United States Patent [19]

Smith

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[54] **PHASED ARRAY ANTENNA WITH PHASE SHIFTER COOLING**

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[52] **U.S. Cl.** **343/778,** 343/904
[51] **Int. Cl.** **H01q 13/00**
[58] **Field of Search** .... 333/22 F; 343/777, 778

[56] **References Cited**

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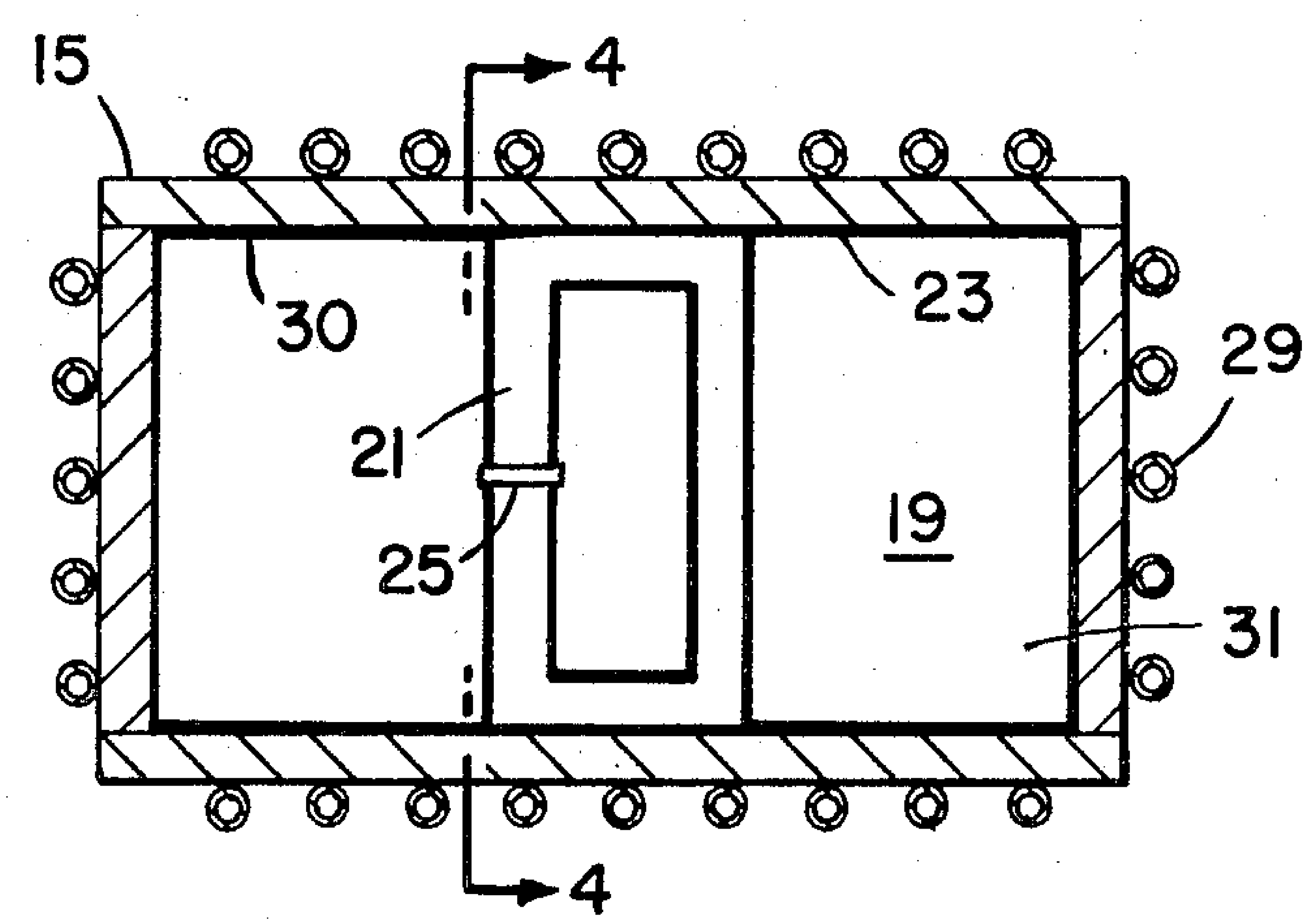
[57] **ABSTRACT**

A phased array radar antenna including a plurality of individual radar emitters disposed in honeycomb arrangement and supplied through corresponding waveguides from a common source of microwaves to propagate a radar wavefront. The phases of the microwaves in the conduits are shifted to slow the waves and scan the wavefront by changing the magnetization of ferrite toroids in the conduits. Capillary means and a coolant cooperate in the conduits to remove excess heat from the toroids.

5 Claims, 5 Drawing Figures



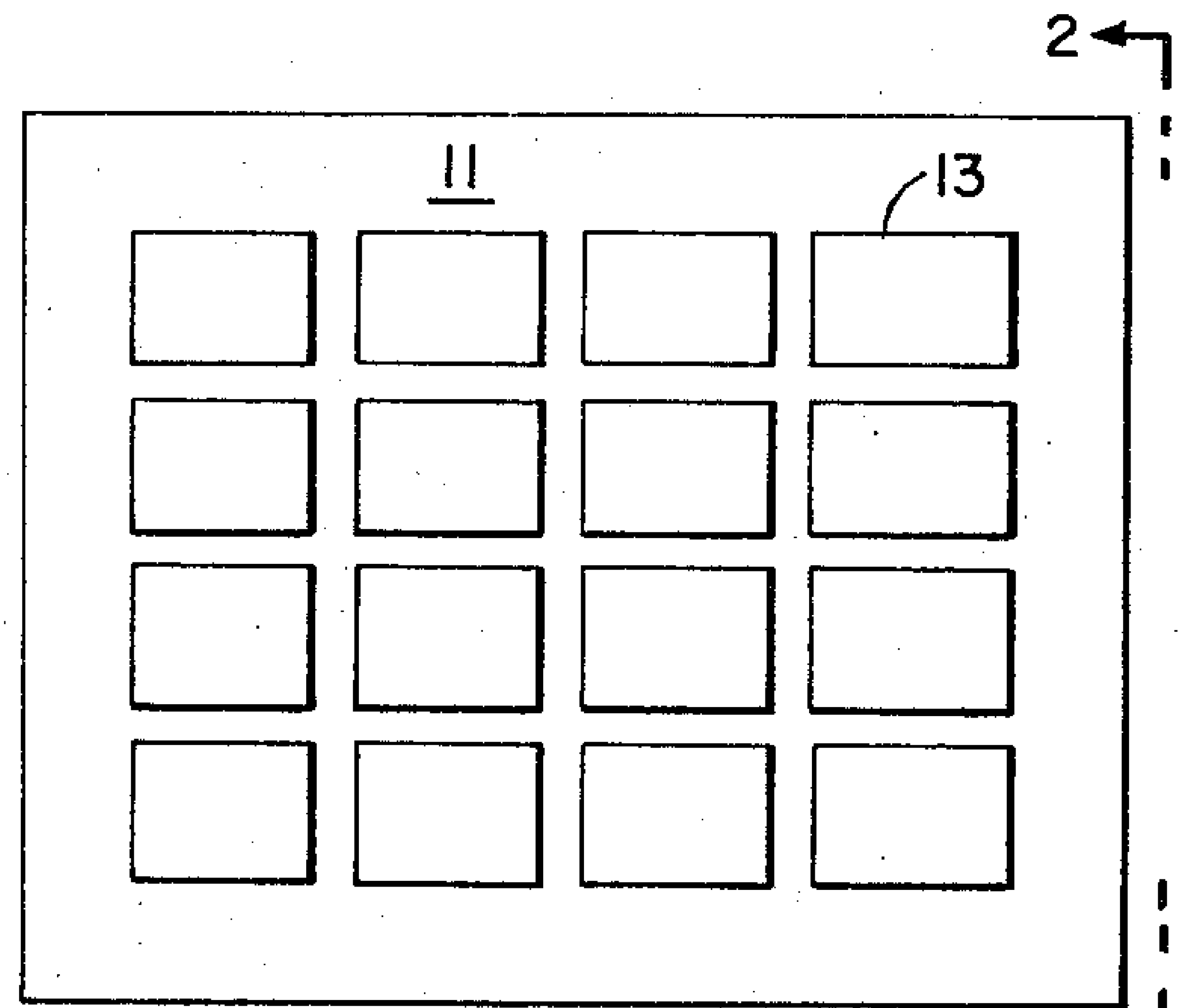


FIG. 1

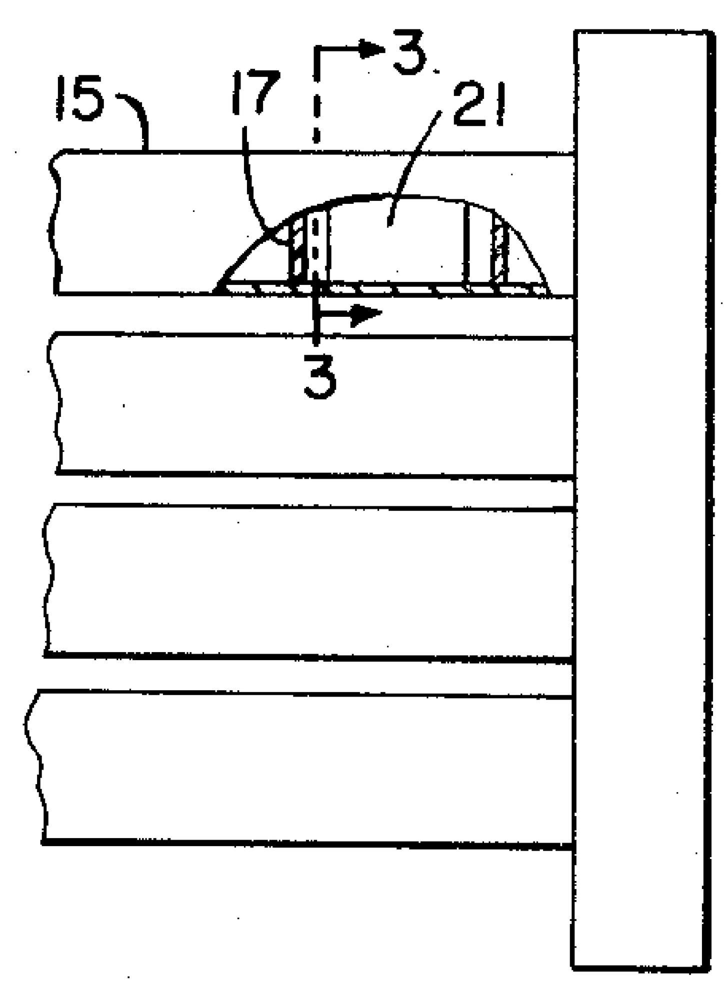


FIG. 2

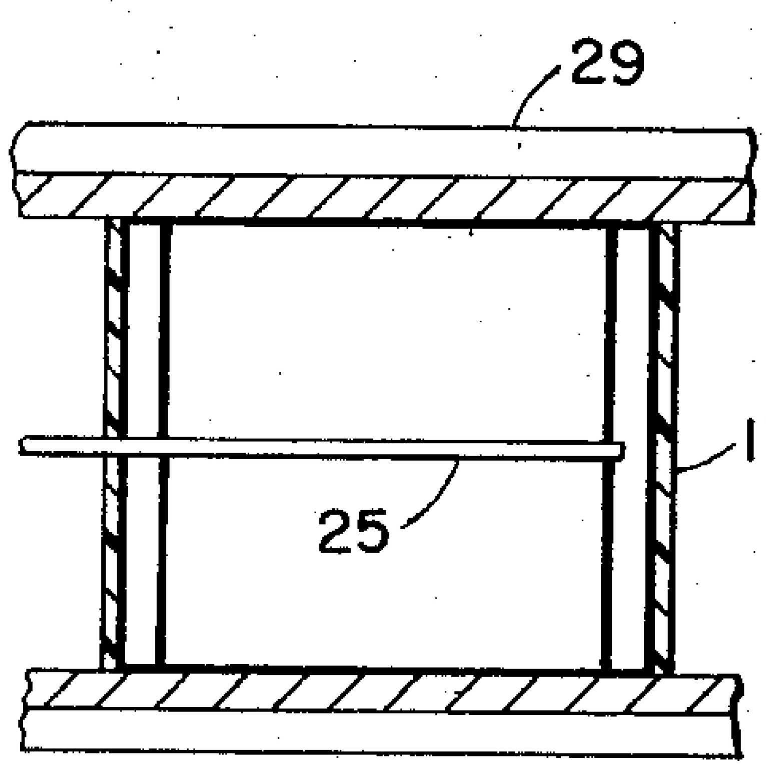


FIG. 4

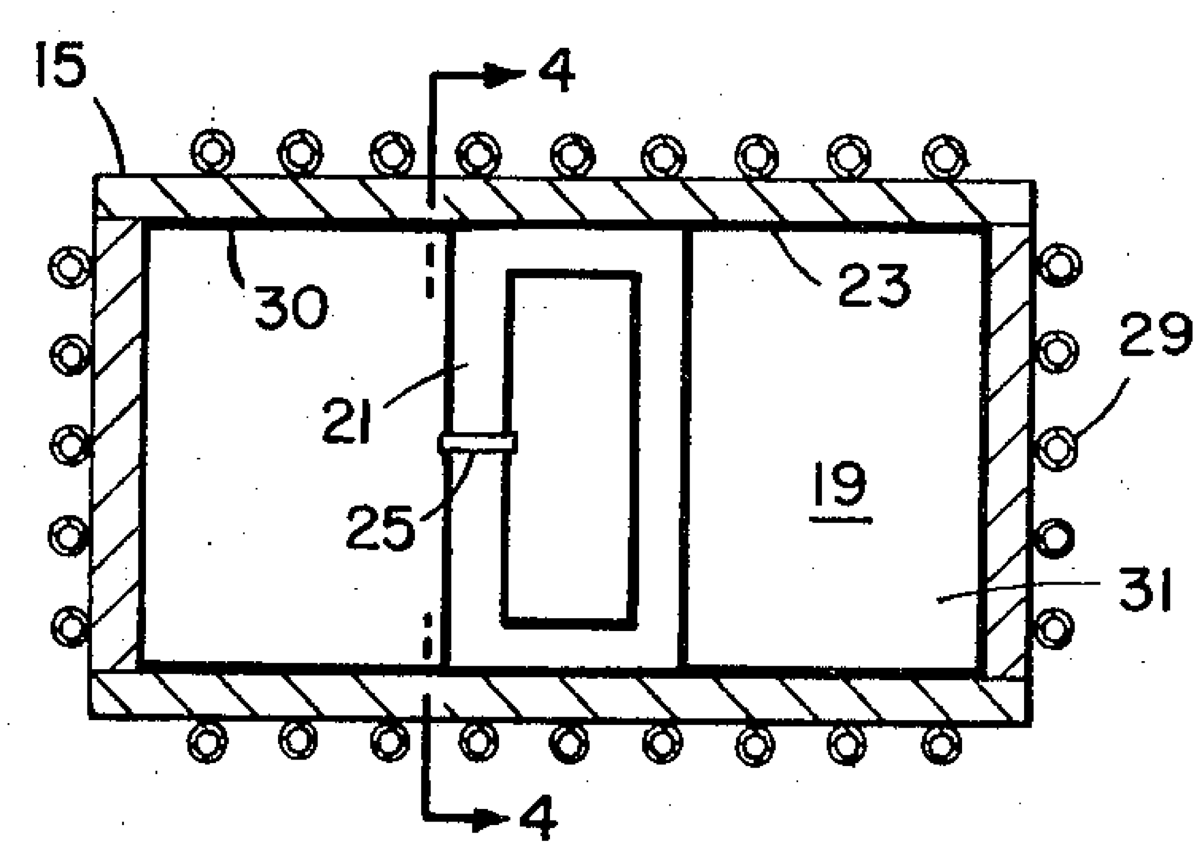


FIG. 3

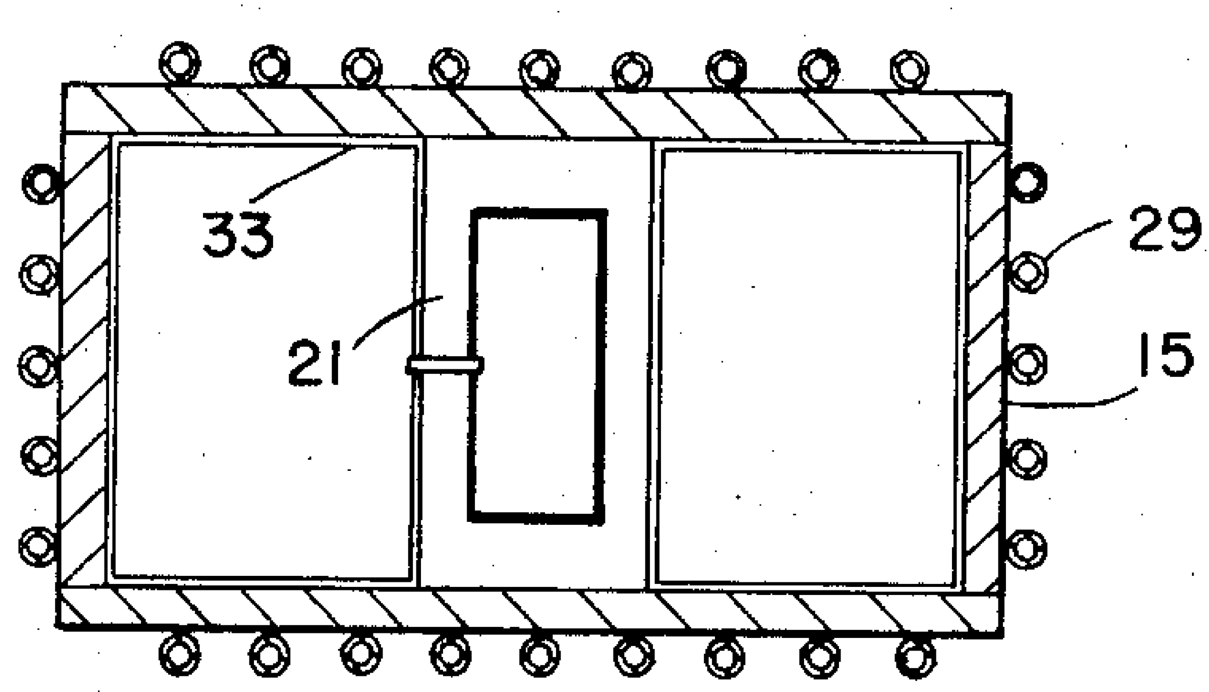


FIG. 5

PHASED ARRAY ANTENNA WITH PHASE SHIFTER COOLING

BACKGROUND OF THE INVENTION

Prior efforts to remove excess heat from the close confines of similar honeycomb structures have proven to be many times as expensive as the instant invention. For instance the prior art would require ferrite toroids of materially increased length and/or provided with ceramic inserts to achieve a similar effect at more than double the cost of the instant device. For applications having an average power level of the order of **one** megawatt such as might be required for continental defense the cost would be upwards of 100 times as great in the prior art.

SUMMARY OF THE INVENTION

A microwave phase shifter incorporates a rectangular toriod of ferrite longitudinally disposed in a sealed section in each of the waveguides and secured in electrical connection with the wide sides of the waveguides. An insulated conductor loop encloses one of the remaining sides of the toroid to carry electrical current to magnetize the toroid for the phase shift. Cooling means usually disposed along the wide sides of such waveguides remove sufficient heat from the attached surfaces of the toroid. The material of the toroid, ferrite, is excellent dielectric material but a poor heat conductor so that accumulation of heat in the unattached legs of the toroid would cause the ferrite to crack and the toroid to fail or at least would change the electrical characteristics of the toroid. The walls of the spaces within the toroid and adjacent thereto are lined with connected wicking material for capillary action between the unattached walls of the waveguide and toroid. A coolant that vaporizes below the critical temperature of the ferrite is selected and the wicking or grooves are saturated with the coolant. As the toroid becomes heated, the coolant is vaporized, only to be condensed again by encounter with the unattached walls of the waveguide that are provided with additional cooling coils for dissipation of the excess heat. The capillary means return the condensed coolant to the toroid to repeat the cycle.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is an elevation of a radar antenna showing the individual emitters.

FIG. **2** is a view along line **2—2** of FIG. **1** showing the waveguides to the emitters.

FIG. **3** is a view along line **3—3** of FIG. **2.**

FIG. **4** is a view along line **4—4** of FIG. **3.**

FIG. **5** is a view similar to FIG. **3** with the capillary means including grooves engraved on unattached surfaces.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A radar antenna **11** includes individual emitters **13** connected by waveguides **15** to a common source (not shown) of radar waves. Waveguides **15** include lateral bulkheads or windows **17** of dielectric material transparent to microwaves to form sealed chambers **19** therebetween. A hollow rectangular core or toroid **21** substantially 10 cm long and 1 cm wide of a 3 mm thick ferromagnetic dielectric material such as ferrite is disposed in each chamber **19** in electrical conductive engagement with the long sides **23** of the chamber. Sides **23** are spaced substantially 1.5 cm apart. An electrical conductor loop **25** is provided around an unattached side of toroid **21** for energization to magnetize toroid **21** and slow the microwaves in the core. The degree of magnetization of the waveguide cores is continuously and selectively varied to produce 90°–120° scanning of the wavefront from antenna **11.**

Resistance of the ferrite to the microwave flow plus the continual scanning produces a great deal of heat and since dielectrics such as ferrite are notoriously poor heat conductors the heat could cause a change in the electrical characteristics of the ferrite and unequal expansions in the unattached sides of core **21** would cause early failure by cracking. Cooling tubes **29** are provided on the unattached sides of waveguide **15,** and wicking **30** is secured to the surfaces within chamber **19** for capillary action between the unattached sides of waveguide **15** and toroid **21.**

Chamber **19** is provided with a coolant **31** to saturate wicking **30,** water or freon may be used since either vaporizes below the critical and/or cracking temperature for toroid **21.** As the antenna is operated coolant **31** vaporizes to absorb excess heat and prevent the toroid temperature from rising to the critical value. The coolant condenses on contact with the unattached walls of waveguide **15** for dissipation of the excess heat by cooling tubes **29** and the condensate is returned by capillary action through the wick to toroid **21** to repeat the cycle.

Alternately, a portion of the unattached surfaces within chamber **19** may be scribed with fine connected grooves **33** as in FIG. **5** to implement the capillary flow of the coolant.

I claim:

1. An antenna comprising a plurality of waveguides disposed in honeycomb relation and connected to a common source of microwaves to produce a wavefront; and toroidal phase shifters respectively disposed in said waveguides for selective control of the speed of the waves in said conduits for scanning the wavefront and wicking means lining portions of the inner surfaces of said waveguides and the outer surfaces of the toroidal phase shifters to dissipate heat by capillary action.

2. An antenna comprising: a plurality of waveguides with respective phase shifters, disposed in honeycomb relation and connected to a single source of microwaves to produce a wavefront with each of said phase shifters including a pair of lateral microwave transparent windows in sealed spaced relation with one of said conduits to form a compartment therein; toroids respectively disposed in longitudinal electrical contact with the wide sides of said compartments to provide enclosures within and adjacent said toroids and individually wound with an insulated electrical loop for magnetization of the toroid to slow the waves in the conduit; cooling coils enclosing each of said waveguides; capillary means disposed on unattached surfaces of said enclosures; and a coolant saturating said capillary means for vaporization to remove excess heat of said toroid and condensation to dissipate the excess heat to the cooling coils; said capillary means being disposed for communication to convey the coolant to said toroid for revaporization.

3. A phase shifter as in claim **2** with said capillary means comprising wicking material secured to the unattached enclosure surfaces.

4. A phase shifter as in claim 2 with said capillary means including narrow grooves engraved in the unattached enclosure surfaces.

5. A phase shifter as in claim 2 with said toroid formed of a material such as ferrite having magnetization capability to slow the microwaves in said conduits and said coolant disposed for vaporization substantially below the critical and/or cracking temperature of said material.

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