **122** with a second swivel connection **128**. The swivel connections **124**, **128** allow the distal and proximal ends of the endoscope to rotate with respect to the breakout box **122** and without twisting the breakout box **122** in the hands of the physician or their assistant.

In the embodiment shown, the single-use endoscope **18** is connected to the control cabinet **14** with a connector **130**. Within the connector **130** are a pair of spools **132**, **134** that are engageable with the driveshafts of the servo motors **110**, **112**. Each spool **132**, **134** drives a pair of control cables that are wound in opposite directions. One pair of control cables drives the distal tip of the endoscope in the up and down direction, while the other pair of control cables drives the distal tip of the endoscope in the left and right direction. In an alternate embodiment, the endoscope may include a manual handle having control knobs that selectively tension or release the control cables to move the distal tip and one or more buttons that activate functions of the endoscope.

The connector **130** also includes a manifold **140** that controls the supply of irrigation fluid, air and vacuum to various tubes or lumens within the endoscope **18**. In addition, the connector **130** includes an electrical connector **142** that mates with the corresponding electrical connector on the control cabinet **14**. The connector **142** transfers signals to and from the image sensor as well as power to the illumination LEDs and allows connection to a thermal sensor at the distal end of the endoscope. In addition, the connector **142** carries signals from one or more remotely located environmental sensors as will be described below. Water or another irrigation liquid is supplied to the endoscope with a pump **145**. The pump **145** is preferably a peristaltic pump that moves the water though a flexible tube that extends into the proximal connector **130**. Peristaltic pumps are preferred because the pump components do not need to come into contact with the water or other fluids within the endoscope and it allows the wetted component to be single-use. A water or other irrigation liquid reservoir **150** is connected to the pump **145** and supplies water to cool the illumination LEDs as well as to irrigate the patient. The water supplied to cool the LEDs is returned to the reservoir **150** in a closed loop. Waste water or other debris are removed from the patient with a vacuum line that empties into a collection bottle **160**. Control of the vacuum to the collection bottle **160** is provided at the manifold **140** within the proximal connector **130**. A gas source provides insufflation by delivering an inert gas such as carbon dioxide, nitrogen, air, etc., to the lumen(s) of single-use endoscope **18** via the manifold **140**.

The processor and control unit **108** executes application software, including a GUI software application, a system control software application, and a network software application that reside on a computer readable medium such as a hard disc drive, CD-ROM, DVD, etc., or in a solid state memory. GUI software application is well known to those skilled in the art, and provides the physician or operator with live endoscopic video or still images and, optionally, with visual, audible, or haptic control and feedback on display **12** using user input device **16**. System control software application is the central control program of application software that receives input from sensors, such as from the one or more environmental sensors at the distal end of the endoscope as described below, as well as from the input device **16**. System control software application provides system control for the functions necessary to operate single-use endoscope system **10**. The network software application operates a network connection to allow the endoscopic imaging system **10** to be connected to a local area network and/or the Internet.

As set forth in the 10/811,781 application, the manifold **140** supplies insufflation gas, water and vacuum to one or more lumens of single-use endoscope **18**. The manifold is preferably constructed as a series of passages that are formed between sheets of a thermoplastic material. Water, air, and vacuum are applied to inputs of the manifold and selectively delivered to outputs that are in turn connected to lumens within the endoscope **18** by pinch valves on the control cabinet **14** that open or close the passages in the manifold. The passages are preferably formed by rf welding the sheets of thermoplastic into the desired pattern of the passages.

In accordance with FIG. **2**, the basic process of insufflation and exsufflation using single-use endoscopic imaging system **10** is as follows:

During operation, live endoscopic video images are provided on display **12** by the GUI software application, which processes information from the imaging board **114**, and the single-use endoscope **18**. Prior to operation, insufflation is initiated upon operator command by means of the user input device **16**, or according to a pre-programmed routine. As a result, system control software application activates the manifold **140** by means of the pinch valves on the control cabinet **14**. Upon advancing single-use endoscope **18**, images are produced by the image sensor at the distal tip of the endoscope and analyzed by the image processor **114** and/or the processor and servo control unit **108** to determine if either irrigation or insufflation is required. If insufflation is required, an insufflation gas is channeled through a lumen of single-use endoscope **18** and into the patient. In one embodiment of the invention, the gas delivery lumen terminates at directional port **256**, that directs the insufflation gas and/or irrigation liquid over a lens **270** of the imaging sensor, as shown in FIG. **3**. As the distal tip of single-use endoscope **18** is advanced into the colon during the endoscopic procedure, further areas of the colon are insufflated, bringing new examination regions into view.

As shown in FIG. **3**, the distal end of the single-use endoscope **18** includes a distal cap **250** having a number of openings on its front face. The openings include an opening to a working channel **252** and an opening **254** for a low pressure lavage lumen, whereby a stream of liquid can be delivered through the endoscope to remove debris or obstructions from the patient. A lens wash and insufflation port includes the integrated directional port or flush cap **256** that directs water across the lens of an image sensor and delivers the insufflation gas to expand the lumen in which the endoscope is inserted. Offset from the longitudinal axis of the endoscope is a lens port **258** that is surrounded by a pair of windows or lenses **260** and **262** that cover the illumination sources. One or more environmental sensors **245** are also disposed on or adjacent the front face of the distal cap **250** to detect environmental conditions within the body cavity of the patient. Signals from the one or more environmental sensors are transmitted back to the processor and servo control unit **108** through the electrical connector **142**. Suitable environmental sensors **245** include, but are not limited to, pressure, temperature, pH sensors to measure conditions in the patient adjacent the distal tip. In addition, sensors such as laser distance sensor or ultrasonic probes can be used to measure the size of the area or thickness of the colon wall surrounding the endoscope.

As best shown in FIG. **4**A, the imaging assembly at the distal end of the endoscope also includes a heat exchanger **280**. The heat exchanger **280** comprises a semi-circular section having a concave recess **282** into which a cylindrical lens assembly **270** is fitted. The concave recess **282** holds the position of the lens assembly **270** in directions perpendicular to the longitudinal axis of endoscope, thereby only permitting the lens assembly **270** to move along the longitudinal axis of the endoscope. Once the lens assembly is positioned such that it is focused on an image sensor **290** that is secured to a rear surface of the heat exchanger **280**, the lens assembly is fixed in the heat exchanger with an adhesive. A pair of LEDs **282**, **284** are bonded to a circuit board that is affixed in the heat exchanger such that a channel is formed behind the circuit board for the passage of a fluid or gas to cool the LEDs. A circuit board or flex circuit **292** containing circuitry to transmit and receive signals to and from the control cabinet is secured behind the image sensor **290** and to the rear surface of the heat exchanger **280**. With the lens assembly **270**, the LEDs **280**, **282**, the image sensor **290**, and associated circuitry **292** secured in the heat exchanger **280**, the heat exchanger assembly can be fitted within the distal cap **250** to complete the imaging assembly.

As discussed, the images obtained from the image sensor are analyzed by an image analysis program to determine when cleaning of the imaging system or the colon itself is desired. In addition, measurements of the colon cavity obtained from the one or more environmental sensors may be combined with image information as analyzed by the image analysis program to control the supply of irrigation and aspiration when a cleaning cycle is required.

The basic process of irrigation and aspiration for the purpose of prepping a poorly prepared patient during a colonoscopy procedure using the endoscopic imaging system **100** is as follows.

The GUI software application displays the live video or still images produced by the imaging board **114** on the display **110**. In addition, an image analysis program that is executed by a processor on the imaging board **114** or the processor and servo control unit **108** analyzes the image signals to determine if it is necessary to employ a wash routine in the patient or to clean the lens of the endoscope **18**. If the image analysis program determines that a lens cleaning or wash routine should be initiated, the control software application activates one or more valves controlling the manifold to deliver an irrigation liquid and vacuum aspiration to the endoscope. The modality of the washing routine supplied can be determined based on an analysis of the images produced as well as volumetric, environmental or other measurements obtained by the one or more environmental sensors **245** at the distal end of the endoscope.

To determine if the field of view of the single-use endoscope **18** is clear or obstructed, the image analysis program analyzes images of the patient's body for the presence of obstructing matter within the area of view or on the surface of imaging optics. For example, the image analysis program determines if the position of an obstruction changes with a change in probe position. If an obstruction remains in the same place within an image despite moving the endoscope, then the system control software initiates a blast of cleaning solution over the surface of the imaging lens. However, if the image appears to indicate that the patient has not been properly prepped, then the system control software proceeds to initiate one or more cleaning or washing routines.

In one embodiment of the invention, the presence of obstructing material in the field of view is detected by the image analysis program on the basis of the color or spectral reflectance of the tissue being observed. Healthy colon tissue is typically characterized by white or pinkish tissue. Therefore, the image analysis program searches an image to determine the number of pixels in the image that display the desired tissue color. If the image contains too many dark or other colored pixels, the presence of obstructing material is presumed. Of course, it will be appreciated that the color of healthy, clean tissue can vary from patient to patient. Therefore, the physician may be prompted to direct the probe at a known portion of healthy, clean tissue to calibrate the image analysis program prior to beginning the colonoscopy.

In performing the washing routine, the system control software may take into consideration measurements obtained from the one or more environmental sensors **245** included in the single-use endoscope **18**. For example, measurements of the size of the colon cavity, thickness of the colon wall, pressure within the colon, or other factors such as temperature, pH, etc. can be obtained from the one or more environmental sensors **245** and used to adjust the volume or rate of delivery and/or aspiration of liquid supplied or the composition of the washing liquid can be adjusted based on the measurements obtained. Similarly, the environmental sensor **245** positioned along the length of the endoscope can measure the depth of insertion of the distal tip of the endoscope.

With the endoscopic imaging system **10**, any obstructions that interfere with the endoscopic procedure are automatically detected. Washing or lens cleaning routines are initiated upon command by the system control software or may be initiated by an operator command received via user interface **16**. Wash routines may include, for example, a continuous spray, a pulsating jet, and a large bolus wash. Sequential mixtures of fluids or gases can be augmented with aeration and/or additives. Additives are added into the irrigant solution, either singularly or in combination, upon operator command using user interface **16** or as directed by preprogrammed wash routines or based on an analysis of signals produced from the image sensor and/or the one or more environmental sensors **245**. New wash routines may be downloaded through network connection by means of network software application. Alternatively, a user may also manually define new irrigant mixes and/or wash routines by recording a series of operator commands on user interface **16**.

After irrigation, the resulting maceration is aspirated under control of the system control software application, which activates the manifold **140**. The manifold **140** applies vacuum through a working or aspiration channel of the single-use endoscope **18**. At any time, the physician or their assistant may manually interrupt the wash routine or aspiration.

The endoscopic imaging system of the present invention also determines if the body cavity is properly inflated. Such a determination is made by measuring the pressure and/or analyzing images obtained from the image sensor. If the body cavity is not properly inflated, insufflation gas is delivered to the patient in a manner that is adjusted for environmental conditions in the patient. As with the washing mode, the insufflation gas can be delivered in accordance with the detected pressure in the body cavity, the size of the cavity, or until the image signals produced by the image sensor indicate that the colon is inflated to produce a desired field of view. Furthermore, the insufflation gas can be adjusted in accordance with the sensed thickness of the colon wall or other parameters that assure that insufflation gas is not delivered too quickly so as to cause discomfort or potential injury to the patient. By automatically controlling the insufflation of the colon at the region of the distal tip a desired field of view is provided and inadvertent collapse of the colon is prevented. Furthermore, the physician can concentrate on performing the procedure without having to manually control insufflation.

As will be appreciated, the automated irrigation and aspiration features of the present invention reduce the need for the physician to actively control the preparation of poorly prepared patients for examination. Because obstructions and poor fields of view are automatically detected and cleared, the physician can concentrate on performing the required procedure. Furthermore, the evacuation wash routines may be tailored to a patient's individual condition as detected by the image analysis program and one or more sensors **122**.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the scope of the invention. For example, although the present invention is described with respect to single use, disposable endoscopes, it will be appreciated that the present invention is also applicable to non-disposable, reusable endoscopes as well. It is therefore intended that the scope of the invention be determined from the following claims and equivalents thereof.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

**1**. A system for automatically controlling the delivery of [insufflation gas] *gas or liquid to a patient*, the system comprising:

[a control cabinet including] a processor [and one or more valves] configured to control the delivery of [insufflation] gas *or liquid* to [a] *the* patient; and

an [endoscope removably connected to the control cabinet and] *elongate member* including a pressure sensor and an image sensor at *or adjacent* a distal end of the [endoscope] *elongate member*;

wherein the processor is configured to obtain *an* image [signals] *signal* from the image sensor and *a* pressure [readings] *reading* from the pressure sensor and automatically control [insufflation] gas *or liquid* delivered to the patient as a function of the image [signals] *signal* and the pressure [readings] *reading*.

**2**. The system of claim **1**, wherein the delivery of [insufflation] gas is controlled to maintain a predefined field of view in the image [signals] *signal* produced by the image sensor.

**3**. The system of claim **1**, further comprising a sensor configured to determine a size of an inflated body cavity, and wherein the processor is configured to control the delivery of [insufflation] gas to maintain a predetermined inflated cavity size.

**4**. The system of claim **1**, wherein the processor is configured to control the delivery of [insufflation] gas to maintain a predetermined pressure in a body cavity.

**5**. The system of claim **1**, further comprising a sensor configured to detect a thickness of a tissue wall surrounding the [endoscope] *elongate member*, and wherein the processor is configured to control the delivery of [insufflation] gas as a function of the wall thickness detected.

[**6**. The system of claim **1**, wherein the endoscope is dispensable.]

**7**. A system for automatically controlling the delivery of [insufflation gas] *fluid*, the system comprising:

a control [cabinet] *unit* including a processor [and at least one valve] configured to control the delivery of [insufflation gas] *fluid*; and

an endoscope removably connected to the control [cabinet] *unit* and including a pressure sensor and an image sensor at *or adjacent* a distal end of the endoscope;

wherein the processor is configured to receive *an* image [signals] *signal* from the image sensor and *a* pressure [readings] *reading* from the pressure sensor and automatically control the delivery of [insufflation gas] *fluid* as a function of the image [signals] *signal* and the pressure [readings by controlling actuation of the at least one valve] *reading*.

**8**. The system of claim **7**, wherein the processor is configured to control the delivery of [insufflation gas] *fluid* to maintain a predefined view produced by the image sensor.

**9**. The system of claim **7**, wherein the processor is configured to control the delivery of [insufflation gas] *fluid* to maintain a predetermined pressure in the body cavity and to maintain a predefined view produced by the image sensor.

**10**. The system of claim **7**, wherein the control [cabinet] *unit* includes a manifold configured to supply [insufflation] *at least one of* gas, [a] liquid, and aspiration to the endoscope.

**11**. The system of claim **10**, [wherein the] *further including* at least one valve *that* is configured to control the supply of [insufflation] *at least one of* gas, [the] liquid, and aspiration from the manifold.

[**12**. The system of claim **11**, wherein the endoscope is removably coupled to the manifold.]

**13**. A system for automatically controlling the delivery of [insufflation] gas *or liquid*, the system comprising:

a control [cabinet] *unit* including a processor and at least one valve configured to control the delivery of [insufflation] gas *or liquid*; and

an endoscope removably connected to the control [cabinet] *unit* and including a pressure sensor configured to determine a pressure in a body cavity and an image sensor;

wherein the processor is configured to receive *an* image [signals] *signal* from the image sensor and *a* pressure [readings] *reading* from the pressure sensor and automatically control the delivery of [insufflation] gas *or liquid* as a function of the image [signals] *signal* and the pressure [readings] *reading* to maintain a predetermined pressure in the body cavity by controlling actuation of the at least one valve.

**14**. The system of claim **13**, wherein the processor is configured to control the delivery of [insufflation] gas *or liquid* to maintain the predetermined pressure in the body cavity and to maintain a predefined view produced by the image sensor.

**15**. The system of claim **13**, wherein the control [cabinet] *unit* includes a manifold configured to supply [insufflation] gas, [a] liquid, and aspiration to the endoscope.

**16**. The system of claim **15**, wherein the at least one valve is configured to control the supply of [insufflation] gas, [the] liquid, and aspiration from the manifold, *wherein the endoscope is removably coupled to the manifold*.

[**17**. The system of claim **16**, wherein the endoscope is removably coupled to the manifold.]

*18. The system of claim 1, wherein the elongate member is an endoscope.*

*19. The system of claim 18, wherein a control cabinet includes the processor and one or more valves configured to control the delivery of gas or liquid to the patient, and wherein the endoscope is removably connected to the control cabinet.*

*20. The system of claim 19, wherein the processor is configured to obtain image signals from the image sensor and pressure readings from the pressure sensor and automatically control gas or liquid delivered to the patient as a function of the image signals and the pressure readings.*

*21. The system of claim 7, wherein the control unit is a control cabinet that further includes at least one valve, and the processor is configured to control the delivery of fluid by controlling actuation of the at least one valve.*

*22. The system of claim 21, wherein the processor is configured to receive image signals from the image sensor and pressure readings from the pressure sensor and automatically control fluid delivered to the patient as a function of the image signals and the pressure readings.*

*23. The system of claim 13, wherein the control unit is a control cabinet, and wherein the processor is configured to obtain image signals from the image sensor and pressure readings from the pressure sensor and automatically control gas or liquid delivered to the patient as a function of the image signals and the pressure readings.*

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