A power generating station (20) having a generator (28) driven by solar heat assisted ambient wind is disclosed. A first plurality of radially extending air passages (32) direct ambient wind to a radial flow wind turbine (34) disposed in a centrally located opening (46) in a substantially disc-shaped structure (21). A solar radiation collecting surface having black bodies (40) is disposed above the first plurality of air passages (32) and in communication with a second plurality of radial air passages (44). A cover plate (50) enclosing the second plurality of radial air passages (44) is transparent so as to permit solar radiation to effectively reach the black bodies (40). The second plurality of air passages (44) direct ambient wind and thermal updrafts generated by the black bodies (40) to an axial flow turbine (48) which also derives additional motive power from the air mass exhausted by the radial flow turbine (34). The rotating shaft (26) of the turbines (34, 48) drive the generator (28). The solar and wind driven power generating system operates in electrical cogeneration mode with a fuel powered prime mover (56). The system is particularly adapted to satisfy the power requirements of a relatively small community located in a geographic area having favorable climatic conditions for wind and solar powered power generation.

20 Claims, 7 Drawing Figures
WIND AND SOLAR POWERED TURBINE

BACKGROUND AND OBJECTS OF THE INVENTION

1. Origin of the Invention
The invention described herein was made in the performance of work under a NASA Contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 STAT 433; 43 USC 2457).

2. Field of the Invention
The present invention is directed to the field of solar and wind energy harnessing devices. More particularly, the present invention is directed to a combination wind and solar energy harnessing device which is particularly adapted for supplying power needs of relatively small communities in remote locations.

3. Brief Description of the Prior Art
Solar collectors adapted for absorbing the radiant energy of solar rays have been known in the art for a long time. Some solar collectors of the prior art use parabolic or like mirrors to concentrate the radiant energy of the sun for the purpose of generating hot water or steam for space heating or electrical power generating applications. Another class of solar collectors utilizes a black body for absorbing the radiant energy of solar rays and to convert said energy to a useable form of thermal energy.

Windmills, wind driven turbines and the like have also been known for a long time. Mankind's awareness of the ability of the ambient wind to provide useful energy in the form of rotary shaft power is exemplified in the ancient art of constructing windmills to drive various (usually primitive) forms of machinery. Principally during the twentieth century, and particularly recently, developments in the fields of aerodynamics and other engineering problems, such as continuously changing torque as the angle of attack of the rotating blades continuously changes relative to the wind, have recently been overcome by highly sophisticated blade design engineering, and by constructing sufficiently large turbines so that the windstream does not emit through to the leeward blade.

For further information relating to wind turbines and the like, reference is made to U.S. Pat. Nos. 2,431,111; 4,134,707; 4,164,382; 2,911,541; 3,902,072; 4,079,264; 4,018,543; and 3,743,848. U.S. Pat. No. 3,743,848 is of particular interest to the present invention because it describes a wind driven power generating apparatus coupled to an auxiliary engine to supplement the power produced by the wind.

In addition to the above-noted separate wind and solar energy harnessing devices, the prior art has also suggested devices wherein thermally-induced updrafts or thermal air currents are harnessed by a wind turbine. In other words, in certain prior art devices, heat developed by absorption of solar radiation is utilized either to create a thermal updraft, or to accelerate the flow of ambient wind which is harnessed by a wind turbine. Such devices are described in U.S. Pat. Nos. 4,224,528; 4,275,309; 3,936,652; 3,979,597; 4,118,636; 4,002,032; and 4,122,675.

However, in spite of the relative abundance of disclosures in the patent literature relating to solar heated or solar assisted wind turbine driven power generating devices, practical utilization of such devices is not widespread. This is perhaps principally due to the fact that the specific structures utilized by the prior art are not well adapted or engineered for efficient power generation at an acceptable cost. Nevertheless, the prior art correctly recognized the potential for power generation by simultaneous harnessing of solar radiation and ambient wind.

In light of the foregoing, a need exists in the prior art for a power generating station which efficiently utilizes ambient solar and wind energy for electrical power generation. There is particularly a need in the art for a solar and wind driven power generating station, which, in conjunction with an auxiliary fossil fuel burning engine, is adapted for economically supplying the power needs of a relatively small community, particularly in remote regions where conventional electrical power is unavailable.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a power generating station which is efficiently driven by ambient wind and solar heat.

It is another object of the present invention to provide a solar heat and ambient wind driven power generating station which is relatively economical to construct and operate.

It is still another object of the present invention to provide a relatively economically ambient wind and solar heat driven power generating station, which is capable of relatively economically supplying the power needs of small communities, particularly in remote regions.

These and other objects and advantages are attained by a power generating station which has a first plurality of radially extending air passages directing ambient wind to a radial flow wind turbine. A solar radiation collecting surface is disposed above the first plurality of air passages. Ambient wind, after having passed
through the radial flow turbine, is directed to an axial flow turbine.

A second plurality of radially extending air passages is disposed above the solar radiation collecting surface. The second plurality of air passages directs the ambient wind to the axial flow turbine. At least a top member of the structure defining the second plurality of air passages is transparent to short wave components of solar radiation so that the collecting surface is exposed to solar rays. The collecting surface heats the mass of ambient air as it passes over the collecting surface, thereby increasing its velocity, and ultimately imparting additional motive power to the axial flow turbine. In a like manner, thermal updrafts generated by the collecting surface impart their motive power to the axial flow turbine. The axial and radial flow turbines drive an electrical generator.

The solar and wind driven turbines are preferably used in association with a fossil fuel burning prime mover, such as a diesel engine. The prime mover, through a sensing device, is supplied with fuel to the extent necessary to supplement the power output of the turbines to adequately provide for the momentarily existing power requirements despite fluctuations in the requirements, the velocity of ambient wind and the intensity of solar radiation.

The features of the present invention can be best understood, together with further objects and advantages, by reference to the following description, taken in connection with the accompanying drawings wherein like numerals indicate like parts.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a schematic perspective view of the solar and ambient wind driven power generating station of the present invention, with portions of a transparent cover plate being broken away;

FIG. 2 is a schematic, partial side view of the power generating station;

FIG. 3 is a highly schematic top view of the power generating station;

FIG. 4 is a highly schematic cross-sectional view, the cross-section being taken on a substantially vertical plane;

FIG. 5 is a schematic enlarged view taken from FIG. 4;

FIG. 6 is another schematic enlarged view taken from FIG. 4, and

FIG. 7 is a highly schematic view showing the wind and solar driven power generating station coupled to a diesel engine for supplementing the usually fluctuating power output of the turbines of the station.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

The following specification, taken in connection with the drawings, sets forth the preferred embodiment of the present invention in such a manner that any person skilled in the solar energy collecting devices and turbine designing arts can use the invention. The embodiment of the invention disclosed herein is the best mode contemplated by the inventors for carrying out their invention in a commercial environment, although it should be understood that various modifications can be accomplished within the parameters of the present invention.

Referring now to the drawing figures, and particularly to FIGS. 1 and 4, the preferred embodiment of the solar and wind powered generating station is disclosed.
The air from which the principal amount of kinetic energy has been extracted by the radial flow turbine 34, is channeled in an upwardly direction in the central opening 46 from the radial flow turbine 34 towards the axial flow turbine 48.

The axial flow turbine 48 is driven principally by ambient wind which is directed to it by the second plurality of slightly upwardly inclined air passages 44. It should be noted in this regard, that the axial flow turbine 48, as incorporated in the present invention, is also substantially insensitive to ambient wind direction. When there is ambient sunshine the air mass moving in the second plurality of air passages 44 is further accelerated because it is directly heated by incident solar rays and by the underlying black body 40. Under relatively windless but sunny conditions, the black body is in and of itself capable of generating thermal updrafts which drive the axial flow turbine 48. The axial flow turbine 48 also extracts further energy from the air mass that had passed through the radial flow turbine 34.

The axial flow turbine 48 may be of the propeller or air screw type construction which is well established in the art. Alternatively, and pursuant to relatively recent development in the art, the axial flow turbine 48 may be of the "Sweeney windmill" or "Princeton sail" type. As is known in the art, the terms "Sweeney windmill" or "Princeton sail" refer to modern double membrane, adjustable blade type windmill construction which offers thickness and camber at a relatively light weight and has a favorable lift to drag ratio.

In order to further permit relatively light weight construction of the turbines 34 and 48, the turbines ride in guard rails 52 or suitable roller bearings 54, as is shown on the enlarged views of FIGS. 5 and 6. FIG. 5 shows the guard rail construction for the radial flow turbine 34, and FIG. 6 show the guard rail construction for the axial flow turbine 48. As it will be readily appreciated by those skilled in the art, the guard rails 52 absorb some of the centrifugal and bending forces which are generated in the rapidly turning turbines, and therefore permit less heavy and more efficient blade construction.

Referring now again principally to FIG. 4, the rotating common shaft 26 of the radial flow and axial flow turbines 34 and 48 is shown to be connected to the electrical generator 28 through a gearbox 56. The gearbox 56 accomplishes a fixed ratio speed reduction or speed increase, which may be necessary, depending on the actual turbine design, in order to efficiently drive the generator 28.

In order to prevent the axial flow turbine 48 from becoming a fan producing considerable drag when there is no significant solar generated contribution to the air flow in the second plurality of air passages 44, in the herein-described preferred embodiment, the turbine design is such that at any given ambient wind velocity the axial flow turbine 48 is driven as fast or faster than the radial flow turbine 34.

In alternative embodiments, a clutch assembly (not shown) may be incorporated between the respective shafts of the two turbines 34 and 48. Generally speaking, various types of clutch and mechanical power transmission assemblies are possible, and may become desirable in various embodiments of the present invention. For example, a clutch mechanism may be used to...
connect the rotating shaft of the axial flow turbine 48 with the rotating shaft of the radial flow turbine 34 only when the rotation of the axial flow turbine 34 reaches a predetermined minimum velocity.

Referring now to FIG. 7, cogeneration of electric power by the solar and wind-driven power generating station and a fossil fuel powered prime mover is shown schematically. As it was noted above, the power generating station 20 of the present invention is adapted, in combination with an auxiliary fossil fuel powered prime mover, such as a diesel engine 56, to provide the electrical power requirements of a community in a remote location. To accomplish this purpose, in view of the well-known variations in weather, total reliance cannot be had on wind and solar power alone. This is usually true even in geographical areas where, on a time average basis, combined wind and solar power harnessed by the generating station of the present invention is sufficient to provide sufficiently all the electrical power requirements.

Therefore, as is shown in FIG. 7, a speed sensor 58, or preferably a speed and electrical load sensor is operationally connected to the generator 28. The sensor 58 senses the electric output of the generator 28 and compares it to the load requirement to generate a signal which is proportional to the momentary deficiency of the output of the solar and wind-driven generator 28. The signal is then utilized to control the speed or fuel supply control 60 of the diesel engine 56. The diesel engine 56 drives a second generator 62, and is utilized only to the extent necessary to make up for the deficiency of the power output of the first generator 28 in light of momentary wind and solar fluctuations and electrical power requirements. Alternatively, the diesel engine 56 may be supplied with sufficient fuel so that a combined power output of the two generators 28 and 62 is always maintained at a minimum predetermined level.

Regarding the amount of energy which may be derived from the solar and wind-powered power generating station of the present invention, the following is noted. The generating station is designed to be quite large, for example, to have a surface area exposed to solar radiation in the one-acre to four-acre range. Stated in another way, the radius of the disc-shaped structure may vary approximately in the 35-foot to 80-foot range, although still larger structures are also contemplated within the scope of the present invention. In a structure of typical size constructed in accordance with the present invention, the air passages 32 wherein the second air passage means for collecting radiant solar energy in the form of thermal energy with the second air passage means, thereby heating said air moving in the second plurality of air passage means, include an axial flow turbine.

The invention provides for the axial flow turbine 48 and the radial flow turbine 34. The present invention provides approximately 6.6 hp useful electrical energy output.

Considering an effective "air tunnel" of the same size for the axial flow turbine 48 as for the radial flow turbine 34, the same wind velocity, a conservative forty (40) percent efficiency of the axial flow turbine 48, an eighty (80) percent efficiency of mechanical to electrical power conversion, and an 18.6 percent increase in air mass velocity due to solar heating of an approximately one-acre solar rays collecting surface, the axial flow turbine 48 is calculated to contribute approximately 6.2 hp of useful electrical energy. The calculations leading to this result postulate a very realistic 1325 Btu/ft² per day (thirteen hundred and twenty-five British thermal unit per square foot per day) solar radiation, which is supported by relevant weather bureau statistics.

Thus the total average power output of the solar and wind-driven power generating station of the present invention, having an approximate one-acre solar ray absorbing surface, is approximately 12.8 Hp. This is in the absence of cogeneration with a fossil fuel powered prime mover. The above-summarized calculations indicate that the power generating system of the present invention is a highly valuable power source.

Several modifications of the power generating system of the present invention may become apparent to those skilled in the art in light of the above disclosure. Therefore the scope of the present invention should be interpreted solely from the following claims when read in light of the teaching of the specification in view of the prior art.

What is claimed is:

1. A combination wind and solar powered generating station to produce energy comprising:

   a. a first plurality of radial air passage means adapted for receiving ambient wind, for providing a first source of air and for directing said air to a first predetermined location;

   b. a second plurality of radial air passage means also adapted for receiving ambient wind for providing a second source of air and for directing said air to a second predetermined location;

   c. means for collecting radiant solar energy in the form of thermal energy with the second air passage means, thereby heating said air moving in the second plurality of air passage means;

   d. first power means communicating with the first predetermined location for extracting energy from the first source of air, and

   e. second power means communicating with the second predetermined location for extracting energy from the second source of air and one for extracting further energy from the first source of air.

2. The invention of claim 1 wherein the first power means include a radial flow turbine.

3. The invention of claim 2 wherein the second power means include an axial flow turbine.

4. The invention of claim 3 further including a generator operatively connected to both turbines.

5. The invention of claim 1 further including an auxiliary power source operatively interconnected with the first and second power means for supplementing the cumulative energy output of the first and second power means and for maintaining a minimum level of generated power output independently of variations in the
cumulative energy output of the first and second power means.

6. The invention of claim 1 wherein the first plurality of air passage means comprise a first plurality of air ducts extending radially outwardly from a central first predetermined location.

7. The invention of claim 6 wherein the second air passage means include a second plurality of air ducts extending radially outwardly from a central second predetermined location.

8. The invention of claim 7 wherein the means for collecting radiant solar energy are positioned between the first and second plurality of air ducts and the second plurality of air ducts are relatively transmissive to the incident solar radiation to expose said means for collecting said solar radiation, and wherein said means for collecting are adapted for generating thermal air currents, thereby directing further air to the second predetermined location.

9. An improved combination wind and solar powered power generating station comprising:

a first series of radial air passages disposed approximately horizontally for directing ambient wind to a first predetermined position;

a second series of radial air passages positioned above the first series of air passages for directing ambient wind to a second predetermined position;

collecting means for solar energy positioned between the first and second series of radial air passages and communicating with the second series for providing thermal air currents to the second predetermined position;

first power means communicating with the first predetermined position and extracting energy from the ambient wind directed to the first predetermined position, said first power means directing exhausted ambient wind to the second predetermined position;

second power means communicating with the second predetermined position for extracting energy from the ambient wind directed to the second predetermined position, for extracting energy from said thermal air currents, and from the exhausted ambient wind directed to the second predetermined position by the second power means.

10. The invention of claim 9 wherein the first predetermined position is a first upwardly directed opening located substantially centrally relative to the first series of radial air passages, and the first power means comprise a radial flow turbine disposed in the first opening, and wherein the second predetermined position is a second upwardly directed opening located substantially centrally relative to the second series of radial air passages and substantially concentrically with the first opening and the second power means comprise an axial flow turbine disposed in the second opening.

11. The invention of claim 10 wherein the radial flow turbine and the axial flow turbine are concentrically mounted on a rotatable shaft, and wherein the first and second power means further comprise a generator connected to and driven by said shaft.

12. The invention of claim 10 further comprising a wall separating the first and second series of radial air passages from one another, wherein the collecting means are disposed over said separating wall and comprise a black body adapted for relatively efficiently absorbing solar radiation, and wherein the second series of radial air passages are sufficiently transparent for permitting solar radiation to effectively reach said collecting means.

13. The invention of claim 12 wherein the first and second series of radial air passages comprise a structure of substantially circular horizontal cross-section, and wherein the radius of the structure is approximately between 35 to 80 feet.

14. An improved wind and solar powered power generating station comprising:

a substantially horizontally disposed substantially disc-shaped structure including a lower compartment and an upper compartment, and a black body disposed between the lower compartment and the upper compartment;

a first plurality of air passages located in the lower compartment of the structure and extending radially in the disc-shaped structure, said first plurality of air passages being open at the edge of the disc-shaped structure to communicate with the ambient wind and also being open substantially in the center of the structure to communicate with an upwardly directed central opening therein;

a second plurality of air passages located in the upper compartment of the structure and extending radially in the disc-shaped structure, said second plurality of air passages being open at the edge of the disc-shaped structure to communicate with the ambient wind, and also being open substantially in the center of the structure to communicate with the upwardly directed central opening therein;

an upper enclosing member of the structure comprising the top cover for the second plurality of air passages, said top cover being of a material substantially transparent to short wave components of solar radiation and permitting said short wave components to substantially reach the black body;

a radial flow turbine operatively disposed in the central opening substantially adjacent to the first plurality of air passages;

an axial flow turbine operatively disposed in the central opening relative to the second plurality of air passages, whereby ambient wind is directed to drive the radial flow turbine by the first plurality of air passages, ambient wind is directed to drive the axial flow turbine by the second plurality of air passages, whereby ambient wind having passed through the radial flow turbine assists in driving the axial flow turbine, and whereby heat generated in the black body as a result of absorption of solar radiation assists in the flow of ambient wind through the second plurality of air passages to drive the axial flow turbine.

15. The invention of claim 14 wherein the radial flow turbine and the axial flow turbine are mounted on a single rotating shaft, said shaft being interconnected with a generator for producing electric power.

16. The invention of claim 14 wherein the black body comprises a multitude of used rubber tires.

17. The invention of claim 14 wherein the black body comprises a black body adapted for relatively efficiently absorbing solar radiation, and wherein the second series of radial air passages are sufficiently transparent for permitting solar radiation to effectively reach said collecting means.

18. The invention of claim 17 further comprising an auxiliary fossil fuel powered prime mover operatively connected with a second generator to drive the same, and a sensing and regulating means for sensing the electric power output of the first generator and for regulating the output of the prime mover to generate sufficient
power in said second generator to maintain a predetermined minimum combined output of power of the first and second generators regardless of variations of the power output of the first generator.

19. The invention of claim 18 wherein the prime mover is a diesel engine.

20. The invention of claim 18 wherein the radial flow turbine and the axial flow turbine are mounted on a single rotating shaft which is operatively connected to the first generator.

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