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[54] **MICROWAVE PLATFORM SYSTEM**
10 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **244/17.11,** 60/203, 244/23, 244/53, 318/16, 416/20
[51] **Int. Cl.** **B64c 27/00**
[50] **Field of Search** 318/16; 244/1SS, 62, 14; 324/92; 329/202, 193; 219/10.55, 10.65, 10.49

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ABSTRACT: An energy summing system, comprising a plurality of means for guiding microwave energy, means for terminating said guiding means, means in each of said terminations to convert said microwave energy into thermal energy, and means for summing said thermal energy.

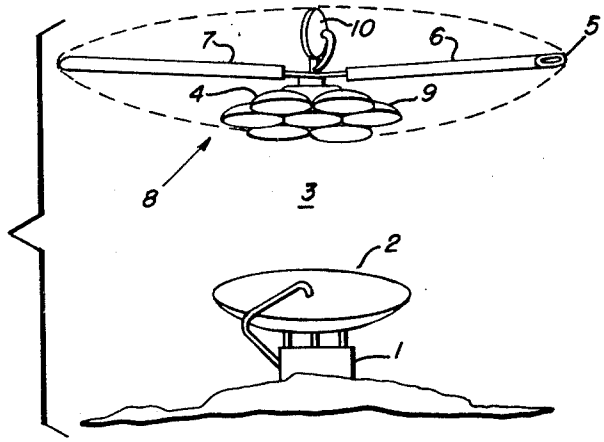


FIG. 2

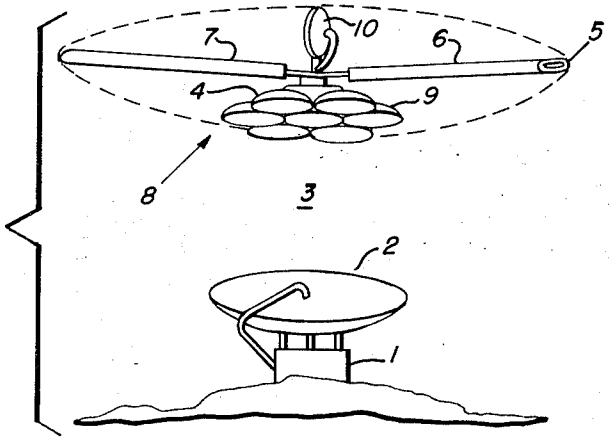


FIG. 1

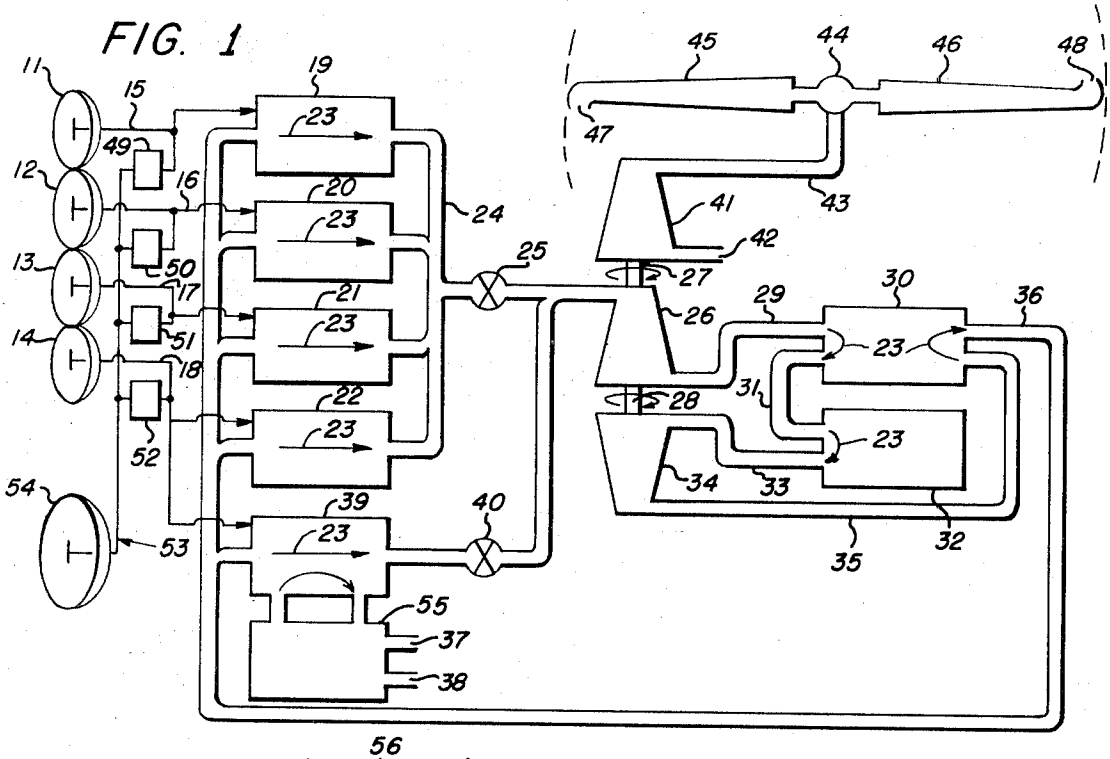
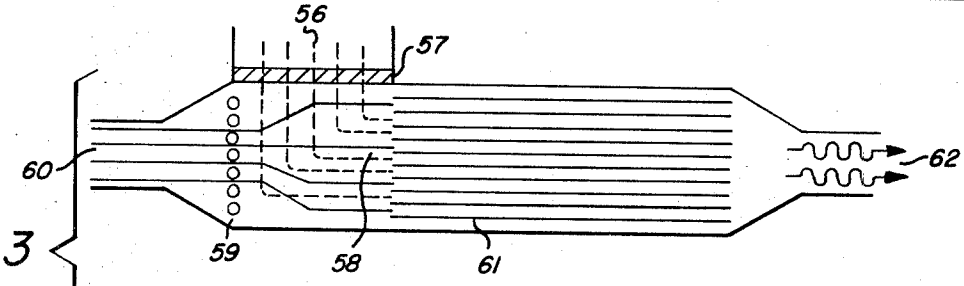


FIG. 3



Cool fluid
Heated fluid
Microwave energy

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MICROWAVE PLATFORM SYSTEM

This invention relates to systems for the reception of radiant electromagnetic energy and more particularly to systems in which a plurality of receiving means are employed from which received energy is combined and converted into thermal energy.

Directional radio reception systems require high gain antennas and adequately broad acceptance beam width to receive radio frequency power uninterrupted by relative motion of the receiving antenna with respect to the transmitting antenna. Where size, weight, fabrication and other considerations dictate the use of a multiple antenna array, the acceptance beam of the array can be as narrow as if a larger antenna, having approximately the total area of the total array were substituted. In addition, adding the output of each antenna of the array, subjects the transmission lines following the vector addition circuits to the total peak and average power received. Further, unless careful phasing of the output of received energy from each unit antenna is employed, the antenna outputs will cancel to some extent, and to the extent that cancellation takes place, power is lost through reflection.

If the receiving system is supported above the earth through the use of radio power transmitted to it, it is essential that minor variations in position and attitude have as little effect as possible on the reception of radio power. With electrical vector addition as described above, either a single antenna or array normally has a narrow width of the acceptance beam, and hence a small motion or tilt results in a loss of power and thus a reduction in the load, which may be supported by the vehicle.

In accordance with the invention, electrical energy is guided along multiple paths, which paths are then terminated such that the electrical energy is converted into thermal energy. The thermal energy thus produced may be utilized or converted into another energy form and utilized without regard to the relative phases of the electrical parameters of the electrical energy terminated.

Accordingly, it is a principal object of the present invention to increase the acceptance beam width of a multiple antenna array without causing cancellation or reflection of energy received by each unit antenna.

It is a further object of this invention to eliminate the requirement for phasing devices at the output of receiving antennas and nevertheless suffer substantially no loss of received power by cancellation.

It is also an object of this invention to reduce power losses in the transmission lines between the receiving antennas and power conversion or utilization device resulting in a cooler transmission line, lower resistivity, and thus incur further power savings.

It is a further object of this invention to reduce breakdown voltage and minimize arcover in transmission lines such that no transmission line is subjected to the total peak received power.

This invention is unique in that it combines all of the above advantages.

As the invention is described in detail, further uses and embodiments shall become apparent wherein:

FIG. 1 shows a functional flow diagram of a microwave conversion system embodying the invention;

FIG. 2 shows a pictorial diagram of a microwave powered rotary wing supported platform hovering above a microwave transmitter; and

FIG. 3 shows a longitudinal sectional view of a microwave-to-thermal energy converter and heat exchanger.

Referring now to FIG. 2, microwave power is generated by microwave power source 1 and emitted into space 3 from antenna 2. A portion of the power transmitted by 1 and 2 together is collected by antenna cluster 4. A portion of the received power is converted to mechanical energy and utilized to compress ambient air and eject the compressed air through pressure jets at the rotor tips. One pressure jet 5 is shown at the edge of rotor tip 6, A similar jet is on the reverse edge of rotor blade 7. The lift supplied by the revolving rotor blades sustains the entire device 8. Another portion of the power received by antenna cluster 4 is vectorially added or coupled from a single antenna, such as 9 in cluster 4, and retransmitted by antenna 10.

Referring next to FIG. 1, a functional flow diagram of device 8 in FIG. 2, microwave power is collected by antennas 11, 12, 13, and 14, and conducted by waveguides 15, 16, 17, and 18, respectively, to microwave-to-thermal energy converters and heat exchangers 19, 20, 21, and 22, respectively. It is understood that any or all of antennas 11, 12, 13, and 14 may be replaced by phased arrays comprising unit antennas having a designed mutual phase relationship. Antennas 11, 12, 13, and 14 may be clustered to receive power from substantially one source or be oriented individually or in groups to receive power from more than one microwave transmitter, such as transmitter 1 and antenna 2 of FIG. 2. In thermal energy converters and heat exchangers 19, 20, 21, and 22, microwave power is converted to thermal energy and this thermal energy is transferred to a working fluid 23, such as air, nitrogen, helium or argon. Working fluid 23 may be chosen to suit the purpose intended and conditions encountered. The heated fluid 23 flows from the thermal energy converters and heat exchangers 19, 20, 21 and 22 into conduit 24 in which the thermal energy in the heated fluid is summed by virtue of the heated fluid from each sharing the same conduit 24 with the heated fluid from the other thermal energy converters and heat exchangers. The heated fluid then flows through valve 25 into turbine 26. The action of the heated fluid in turbine 26 imparts torque to shafts 27 and 28. The expanded and somewhat cooled fluid leaves turbine 26 through conduit 29 and enters regenerator 30. Regenerator 30 is a heat exchanger with the hottest fluid entering from conduit 29. Regenerator 30 supplies the heat which was not completely utilized by turbine 26 to heat the cooled fluid from compressor 34. From regenerator 30 the fluid enters waste heat exchanger 32 through conduit 31. Waste exchanger 32 is used in situations where additional power is needed to operate other subsystems in the platform system. In waste heat exchanger 32, heat is further lost which heat may be used for purposes in subsystems or systems to which the entire receiving station FIG. 1 supplies power. The cooled fluid then enters compressor 34 through conduit 33. The compressor is powered by means of shaft 28, which, in turn, is driven by turbine 26. The compressed fluid leaves compressor 34 through conduit 35 and reenters regenerator 30 in which the fluid absorbs some of the heat remaining in fluid leaving turbine 26. The compressed preheated fluid leaves regenerator 30 through conduit 36 to reenter microwave-to-thermal energy converters and heat exchangers 19, 20, 21, and 22 to repeat the cycle.

The torque available at shaft 27 of turbine 26 operates compressor 41. This compressor accepts ambient air at conduit 42 and forces the compressed air through conduit 43, rotary joint 44 and rotor blades 45 and 46 and finally rotor tip jets 47 and 48. The velocity and mass of air ejected from the rotor tip jets 47 and 48 impart rotary motion to the rotor blades 45 and 46, so that lift is achieved for retransmission of a portion of the total received energy, that part of the received energy is diverted from wave guides 15, 16, 17, and 18, respectively, and shifted in phase by phase shift devices 49, 50, 51, and 52, such that there is vector addition of the output of phase shift devices 49, 50, 51, and 52 in waveguide 53. This vectorially added energy is emitted by antenna 54. Antenna 54 is used as a means for reradiating a portion of the incoming microwave energy from antenna 2 and thus could provide data link over-the-horizon communications between two ground stations. When the energy to be retransmitted differs with respect to phase, frequency, or both, from that energy to be converted to thermal energy, phase shift devices 49, 50, 51, and 52 may be made frequency and/or polarization sensitive to accept only that energy which it is desired to retransmit. Thus, the retransmitted energy may carry any type of information independent of the microwave energy converted to thermal energy for aerodynamic support of the entire system.

FIG. 1 also shows a standby heat source in the form of combustion engine 55 with fuel and oxidizer input 37 and exhaust 38. Combustion engine 36 is coupled to heat exchanger 39 wherein thermal energy generated by combustion engine 55 is transferred to the working fluid 23. The control of whether the working fluid 23 will flow through microwave-to-thermal energy converters and heat exchangers 19, 20, 21, and 22 or through heat exchanger 55 is exercised by valves 25 and 40. Other valve arrangements for more precise control of the working fluid may be readily envisioned, such as controlling each microwave-to-thermal energy converter and heat exchanger separately by means of valves to control the rate of fluid flow through each heat exchange device. Control means may be inserted in the electrical circuits of antennas 11, 12, 13, and 14, to control their outputs to and through waveguides 15, 16, 17, and 18 respectively, singly, or in groups. The standby heat source combustion engine 55 is shown by way of example only. This element may be replaced wholly or in part by any other heat source or sources, such as solar energy collectors or radioactive decay devices, these suggestions not being by way of limitation.

FIG. 3 shows a longitudinal cross section of a microwave-to-thermal energy converter and heat exchanger such as part 19, 20, 21, or 22 of FIG. 1. Microwave energy from an antenna or group of antennas enters waveguide input 56, penetrates dielectric window 57 and enters chamber 58. Metallic screen 59 prevents microwave energy from escaping through fluid input 60. Fluid entering chamber 58 through fluid input 60 and metallic screen 59 enters with the microwave energy an area containing microwave absorbing strips 61 which are simultaneously heat exchanger elements. As microwave energy is dissipated on the surface of microwave absorbing strips 61, the fluid in passing absorbs the resultant heat directly from the strips. The heated fluid then leaves through output 62. Output 62 may be varied in size and shape to include the characteristics of a plenum chamber should fluid flow considerations so require.

In constructing a system embodying the invention disclosed herein, it must be realized that the frequency and power of the output from transmitter 1 of FIG. 2, the dimensions of the transmitting reflector 2, the dimensions of each of the receiving members in antenna cluster 4, and the distance between antenna means 2 and 4 are all functionally interrelated. Any one of an infinite variety of combinations may be chosen by persons skilled in the art.

For example, a system weighting in the order of 4 tons embodying the invention disclosed herein utilizes equipments with the following characteristics: transmitter 1, frequency 5850 mc.; output power 12,000 kilowatts; antenna reflector 2, diameter 300 feet; antenna cluster 4 comprising four independent receiving antennas 11, 12, 13, and 14, each of the independent antenna diameters, 13 feet; altitude, 65,000 feet; to provide a system with an overall energy conversion efficiency of 13 percent.

The calculations upon which these figures rest are described in Brown, W. C., "A Survey of the Elements of Power Transmission by Microwave Beam," Transactions of the International IRE Convention, P.G.E.D., Mar., 1961. The portions of that article relating to the focusing microwave power are drawn from Jenkins and White, "Fundamentals of Optics," McGraw Hill, Second Edition (1950) pp. 279—288.

This invention is not limited to the particular details of construction, materials and processes described as many equivalents will suggest themselves to those skilled in the art. Accordingly, it is desired that this invention not be limited to the particular details of the embodiments disclosed except as defined by the appended claims.

I claim:

1. An energy summing system, comprising:
a plurality of means for guiding microwave energy;
means for terminating said guiding means;
means in each of said terminations to convert said microwave energy into thermal energy; and
means for summing said thermal energy.

2. A system for receiving radiant electromagnetic energy comprising:
a plurality of means for collecting electromagnetic energy;
means for conducting said electromagnetic energy from each collection means to separate means for terminating each of said conduction means;
means in each of said terminations to convert said electromagnetic energy into thermal energy; and
means for summing the thermal energy thus produced.

3. A system for receiving electromagnetic energy comprising:
a plurality of means for collecting electromagnetic energy;
means for conducting said electromagnetic energy from each collection means to separate means for terminating each of said conduction means;
means in each of said termination to convert said electromagnetic energy into thermal energy;
means for summing the thermal energy thus produced; and
means for converting said thermal energy into mechanical energy.

4. A system for receiving electromagnetic energy comprising:
a plurality of means for collecting electromagnetic energy;
means for conducting said electromagnetic energy from each collection means to separate means for terminating each of said conduction means;
means in each of said terminations to convert said electromagnetic energy into thermal energy;
means for summing the thermal energy thus produced;
means for converting said thermal energy into mechanical energy; and
means powered by said mechanical energy to support at least a part of said electromagnetic energy receiving system against the force of gravity.

5. A system for receiving electromagnetic energy comprising:
a plurality of means for collecting electromagnetic energy;
means for conducting said electromagnetic energy from each collection means to separate means for terminating each of said conduction means;
means in each of said terminations to convert said electromagnetic energy into thermal energy;
means for summing the thermal energy thus produced;
means for dividing a portion of said received electromagnetic energy from at least one collection means;
means for producing vector addition of said diverted energy; and
means to retransmit said vectorially added energy.

6. A system for receiving electromagnetic energy comprising:
a plurality of means for collecting electromagnetic energy;
separate means for terminating each of said collecting means;
means in each of said terminations to convert said electromagnetic energy into thermal energy;
means for summing the thermal energy thus produced;
means for diverting a portion of said received electromagnetic energy from a plurality of said collection means;
means for producing vector addition of said diverted energy;
means to retransmit said vectorially added energy;
means for converting said thermal energy into mechanical energy; and
means powered by said mechanical energy to support at least a part of said electromagnetic energy receiving system against the force of gravity.

7. In combination:
multiple means for receiving microwave energy;
independent means for the energy conversion of microwave energy received at each of said multiple means; and
means for utilizing the converted microwave energy.

8. A system for receiving energy to operate a hovering platform comprising:
a plurality of antenna means;

individual energy feeding means connected to each of said antenna means;

energy conversion means connected to each of said energy feeding means; and

means for utilizing the energy converted to operate said hovering platform.

9. In combination:

a plurality of microwave directive antenna means;

individual microwave feeding means connected to each of said microwave directive antenna means; and

a separate r-f heat exchanger means connected to each of said feeding means to supply thermal energy to an aerodynamic device.

10. In combination:

means for providing microwave energy;

a plurality of receiving devices for collecting said microwave energy, said plurality of receiving devices positioned in a spaced relationship to said means for providing microwave energy;

a plurality of energy conversion devices, one of said plurality of conversion devices coupled to each one of said plurality of receiving devices; and

means for summing energy from said plurality of conversion devices, said summed energy being independent of the phase relationship of the energy collected by each of said plurality of receiving devices.