

[54] **METHODS AND APPARATUS FOR  
COORDINATING SHARED MULTIPLE RAID  
CONTROLLER ACCESS TO COMMON  
STORAGE DEVICES**

[75] Inventors: **Rodney A. DeKoning; Gerald J. Fredin**, both of Wichita, Kans.

[73] Assignee: **LSI Logic Corp.**, Milpitas, Calif.

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[51] Int. Cl.<sup>7</sup> ..... **G06F 13/16**

[52] U.S. Cl. .... **711/150; 711/114; 711/148;  
711/149; 711/151; 711/152; 711/153; 711/162;  
711/168; 710/20; 710/21; 710/38; 710/241;  
714/6; 714/11**

[58] **Field of Search** ..... **711/114, 152,  
711/145, 148, 149, 150, 151, 153, 168,  
162; 714/6, 11; 710/20, 21, 38, 241**

[56] **References Cited**

**U.S. PATENT DOCUMENTS**

3,702,006	10/1972	Page	444/1
5,101,492	3/1992	Schultz et al.	395/575
5,148,432	9/1992	Gordon et al.	371/10.1
5,210,860	5/1993	Pfeffer et al.	395/575
5,249,279	9/1993	Schmenk et al.	395/425
5,317,731	5/1994	Dias et al.	395/600
5,331,476	7/1994	Fry et al.	360/53
5,367,669	11/1994	Holland et al.	395/575
5,379,417	1/1995	Lai et al.	706/916
5,386,324	1/1995	Fry et al.	360/53
5,388,108	2/1995	DeMoss et al.	371/51.1
5,434,970	7/1995	Schiffleger	395/200
5,440,743	8/1995	Yokota et al.	395/650
5,446,855	8/1995	Dang et al.	395/401
5,455,934	10/1995	Holland et al.	395/404
5,459,864	10/1995	Brent et al.	395/650
5,495,601	2/1996	Narang et al.	395/600
5,535,365	7/1996	Barriso et al.	711/152
5,546,535	8/1996	Stallmo et al.	395/182.07

(List continued on next page.)

**FOREIGN PATENT DOCUMENTS**

0493984	7/1992	European Pat. Off.	G06F 11/10
0551718	7/1993	European Pat. Off.	G06F 11/20
0707269	4/1996	European Pat. Off.	G06F 12/08
0645702	3/1995	Germany	.
9513583	5/1995	WIPO	G06F 12/00

**OTHER PUBLICATIONS**

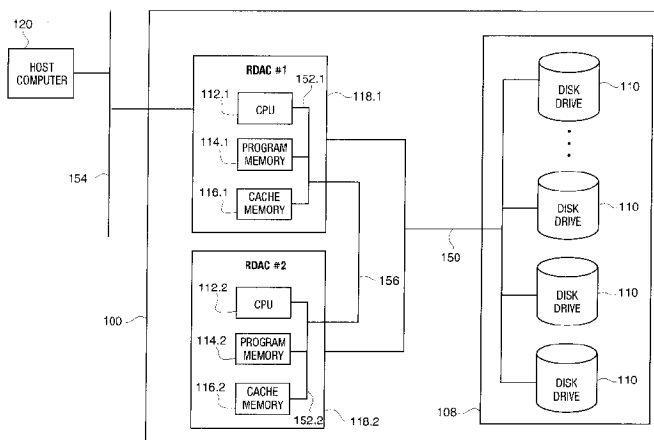
A. Case for Redundant Arrays of Inexpensive Disks (RAID); David Patterson, Garth Gibson & Randy kata; Dec., 1987; pp. 1-24.

*Primary Examiner*—Hiep T Nguyen

[57] **ABSTRACT**

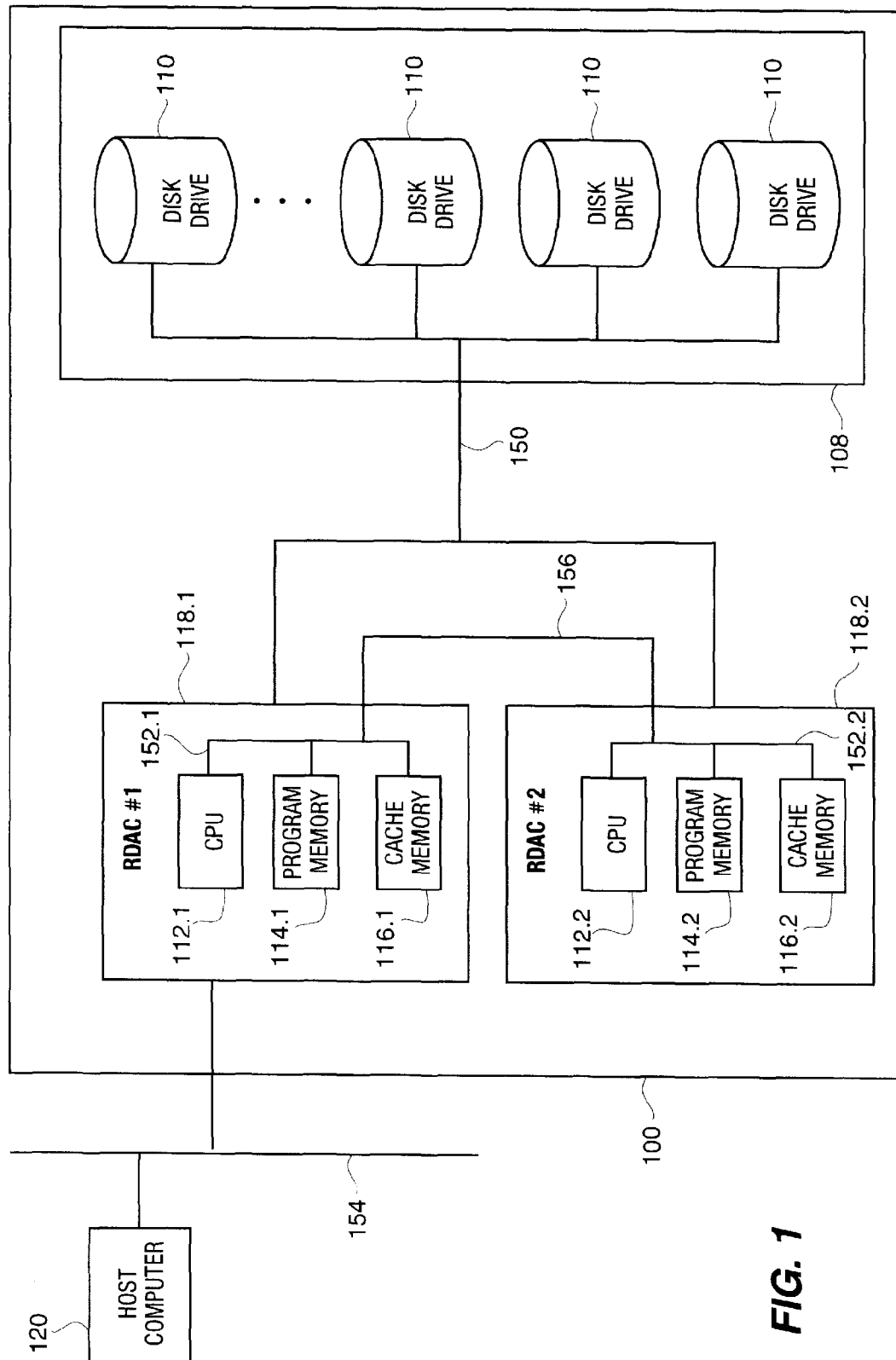
Methods and associated apparatus for performing concurrent I/O operations on a common shared subset of disk drives (LUNs) by a plurality of RAID controllers. The methods of the present invention are operable in all of a plurality of RAID controllers to coordinate concurrent access to a shared set of disk drives. In addition to providing redundancy features, the plurality of RAID controllers operable in accordance with the methods of the present invention enhance the performance of a RAID subsystem by better utilizing available processing power among the plurality of RAID controllers. Under the methods of the present invention, each of a plurality of RAID controllers may actively process different I/O requests on a common shared subset of disk drives. One of the plurality of controllers is designated as primary with respect to a particular shared subset of disk drives. The plurality of RAID controllers then exchange messages over a communication medium to coordinate concurrent access to the shared subset of disk drives through the primary controller. The messages exchanged include semaphore lock and release requests to coordinate exclusive access during critical operations as well as cache and meta-cache data to maintain cache coherency between the plurality of the RAID controllers with respect to the common shared subset of disk drives. These messages are exchanged via any of several well known communication mediums including, a shared memory common to the plurality of controllers and the communication bus connecting the shared subset of disk drives to each of the plurality of controllers.

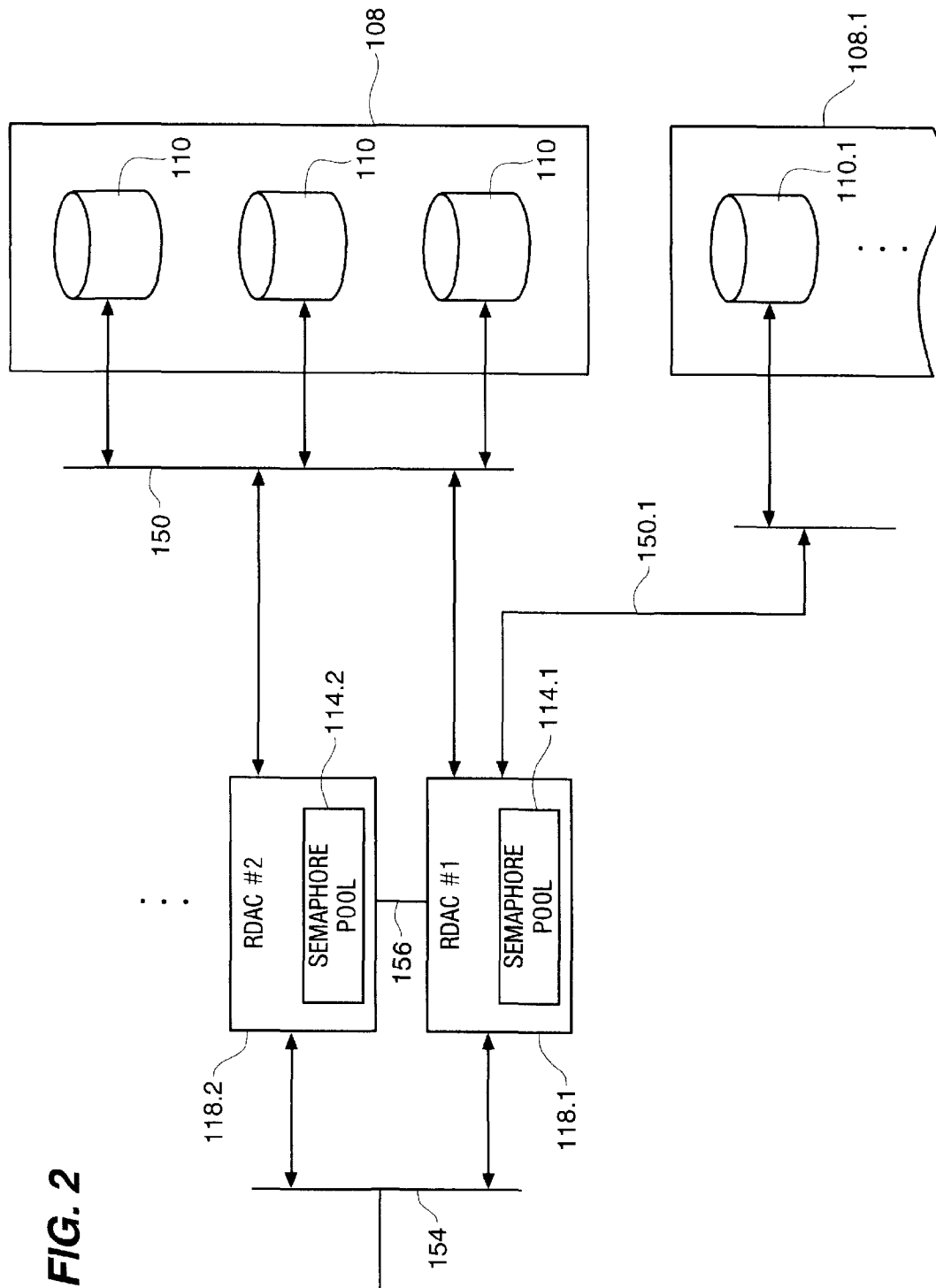
**36 Claims, 11 Drawing Sheets**



## U.S. PATENT DOCUMENTS

5,548,711	8/1996	Brant et al. ....	395/182.03	5,694,571	12/1997	Fuller .....	395/440
5,603,062	2/1997	Sato et al. ....	710/52	5,715,447	2/1998	Hayashi et al. ....	395/608
5,666,511	9/1997	Suganuma et al. ....	711/114	5,761,705	6/1998	DeKoning et al. ....	711/113
5,678,026	10/1997	Vertti et al. ....	711/152	5,764,922	6/1998	Peacock et al. ....	395/275
5,682,537	10/1997	Davies et al. ....	395/726	5,787,304	7/1997	Hodges et al. ....	395/821
				5,845,292	12/1998	Bohannon et al. ....	707/202

**FIG. 1**



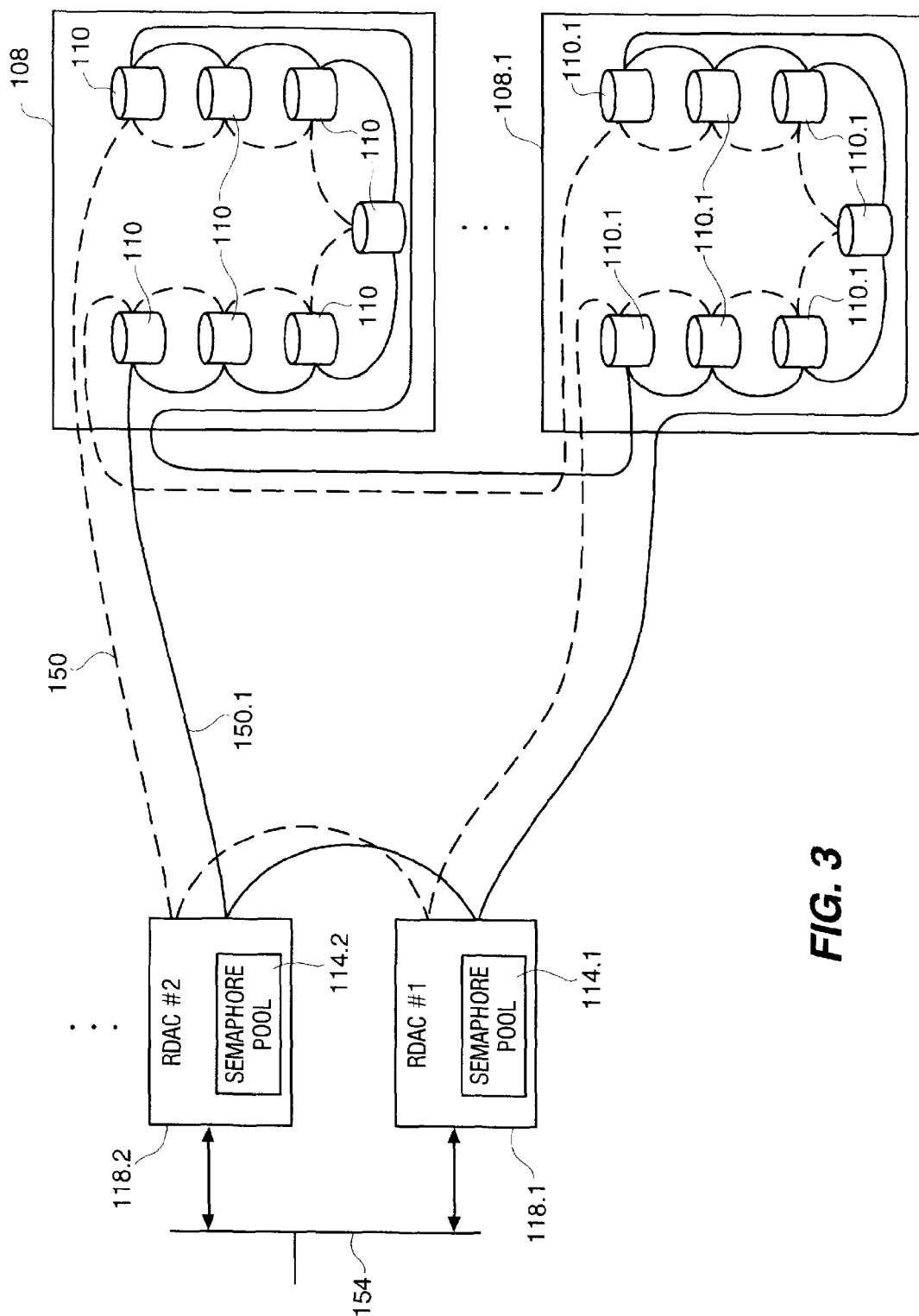


FIG. 3

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