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United States Patent [19]
Mueller et al.

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- [54] **RECOVERABLE BOOSTER STAGE AND RECOVERY METHOD**
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- [73] Assignee: **Kistler Aerospace Corporation**,
Kirkland, Wash.
- [21] Appl. No.: **09/030,724**
- [22] Filed: **Feb. 25, 1998**
- [51] **Int. Cl.**⁷ **B64G 1/00**
- [52] **U.S. Cl.** **244/158 R**; 244/172; 244/2
- [58] **Field of Search** 244/158 R, 172,
244/160, 2

- [56] **References Cited**
- U.S. PATENT DOCUMENTS
- | | | | |
|-----------|---------|----------------|---------|
| 3,065,596 | 11/1962 | Schultz | 60/35.3 |
| 3,065,597 | 11/1962 | Adamson et al. | 60/35.3 |
- (List continued on next page.)
- FOREIGN PATENT DOCUMENTS
- | | | |
|---------|---------|-------|
| 9013481 | 11/1990 | WIPO. |
|---------|---------|-------|
- OTHER PUBLICATIONS
- Gary C. Hudson, "Phoenix: A Commercial, Reusable Single-Stage Launch Vehicle," *Pacific American Launch Systems, Inc.*, date unknown, pp. 1-13.
- Dr. William A. Gaubatz, "Space is a Place," *McDonnell Douglas Aerospace*, date unknown, pp. 1-13.
- D.E. Koelle, et al., "The Single-Stage Reusable Ballistic Launcher Concept for Economic Cargo Transportation," *37th Congress of the International Astronautical Federation*, Oct., 1986, 7 pages.

- Maxwell W. Hunter, "Draft II The SSX Spaceship, Experimental," source unknown, Mar. 15, 1998, updated Mar. 11, 1989, pp. 1-32.
- Rudi Beichel, et al., "IAF-88-229 The Next Generation Rocket Engines," *39th Congress of the International Astronautical Federation*, Oct., 1988, 7 pages.
- Robert L. Staehle, et al., "Crew Transportation for the 1990s: Commercializing Manned Flight with Today's Propulsion," *World Space Foundation*, 1989, 19 pages.
- A. P. Bruckner, et al., "IAF 92-0859 Antares: A Low Cost Modular Launch Vehicle Concept," *43rd Congress of the International Astronautical Federation*, Aug./Sep., 1992, pp. 1-13.
- D. E. Koelle, "IAA 92-0164 Cost Analysis of Single-Stage (SSTO) Reusable Ballistic Launch Vehicles," *43rd Congress of the International Astronautical Federation*, Aug./Sep., 1992, pp. 1-7.

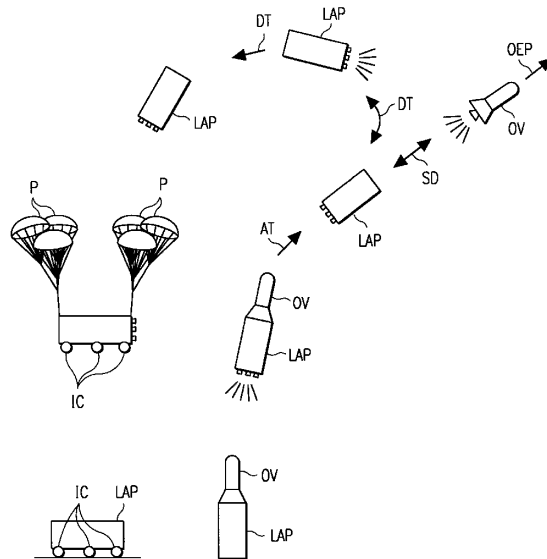
(List continued on next page.)

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[57] **ABSTRACT**

A recoverable/reusable booster stage has a restartable center liquid-fueled rocket engine mounted in the aft portion of a vehicle body in alignment with the center axis of the body. The booster stage may also include two side liquid-fueled rocket engines mounted in the aft portion of the body in symmetrical relation to the center rocket engine. After booster stage separation, the center engine is restarted to direct the booster stage towards a recovery site.

23 Claims, 6 Drawing Sheets



U.S. PATENT DOCUMENTS

3,065,598	11/1962	Schultz	60/35.3	5,217,188	6/1993	Thole et al.	244/172
3,168,266	2/1965	Yost	244/138	5,295,642	3/1994	Palmer	244/2
3,173,252	3/1965	Ziegenhagen	60/35.6	5,404,714	4/1995	Vuillamy et al.	60/257
3,246,467	4/1966	Rossetto	60/35.6	5,456,424	10/1995	Palmer	244/2
3,248,875	5/1966	Wolcott	60/35.6	5,531,067	7/1996	Koppel	60/259
3,254,486	6/1966	Kenny	60/35.6	5,564,648	10/1996	Palmer	244/2
3,254,603	6/1966	Gould	102/70	5,568,901	10/1996	Steinon	244/63
3,262,655	7/1966	Gillespie, Jr.	244/1	5,626,310	5/1997	Kelly	244/2
3,266,237	8/1966	Crowell, Jr. et al.	60/35.3	5,661,970	9/1997	Müller et al.	60/233
3,286,629	11/1966	Laue	102/19	5,667,167	9/1997	Kistler	244/110 E
3,293,855	12/1966	Cuttill et al.	60/229	5,689,949	11/1997	DeFreitas et al.	60/39.9E
3,300,981	1/1967	Webb	60/259				
3,302,400	2/1967	Mangum	60/39.82				
3,534,686	10/1970	Watson	102/49.5				
3,541,796	11/1970	Morris	60/256				
3,597,923	8/1971	Simon	60/260				
3,603,093	9/1971	Isley et al.	60/260				
3,702,683	11/1972	Foust	244/153				
3,732,693	5/1973	Chu	60/207				
3,815,359	6/1974	Thurston	60/254				
3,828,551	8/1974	Schmidt	60/204				
3,882,676	5/1975	Schmidt	60/245				
3,910,037	10/1975	Salkeld	60/250				
3,943,706	3/1976	Grafwallner et al.	60/204				
4,163,534	8/1979	Seeger	244/3.22				
4,265,416	5/1981	Jackson et al.	244/2				
4,357,795	11/1982	Bastian et al.	60/204				
4,796,839	1/1989	Davis	244/158 R				
4,802,639	2/1989	Hardy et al.	244/2				
4,834,324	5/1989	Criswell	244/160				
4,844,380	7/1989	Peoples et al.	244/3.22				
4,884,770	12/1989	Martin	244/158 R				
4,912,925	4/1990	Foust	60/259				
5,031,857	7/1991	MacConochie et al.	244/3.28				
5,058,833	10/1991	Carmouche	244/158 R				
5,090,642	2/1992	Salkeld	244/158 R				
5,119,627	6/1992	Bradford et al.	60/251				
5,133,183	7/1992	Asaoka et al.	60/204				
5,141,181	8/1992	Leonard	244/172				
5,143,327	9/1992	Martin	244/158 R				
5,158,248	10/1992	Mockovciak, Jr.	244/160				

OTHER PUBLICATIONS

H. O. Ruppe, "Design Considerations For Future Space Launchers," *Acta Astronautica*(?), vol. 29, No. 9, (printed in Great Britain), 1993, pp. 705-722, Pergamon Press Ltd.

Col. Simon P. Worden, et al., "Single stage rocket technology: Here today," *Aerospace America*, Jul., 1993, 8 pages.

Ray R. Smiljanic, et al., "Delta Clipper: Design for supportability," *Aerospace America*, Jul. 1993, pp. 24-27.

Scott W. Benson, et al., "Titan III Feasibility for HL-20 Prototype Missions," *Journal of Spacecraft and Rockets*, Sep./Oct., 1993, pp. 615-621.

Mark K. Sellards, "The DC-X makes its first test hops A rocketship has landed on Earth!," *Countdown*, Oct., 1993, pp. 10-11.

Michael A. Dornheim, "DC-X Proving Initial Operational Concepts," *Aviation Week & Space Technology*, Oct. 11, 1993, 3 pages.

Ivan Beckey, "Why SSTO Rocket Launch Vehicles Are Now Feasible And Practical," *NASA Headquarters*, Nov. 21, 1993, pp. 1-21.

Arnold D. Aldrich, "NASA's Access To Space Study," *NASA Headquarters*, Nov. 21, 1993, pp. 12.

Alan W. Whilite, et al., "Technology and Staging Effects on Two-Stage-to-Orbit Systems," *Journal of Spacecraft and Rockets*, Jan./Feb., 1994, pp. 31-38.

Steven J. Isakowitz, "International Reference Guide to Space Launch Systems," American Institute of Aeronautics and Astronautics, 1991, 295 pages.

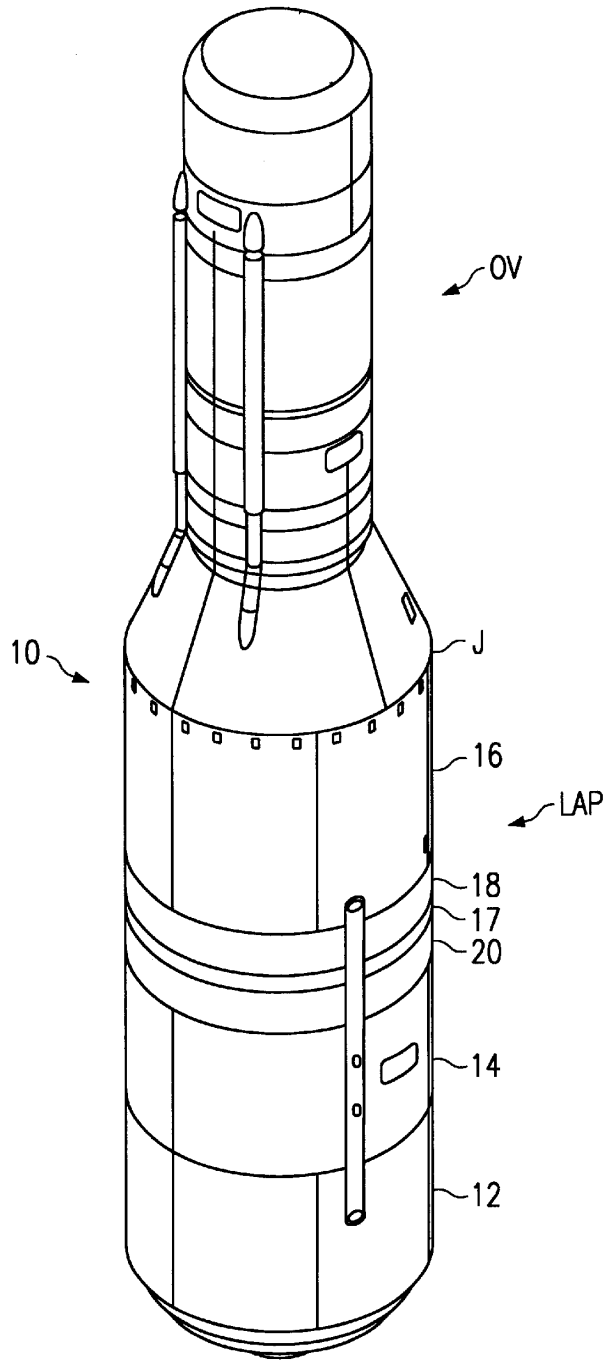


FIG. 1

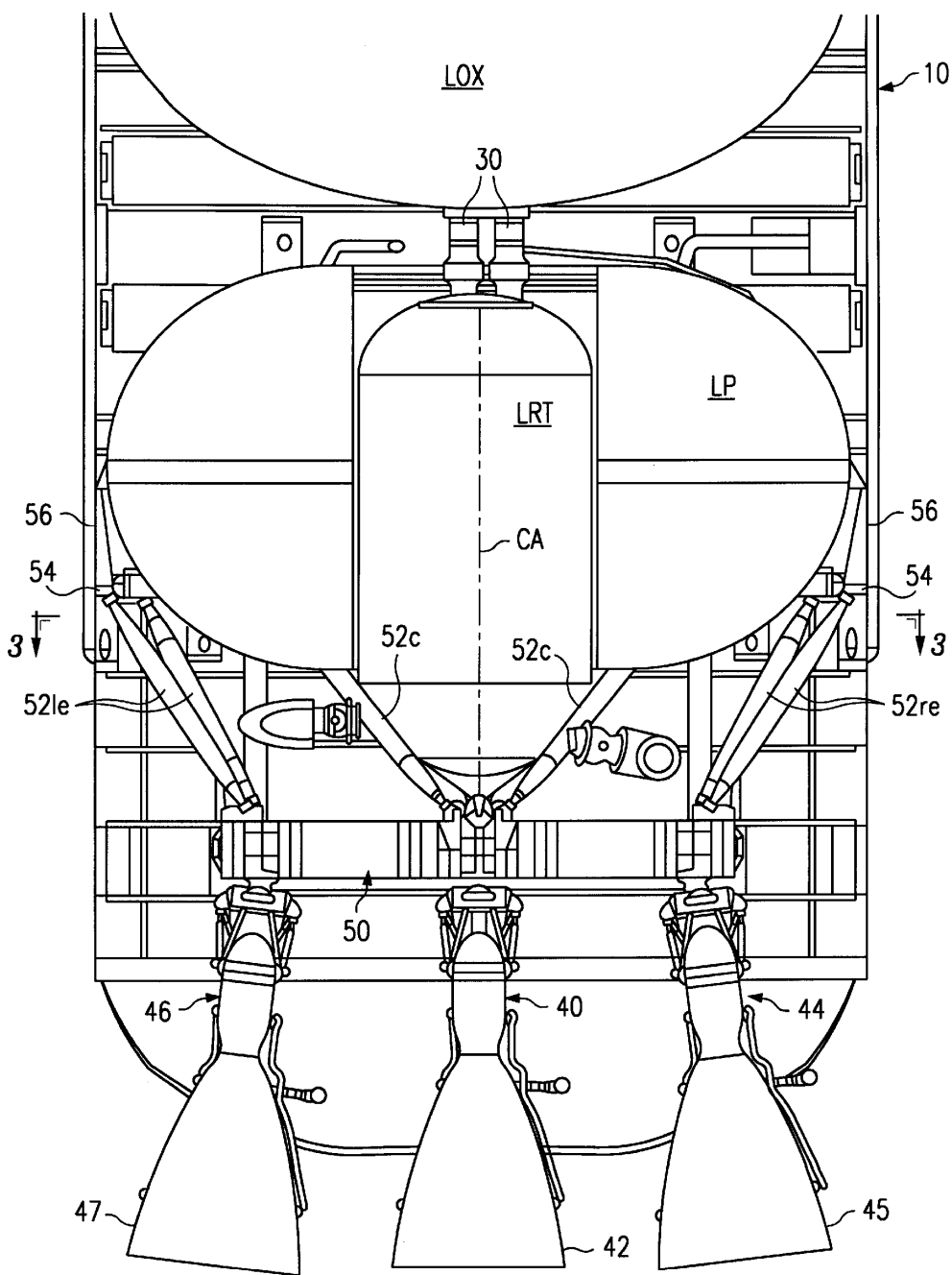


FIG. 2

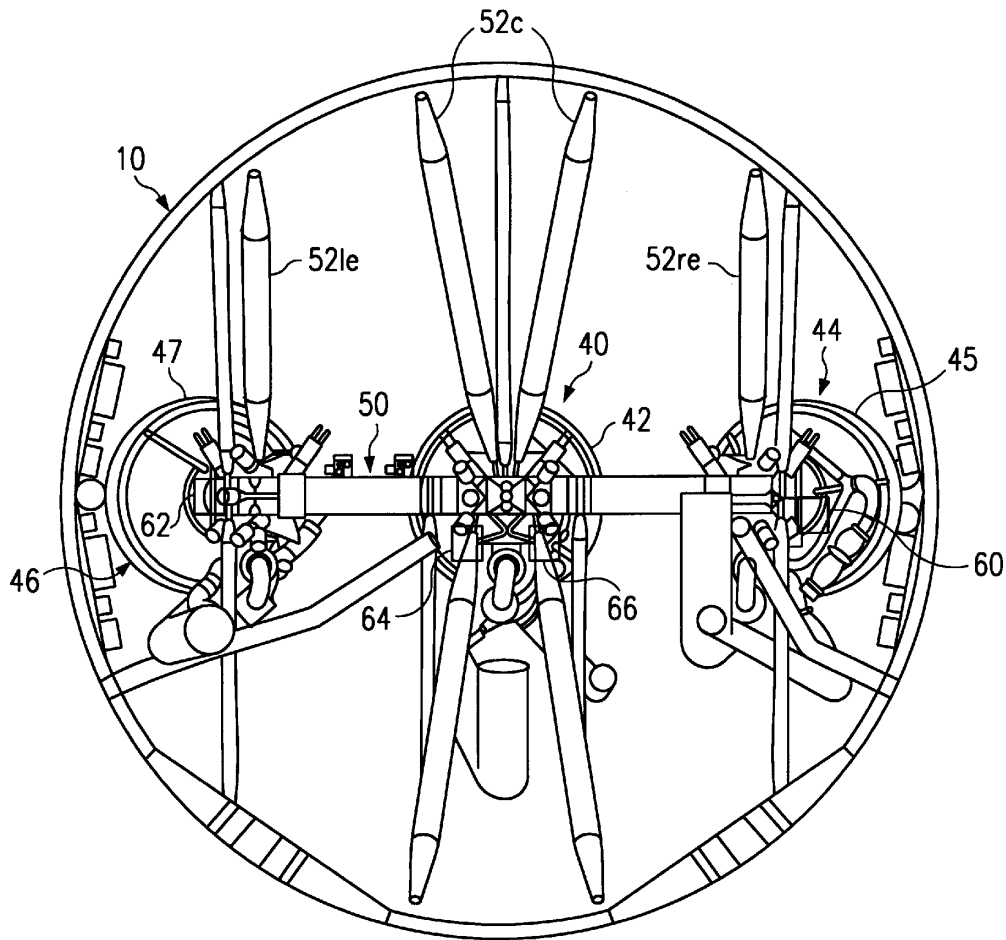


FIG. 3

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