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# United States Patent [19]

Hanawa

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[54] **AUTOMATIC FREQUENCY TUNING OF AN RF POWER SOURCE OF AN INDUCTIVELY COUPLED PLASMA REACTOR**

5,540,824 7/1996 Yin et al. .... 204/298.34  
5,558,722 9/1996 Okumura et al. .... 118/723 I

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[21] Appl. No.: **389,888**

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[51] Int. Cl.<sup>6</sup> ..... **C23F 1/02**

[52] U.S. Cl. .... **156/345; 156/643.1**

[58] Field of Search ..... 118/723 I, 723 IR,  
118/723 E, 723 ER, 723 MP, 671; 156/345,  
643.1, 626.1, 627.1; 216/68; 204/298.08,  
298.32, 298.03

### [56] References Cited

#### U.S. PATENT DOCUMENTS

3,573,840	4/1971	Gouillou et al. ....	343/895
4,795,529	1/1989	Kawasaki et al. ....	156/643
4,842,683	6/1989	Cheng et al. ....	156/345
4,844,775	7/1989	Keeble ....	156/643
4,872,947	10/1989	Wang et al. ....	156/643
4,948,458	8/1990	Ogle ....	156/643
4,954,212	9/1990	Gabriel et al. ....	156/627
4,992,665	2/1991	Mohl ....	250/423 R
5,122,251	6/1992	Campbell et al. ....	204/298.06
5,234,529	8/1993	Johnson ....	156/345
5,277,751	1/1994	Ogle ....	156/643
5,280,154	1/1994	Cuomo et al. ....	219/121.52
5,346,578	9/1994	Benzing et al. ....	156/345
5,368,710	11/1994	Chen et al. ....	264/192.32
5,401,350	3/1995	Patrick et al. ....	156/345
5,474,648	12/1995	Patrick et al. ....	156/627.1

#### FOREIGN PATENT DOCUMENTS

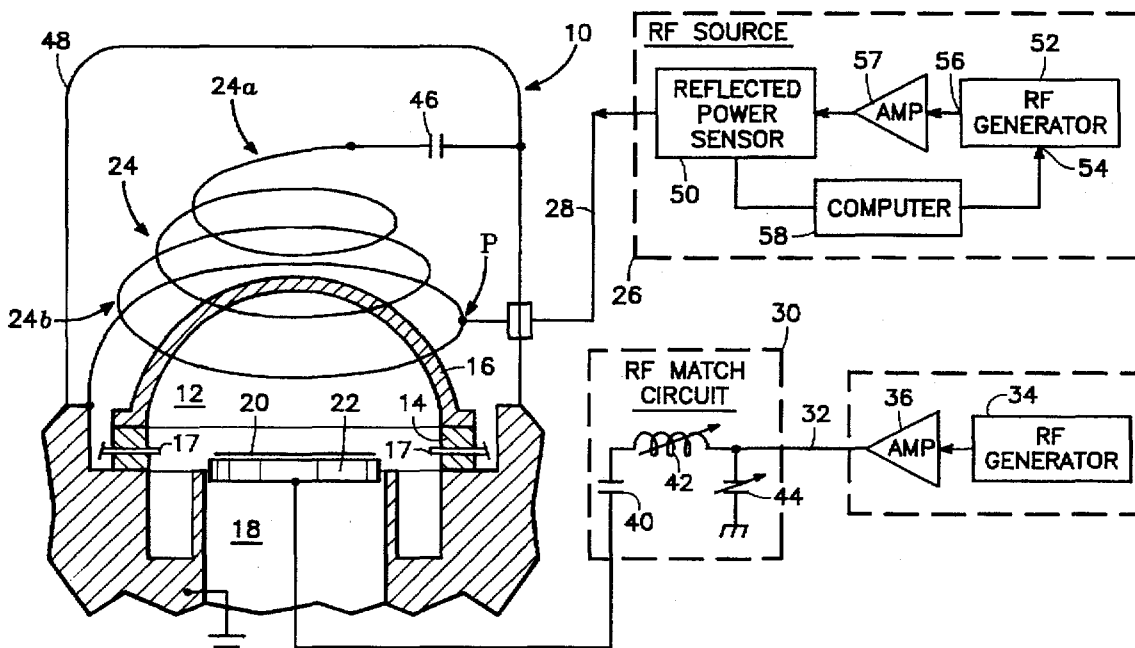
0 058 820	1/1982	European Pat. Off. .
0 379 828 A2	8/1990	European Pat. Off. .
0 379 828 A3	8/1990	European Pat. Off. .
0 489 407	6/1992	European Pat. Off. .
0 520 519 A1	12/1992	European Pat. Off. .
0 552 491 A1	7/1993	European Pat. Off. .
0 593 924	4/1994	European Pat. Off. .
0 596 551 A1	5/1994	European Pat. Off. .
0 602 764	6/1994	European Pat. Off. .
2 231 197	11/1990	United Kingdom .
WO 92/20833	11/1992	WIPO .

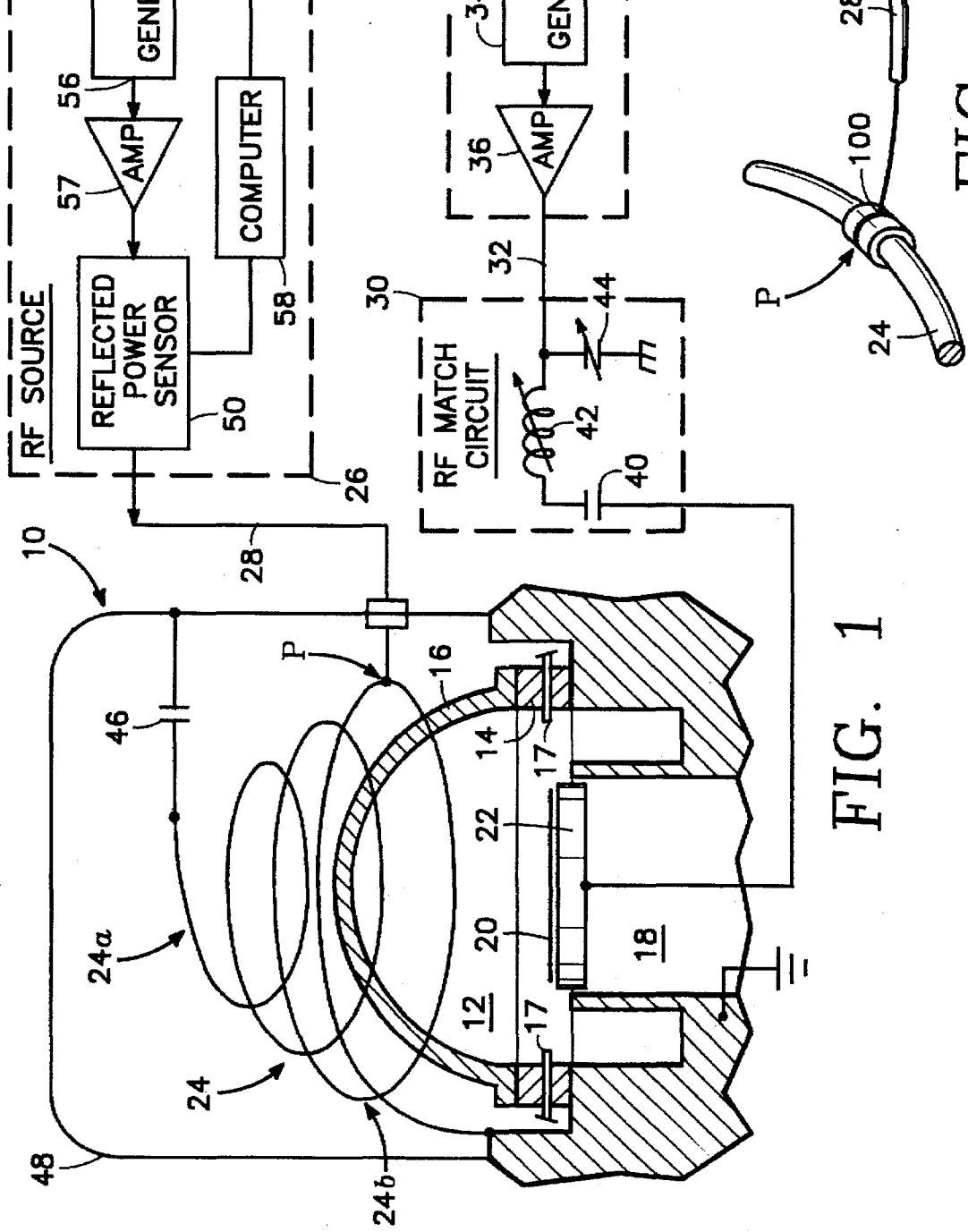
Primary Examiner—John Niebling  
Assistant Examiner—Joni Y. Chang  
Attorney, Agent, or Firm—Michaelson & Wallace

### [57] ABSTRACT

A plasma reactor has a reactor chamber for containing a semiconductor wafer to be processed and gas inlet apparatus for introducing an ionizable gas into the chamber, a variable frequency RF power source, an RF antenna near the chamber, the antenna connected to the RF power source for coupling RF power to the ionizable gas to produce a plasma therefrom, a power sensor connected to the antenna for sensing either (or both) transmitted power to the plasma or reflected power to said source, and a control circuit connected to a control input of the variable frequency RF power source and responsive to the power sensor for changing the frequency of the variable frequency RF power source so as to either increase the transmitted power or decrease the reflected power, so as to provide an accurate RF match instantly responsive to changes in plasma impedance.

30 Claims, 13 Drawing Sheets





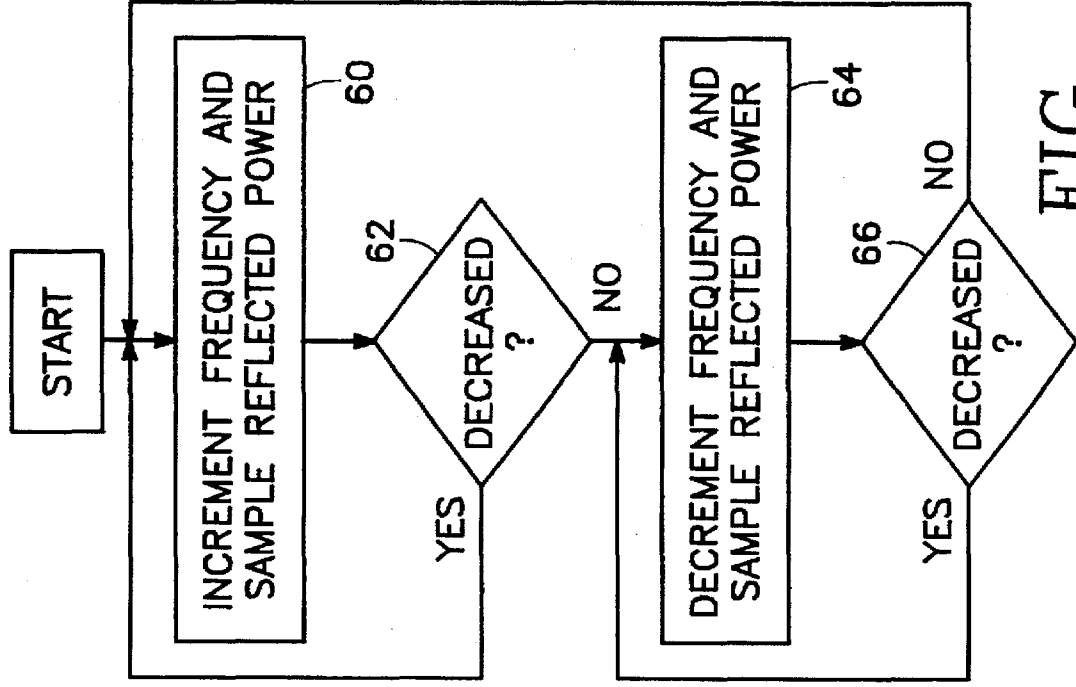


FIG. 2

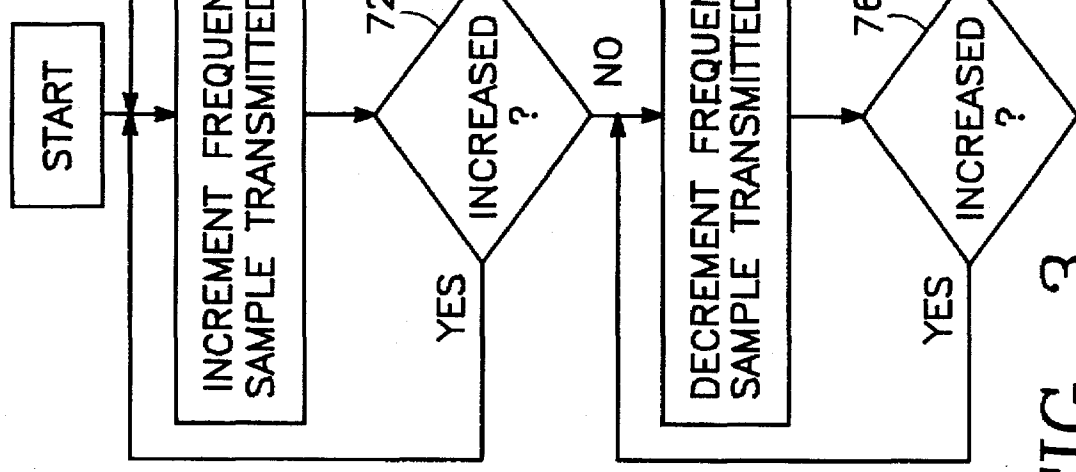


FIG. 3

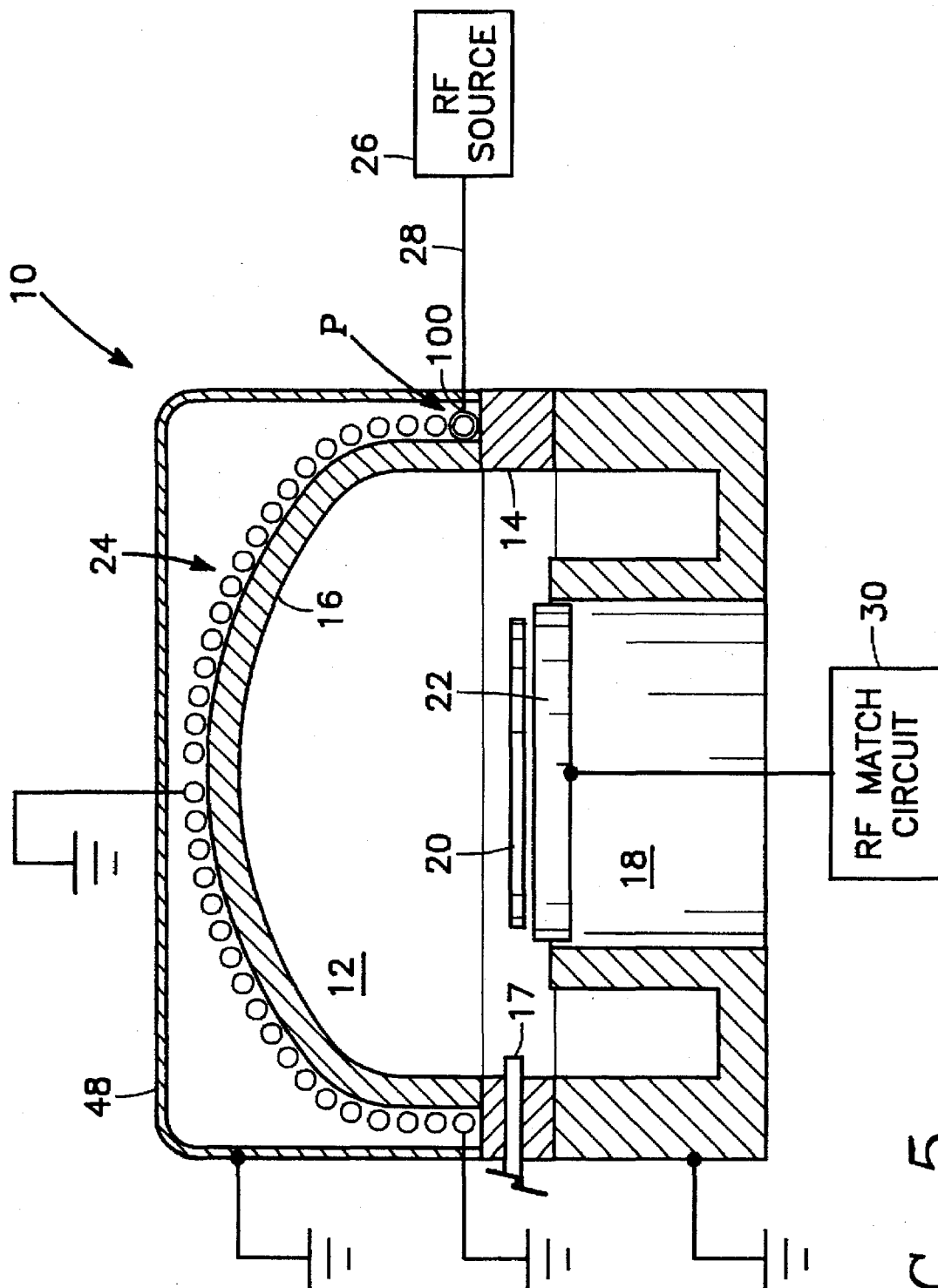


FIG. 5

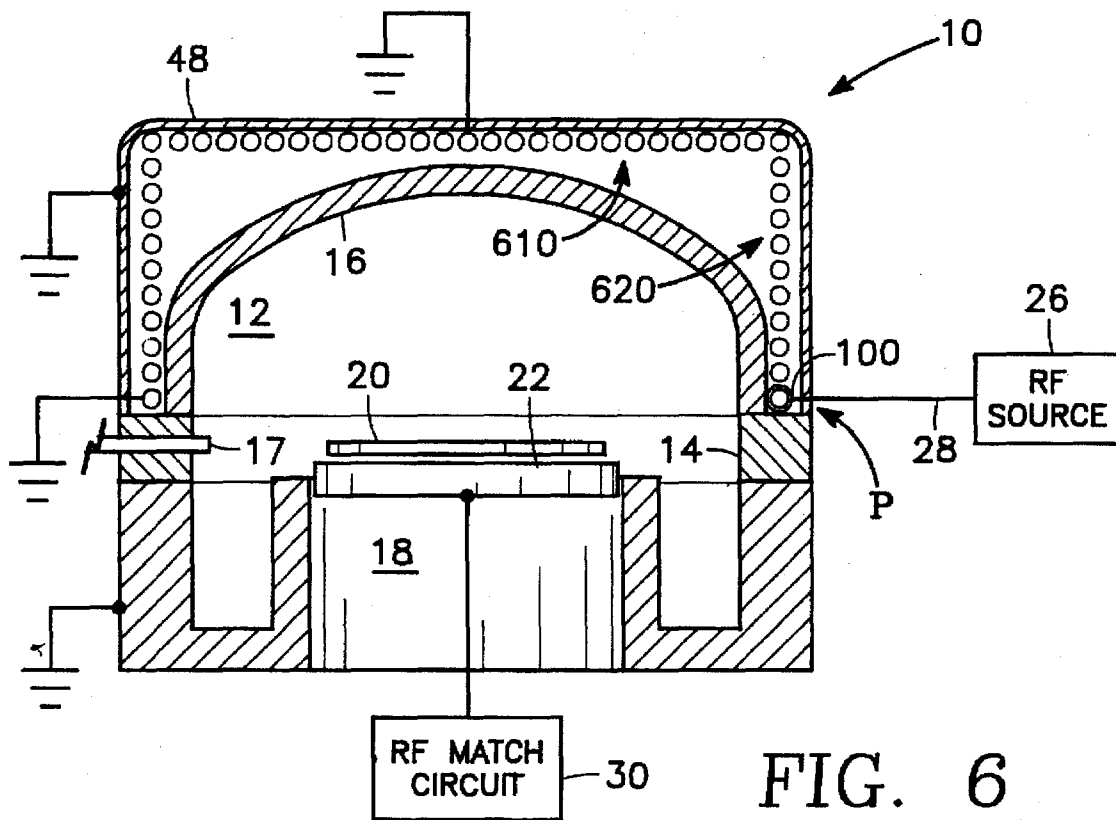


FIG. 6

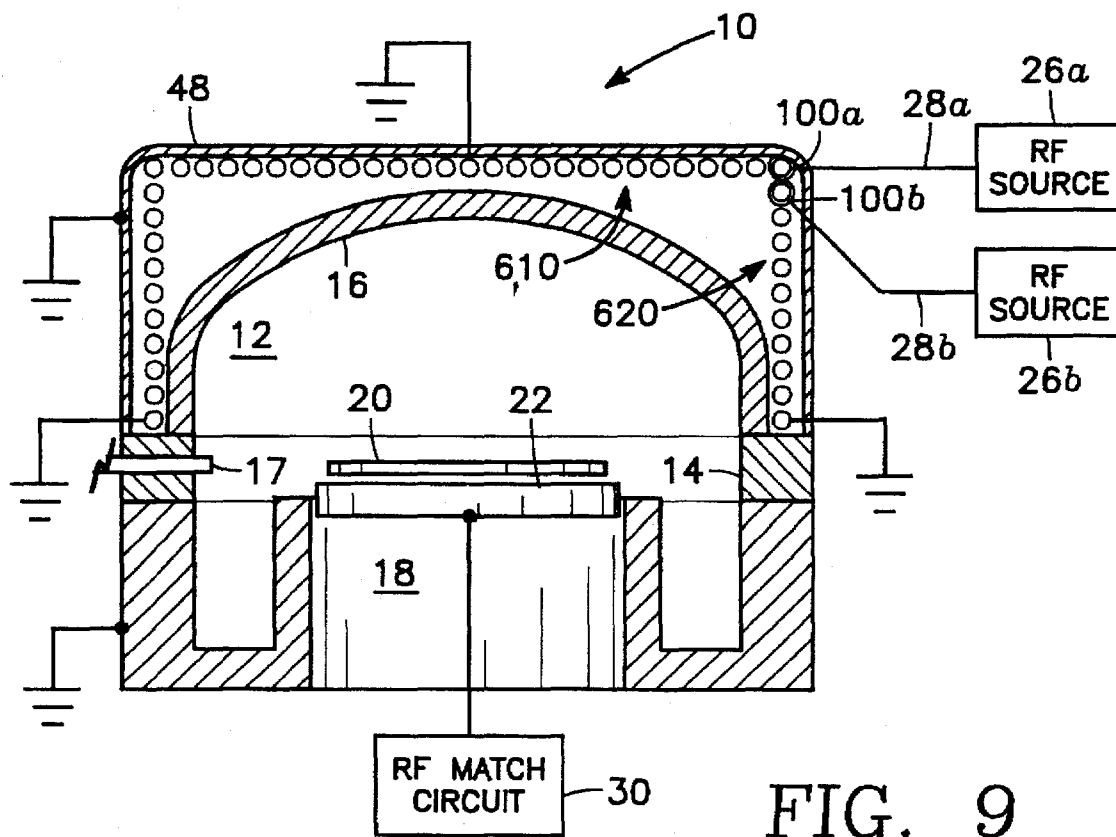


FIG. 9

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