



US005875103A

United States Patent [19]
Bhagwat et al.

[11] **Patent Number:** **5,875,103**
[45] **Date of Patent:** **Feb. 23, 1999**

- [54] **FULL RANGE SOFT-SWITCHING DC-DC CONVERTER**
- [75] Inventors: **Pradeep Madhay Bhagwat**, Baltimore, Md.; **Chadd Dial Justo**, Jersey City, N.J.; **Hamid Kashani**, Ocean, N.J.; **Harry J. Britton**, South Toms River, N.J.; **Atluri Rama Prasad**, Fords, N.J.
- [73] Assignee: **Electronic Measurements, Inc.**, Neptune, N.J.

5,221,887	6/1993	Gulczynski	323/285
5,235,502	8/1993	Vinciarelli et al.	363/20
5,245,520	9/1993	Imbertson	363/17
5,267,133	11/1993	Motomura et al.	363/21
5,274,543	12/1993	Loftus, Jr.	363/127
5,287,261	2/1994	Ehsani	363/124
5,291,382	3/1994	Cohen	363/16
5,291,384	3/1994	Mammano et al.	363/17
5,305,191	4/1994	Loftus, Jr.	363/17
5,438,498	8/1995	Ingemi	363/17
5,451,962	9/1995	Steigerwald	363/71
5,546,295	8/1996	Prete	363/98

- [21] Appl. No.: **577,628**
- [22] Filed: **Dec. 22, 1995**

- [51] Int. Cl.⁶ **H02M 3/335**
- [52] U.S. Cl. **363/17; 363/65; 363/71; 363/98**
- [58] Field of Search **363/170, 24, 25, 363/26, 65, 71, 97, 98, 132, 134**

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,027,038	6/1991	De Bijl et al.	363/132
5,079,686	1/1992	Vinciarelli	363/15
5,097,196	3/1992	Schoneman	323/222
5,113,334	5/1992	Tuson et al.	363/25
5,126,931	6/1992	Jitaru	363/21
5,132,888	7/1992	Lo et al.	363/17
5,132,889	7/1992	Hitchcock et al.	363/17
5,140,283	8/1992	Reed	330/284
5,157,592	10/1992	Walters	363/17
5,166,869	11/1992	Hesterman	363/25
5,172,309	12/1992	DeDoncker et al.	363/132

Primary Examiner—Jeffrey L. Sterrett
Attorney, Agent, or Firm—Michaelson & Wallace; Peter L. Michaelson; John C. Pokotylo

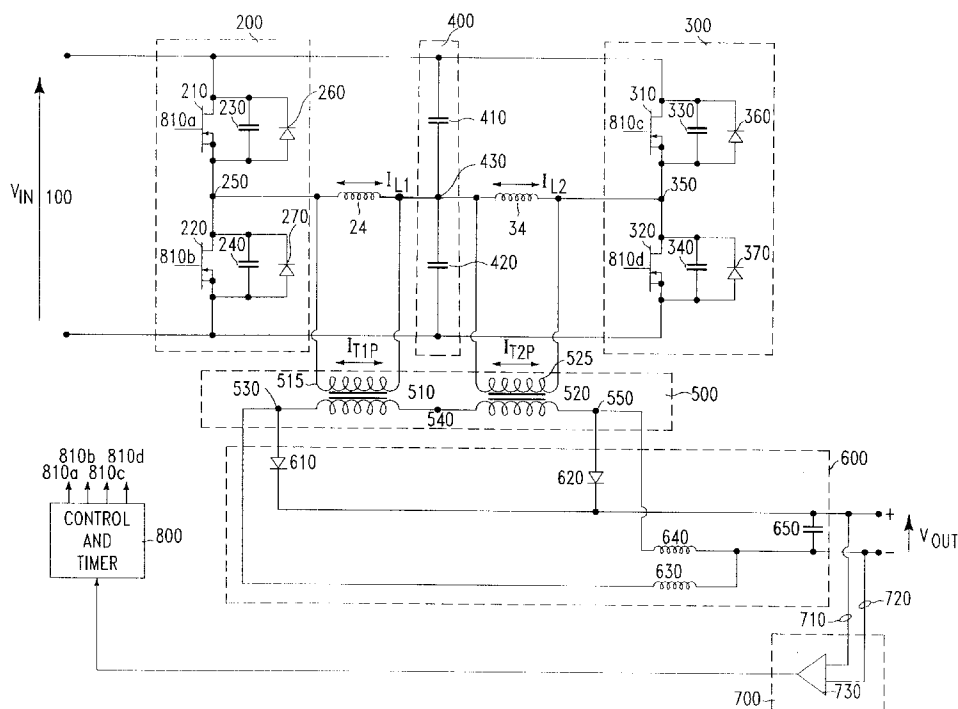
[57] **ABSTRACT**

A soft-switching DC to DC power converter which minimizes switching losses from a no load condition to a full load condition while operating at fixed frequency. Output voltage control is achieved by controlling the phase angle between the two switching networks. High frequency transformer primaries are always excited with a square wave input voltage equal to

$$\pm \frac{V_{in}}{2}$$

The power converter can be implemented with a single transformer. Moreover, the switch voltage never increases the input DC voltage from no load to full load. The power converter can be used in both low voltage high current applications and high voltage low current applications.

18 Claims, 12 Drawing Sheets



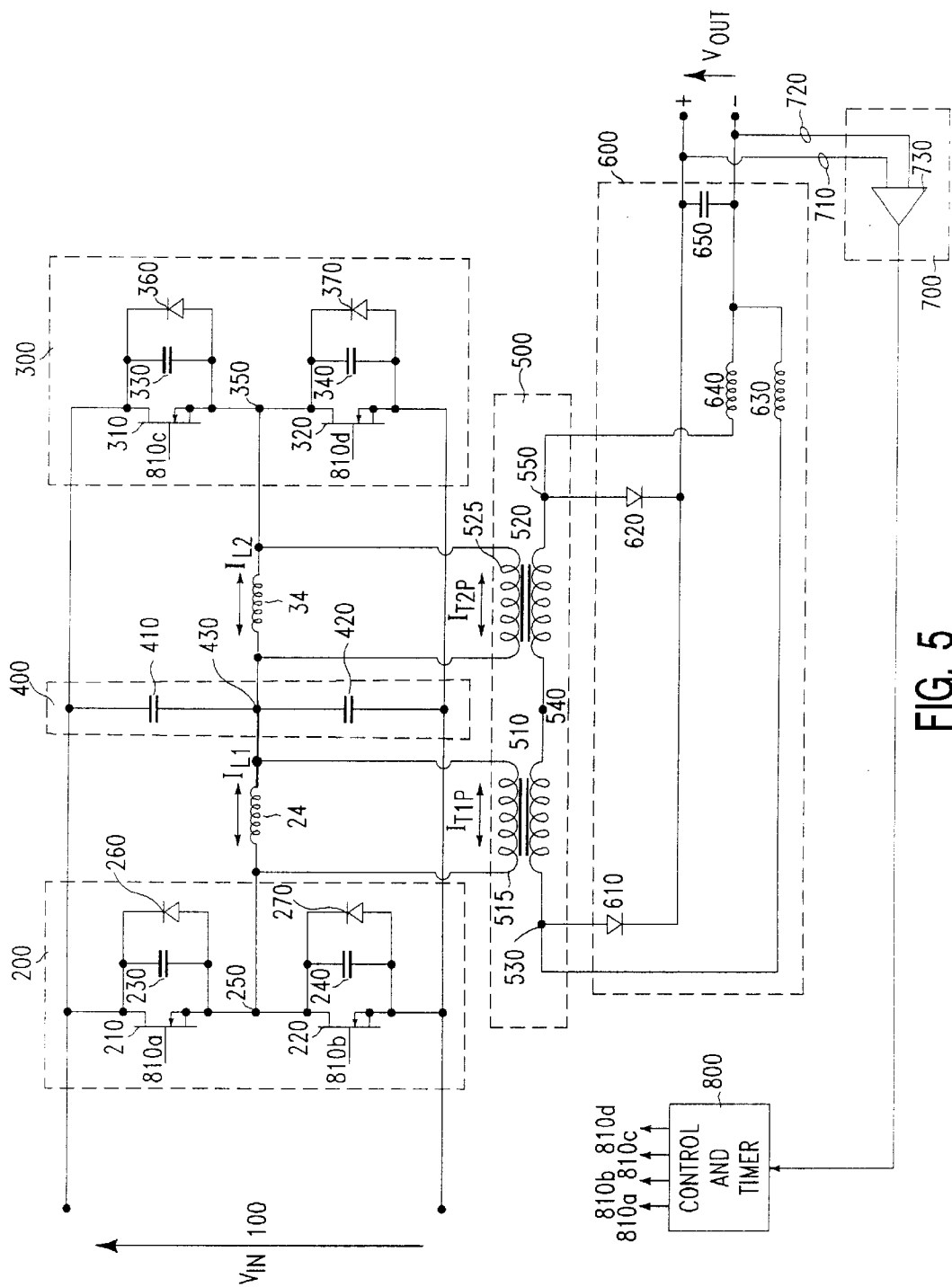


FIG. 5

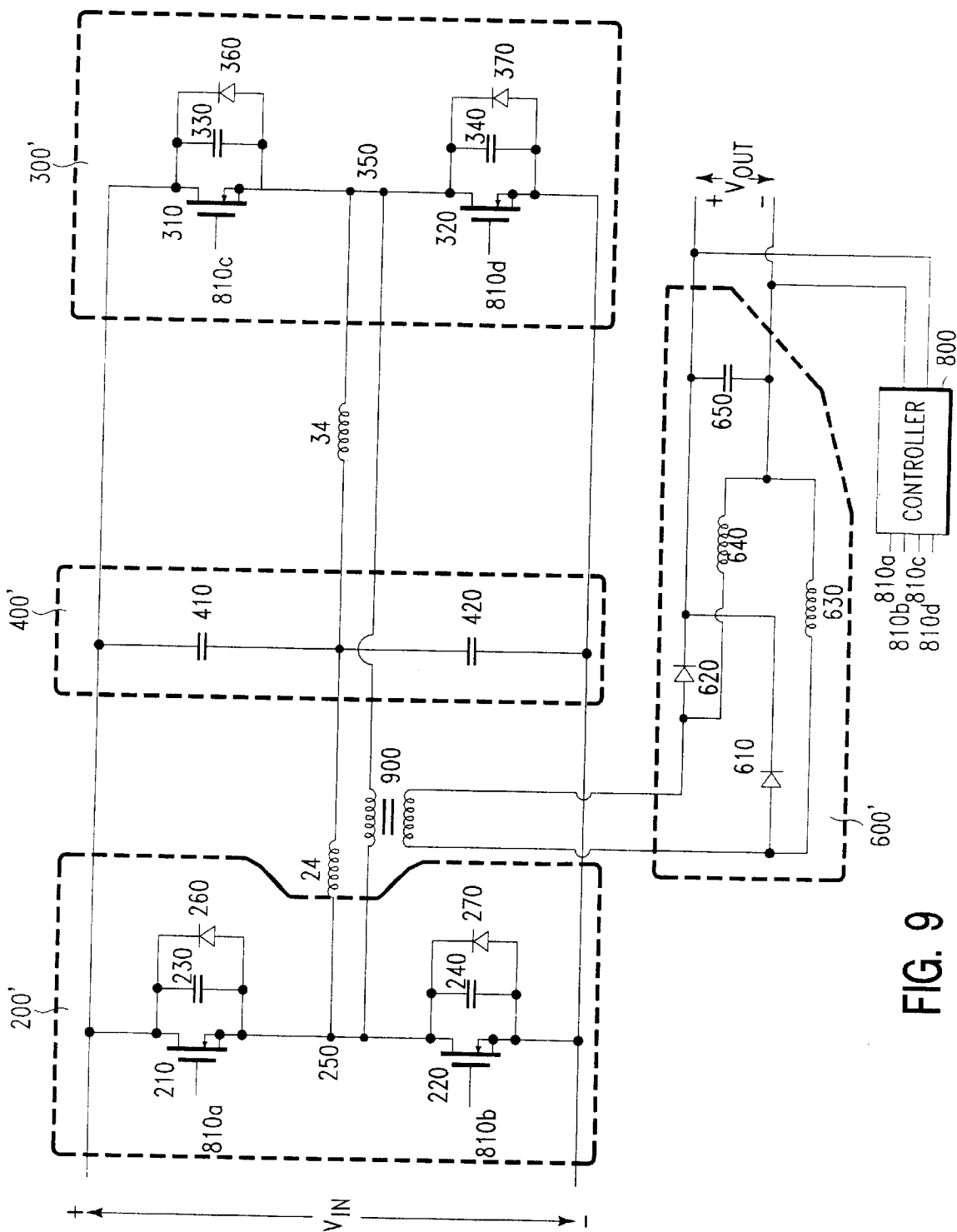


FIG. 9