tunnel diodes the degree of non-linearity of tunnel diodes can be different from that of classical diodes. It can be shown using a similar method of analysis to that given in the above listed paper in the Physical Review by J. C. Yater that the efficiency of rectification is increased using tunnel diodes as the heated diodes **9** when the non-linearity is less than that for classical diodes and as the cooled diodes **12** and **24** when the non-linearity is larger than that of the classical diodes.

As hereinbefore noted, the efficiency of conversion is improved by eliminating or minimizing the power losses from electron cooling, radiation cooling and lead losses. These losses are minimized since there is no electron flow from the hotter layer **1** to the cooler layer **3** of FIGS. **1***a* and **2**, since the thermal barrier **2** can be a vacuum with negligible radiation losses, and since there are no electrical leads from the hot layer **1** to the cooler layer **3** of FIGS. **1***a* and **2**. The inherent higher efficiency of the invention provides an increase of several hundred percent in the efficiency of power conversion over existing thermionic converters, solar cells, or thermoelectric power generators. Since the theoretical efficiency using the classical Schottky barrier diodes for the rectifying diodes **12** and **24** is given by the Carnot cycle efficiency, the thermal cycles are reversible cycles so that the device also operates in a heat pump or refrigeration mode by using an input power to reverse the direct current flow. The circuits of this invention can be made extremely small by current state-of-the-art technology. (See prior references). The mean free path of an electron in a resistive material is as low as 10^{-6} cm with the result that conductors can be placed less than every 10^{-5} on a heated resistive film without resulting in any significant correlation between the fluctuations of individual circuits. Accordingly, as the elemental circuit size is reduced to the order of the electron mean free path the production of kilowatts of power output per square centimeter of surface area of layer is obtained.

The effect of the statistics of fluctuation effects on the thermally caused electrical fluctuations across a single resistor is that the output power is independent of the physical size or the number of conducting electrons in the resistor. This power is shown by C. J. Bakker and G. Heller in the March 1939 issue of Physica (pp. 262–274) to be approximately kT/t, with *k* being the Boltzmann constant, T being the absolute temperature, and *t* being the mean time between collisions for an electron. The effective mean time *t* to give the fluctuation power in a metal resistor is computed in this paper and the result shows an effective electron velocity of 10^8 cm/sec and an effective mean free-path length of 10^{-6} cm so that the effective mean time *t* is of the order of 10^{-14} sec for electrons at room temperature. For this value for *t* and for $T = 700°$ K the fluctuation power available is of the order of 10^{-6}W. Conductors placed every 10^{-5} cm on an extended heated resistive film result in an available power output of 10^8W of available fluctuation energy per square meter of a resistive film at a temperature of 700° K when these are used as the resistor **26** in FIG. **4**. The thickness of layers **1** and **3** is comparable to the spacing of modules **7** and **8** in the plane of layers **1** and **3**. For cubical modules of this size, the potential power output per cubic centimeter of modules is 10^9W.

The potential barrier of the diodes **9**, **12** and **24** and the output voltage of the output power can be optimized for each temperature range so as to achieve the highest possible efficiency for each required operating temperature range. As shown in the above listed paper in the Physical Review by J. C. Yater, the non-linearity of the classical diodes are a function of both the temperature and the capacity of the diode potential barriers. This relationship enables a larger non-linearity to be obtained for the rectifying diodes **12** and **14** of module **7** as these diodes are operated at cooler temperatures. From this relationship the capacity of the diode potential barriers can be designed to achieve the highest possible efficiency for each operating temperature range. For diodes having a larger capacity than required to give the maximum efficiency for a given operating temperature range when operating in the embodiment shown in FIG. **1***a*, the embodiment shown in FIG. **2** can be used to enable the given diodes to operate at the highest possible efficiency as the temperature of the rectifying module **8** in layers **3** and **28** are lowered.

The reversible cycle resulting from the elimination or minimization of losses thus enables the same thermal cycle to be used in a power conversion mode, a heat pump mode and a refrigeration mode. The same device can be used to generate power for the home, heating for the home and air conditioning for the home. As an example, the power in a square meter of sunlight is converted efficiently by the device to 1 KW of output power. This 1 KW output power can be used as the input power to the same device operating in the efficient heat pump mode between 32° and 80° Fahrenheit. The equivalent heat of 10 KW of power can then be delivered into the higher temperature reservoir.

By using thin flexible layers **1**, **3**, **37** and **58** that can be shaped and sized so as to be used with maximum efficiency for each heat source including solar, fossil, nuclear and geothermal, the use of a radiation collection layer **42** can achieve a high efficiency when the incoming source of heat is in the form of radiation. For incoming solar radiation on layer **42**, the efficiency of the power conversion is increased to a much higher value than can be obtained from existing solar cells. The highest efficiency obtainable from existing silicon solar cell is 16% and the highest theoretical value predicted for any material is 25% for Al Sb at ambient temperatures. The value obtainable from this device is over 90% using classical diodes **12** and **24** in the rectifying modules **8**.

The efficient operation of the device can be extended to lower temperature range using the two stage temperature embodiment shown in FIG. **2** in which layers **28** and **29** are added to enable a larger temperature range to be used for each stage of the cycle. This extends the range of operating temperatures to the range where modules **8** in layer **3** and modules **8** in layer **28** are in the temperature range where the diodes of module **8** are in the super-conducting state. The extension of the operating temperature range for the thermal cycles can for some diodes increase the efficiency of the thermal cycle by a factor that is larger than the increase in efficiency for the Carnot cycle for this same extension in the operating temperature range. As hereinbefore noted, this increase in efficiency results from the dependence of the non-linearity of the rectifying diodes **9** and **24** on the diode temperature. As the diode temperature is lowered the diode non-linearity and rectification efficiency are increased. By using the two stage thermal cycle the diode rectification efficiency is increased when larger diodes are used and when the operating temperature range is low. The low operating