Apparatus for cooling a conventional oil filled electrical transformer by using a conventional refrigeration unit. The transformer liquid coolant may be either circulated through a remotely located heat exchanger cooled by an electrical refrigeration unit, or the heat exchanger may be directly located within the transformer’s housing and within its liquid coolant.
REFRIGERATION COOLED TRANSFORMER

BACKGROUND OF THE INVENTION.

[0001] 1. Field of the Invention

The invention pertains to cooling systems for liquid cooled electrical transformers.

[0002] 2. Description of the Related Art

Large electrical transformers commonly use a liquid coolant, usually oil, to dissipate the heat generated during the operation of the transformer. The cooling oil may substantially fill the transformer housing and, in most cases, convection circulation of the oil produces the cooling action. The transformer housing may include a sinuous configuration to define the surface area to increase heat dissipation to the atmosphere, and in some transformer designs, conduits vertically extending along the transformer exterior communicating with the transformer housing upper and lower regions permits the coolant to be effectively dissipated to the atmosphere. However, in some applications, particularly when electrical circuits are operating at maximum potential, the coolant may reach a temperature higher than that desired lowering the efficiency of the transformer and threatening the transformer’s operation. The need for cooling systems for electrical apparatus has been known for some time, and various solutions have been proposed as shown in U.S. Patent Nos. 3,371,298; 3,524,327; 4,394,635; 4,467,305 and 4,485,367. However, a practical and cost effective system for cooling electrical transformers, particularly under extreme conditions, has not previously been available.

OBJECTS OF THE INVENTION

[0005] It is an object of the invention to provide a cooling system for electrical transformers utilizing a liquid coolant wherein a standard refrigeration unit may be used to lower the temperature of the liquid coolant.

[0006] Another object of the invention is to provide a cooling system for liquid cooled electrical transformers wherein substantially conventional components may be utilized and relatively minor modifications to the transformer housing are required.

[0007] An additional object of the invention is to provide a cooling system for liquid cooled electrical transformers which may be rapidly transported to the location needed and refrigeration units may be quickly connected to the transformers.

SUMMARY OF THE INVENTION

[0008] The concepts of the invention may be practiced with a wide variety of liquid cooled transformers wherein a liquid coolant, such as oil, is in contact with the transformer coils wherein heat generated by the transformer operation is transferred to the oil for dissipation. Liquid cooled transformers come in a variety of configurations and coolant path systems whereby the heated coolant circulates within the transformer housing due to convection transferring heat to the housing permitting such heat to be dissipated to the atmosphere. The transformer housing may be sinuously configured to increase the surface area, and rate of heat dissipation, and/or vertically extending conduits may be exteriorly located of the housing communicating with the upper and lower housing regions through which coolant will flow under convection aiding heat transfer to the atmosphere. Also, it is known to utilize small pumps to augment the coolant movement.

[0009] In the practice of the invention, the transformer liquid coolant is exposed to the heat removing abilities of a heat exchanger receiving a refrigerant from an electrically operated refrigeration unit of conventional construction. Such a refrigeration unit would include a refrigerant compressor, a condenser dissipating the heat of the refrigerant, and an expansion coil absorbing heat. The expansion coil is located within a heat exchanger through which the transformer liquid coolant is circulated wherein the refrigerant will absorb the heat of the transformer and provide a more effective and efficient cooling of the transformer liquid coolant than is provided by coolant convection circulation and exposure to ambient temperatures. For instance, high electrical loads are experienced during hot days due to heavy air conditioner usage, and such high ambient temperatures reduce the efficiency of heat transfer between a transformer’s liquid coolants and the atmosphere. The practice of the invention permits transformer liquid coolants to be effectively cooled even under high ambient atmosphere temperatures.

[0010] The heat exchanger may either be located adjacent the refrigeration unit and the transformer liquid coolant pumped from the transformer housing through the heat exchanger, or the heat exchanger may be located within the transformer housing in contact with the liquid coolant. Both systems have advantages and disadvantages. For instance, when the heat exchanger is located exteriorly of the transformer, no significant modifications to the transformer are required. When the heat exchanger is located within the transformer housing, the transformer housing design must accommodate this added component.

[0011] As the need for the high transformer cooling capacity of the invention may only be occasional, it is contemplated that the refrigeration units may be mounted upon trucks or trailers to be quickly located at electrical substations having the greatest need for transformer cooling. By the use of quick connect couplings attached to conduits communicating with the transformer liquid coolant, it is possible to quickly connect the portable heat exchanger to the transformers by means of flexible hose, and a single refrigeration unit may be used to cool several transformers.

[0012] As the heat exchangers and refrigeration units are of conventional construction, little specialized engineering is required to use the concepts of the invention with conventional liquid cooled transformers, which may be readily retrofitted to accommodate the invention. With systems utilizing heat exchangers internally housed within transformer housings, a specially designed transformer must be employed, but the design of such transformers is readily within the scope of a transformer designer skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The aforementioned objects and advantages of the invention will be appreciated from the following description and accompanying drawings wherein:

[0014] FIG. 1 is a side elevational view of a trailer mounted refrigeration and heat exchanger unit connected to a conventional liquid cooled transformer,
FIG. 2 is a schematic view of the embodiment of the invention wherein the heat exchanger is located exteriorly of the transformer,

FIG. 3 is a schematic view of an embodiment of the invention wherein the heat exchanger is mounted within the electrical transformer, and

FIG. 4 is a schematic illustration wherein two refrigeration units are used to cool four transformers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A typical system utilizing concepts of the invention is shown in FIG. 1 wherein a large oil cooled transformer housing is shown at 10 having electrical insulators 12 extending from the upper side thereof for handling the high voltage electrical wires, not shown, connected to the transformer 10.

A wheeled trailer 14 is located adjacent the transformer 10 having been towed to this location by a conventional truck. The trailer 14 supports a refrigeration unit 16 of conventional construction including a refrigerant compressor and condenser. The refrigeration unit 16 is normally powered by an electric motor, but an internal combustion engine may be used.

A heat exchanger 18 is also mounted upon the trailer 14 and is connected by conduits 20 to the refrigeration unit 16. The heat exchanger 18 may be of a conventional design utilizing an evaporation chamber wherein evaporation of the refrigerant occurs, and the evaporation chamber, which may constitute a finned radiator of conventional construction, is located within the housing for the heat exchanger through which the transformer cooling oil will be circulated.

The heat exchanger 18 includes an outlet port 22 and an inlet port 24 for the transformer cooling oil. The transformer housing 10 includes an outlet port 26 and an inlet port 28 communicating with the transformer coolant oil. Flexible hose 30 connects outlet 22 to inlet 28, and flexible hose 32 interconnects inlet 24 with outlet 26.

The hoses 30 and 32 are connected to their respective inlets and outlets by easily operable couplings, which may be of the quick-connect type wherein the hoses may be quickly affixed to the respective inlet or outlet fitting. The heat exchanger 18 will include a coolant oil pump having an inlet in communication with the heat exchanger inlet and an outlet communicating with outlet fitting 22. Accordingly, upon operation of the refrigeration unit 16, the evaporator coil within the heat exchanger 18 will cool the transformer coolant within the heat exchanger and the cooled coolant is pumped through hose 30 into the lower regions of the transformer 10. The coolant oil located within the transformer 10 will rise due to convection as it absorbs heat and be removed from the transformer 10 through hose 32 into the heat exchanger 18 wherein the heat of the coolant oil removed from the transformer is absorbed by the refrigeration unit evaporator located within the heat exchanger. A coolant pump, not shown, is located either in the heat exchanger 18 or transformer 10. In this manner, effective cooling of the transformer 10 is achieved by using conventional refrigeration equipment having readily available components, and transformers cooled in accord with the inventive concepts may be operated on very hot days without a loss of efficiency and the danger of transformer malfunction or explosions is significantly reduced.

FIG. 2 is a schematic diagram of a system similar to that previously described wherein the refrigeration unit is illustrated at 34 and is communicating with the heat exchanger 36. The transformer 38 is connected by a conduit system 40 with the heat exchanger 36, and the conduit system includes a pump 42 and a valve 44 as well as quick-connect coupling 46. The conduit 48 constitutes the coolant return system and includes quick-connect coupling 50. If desired, quick-connect couplings may also be included in the conduit systems adjacent the inlet and outlet ports of the heat exchanger. The direction of coolant movement is indicated by the arrows.

The pump 42 and valve 44 may be incorporated into the heat exchanger, as may be the case with the embodiment shown in FIG. 1, and it will be appreciated that the operation of the system of FIG. 2 is identical to the operation of the apparatus shown in FIG. 1.

Another embodiment of the invention is shown schematically in FIG. 3 wherein a conventional refrigeration unit is shown at 52 and the transformer and its housing is represented at 54. A heat exchanger 56 is located within the transformer housing 54 in direct contact with the cooling oil within the transformer. Conduit system 58 connects the refrigerant outlet of the refrigeration unit 52 to heat exchanger 56 and includes a valve 60 and a quick-connect coupling 62. The refrigerant return from the heat exchanger is handled by conduit system 64 communicating with the outlet of the heat exchanger and the inlet of the refrigeration unit 52, and contains the quick-connect coupling 66.

In the embodiment of FIG. 3, the transformer 54 must be of a special construction wherein the heat exchanger is incorporated into the transformer housing, which is a relatively simple modification. Because the coolant within the transformer 54 is in direct contact with the heat exchanger 56, operation of the refrigeration unit 52 will cause the evaporator within the heat exchanger to absorb heat from the transformer coolant oil and cool the transformer while operating without requiring a coolant pump.

A pair of refrigeration units 76 and 78 are mounted upon a trailer or truck and the refrigeration units include heat exchangers, not shown, which may be located adjacent the compressors of the refrigeration units and both the refrigeration unit and heat exchanger may be mounted within a common housing. The cooled transformer oil leaving the refrigeration units 76 and 78 is pumped into a manifold 80 through a pair of oil pumps 82. Conduit systems 84 connect the manifold 80 to the transformers 68-74 and conduit systems 86 connect each of the transformers to the refrigeration unit inlet manifold 87. Valves 88 are located within conduit system 84 and quick-connect couplings 90 are included in both of the conduit systems 84 and 86. In this manner, a pair of portable refrigeration units/heat exchangers can be quickly set up to provide cooling for a plurality of transformers.
From the above description, it will be appreciated that effective cooling of high output electrical transformers can be effectively produced by the utilization of conventional industrial grade refrigeration units, and it is to be understood that modifications to the disclosed embodiments may be apparent to those skilled in the art without departing from the spirit and scope of the invention.

1. In combination, an electrical transformer of substantially conventional construction having a housing and a liquid coolant therein, an electrically operated refrigeration unit, and a heat exchanger cooled by said refrigeration unit in communication with the liquid coolant within said transformer housing to cool said liquid coolant.

2. In a combination as in claim 1, said heat exchanger being remotely located with respect to said transformer housing, a liquid coolant inlet defined in said housing, a liquid coolant outlet defined in said housing, a liquid coolant inlet defined in said heat exchanger, a liquid coolant outlet defined in said heat exchanger, a first conduit system interconnecting said housing inlet with said heat exchanger outlet, and a second conduit system interconnecting said housing outlet with said heat exchanger inlet.

3. In a combination as in claim 1, said heat exchanger being located within said transformer housing within said liquid coolant therein, a refrigerant inlet defined in said housing in connection with said heat exchanger, a refrigerant outlet defined in said housing in communication with said heat exchanger, a first conduit system interconnecting said refrigerant inlet with said refrigeration unit and a second conduit system interconnecting said refrigerant outlet with said refrigeration unit.

4. In a combination as in claims 2 and 3, said first and second conduit systems including quick-connect couplings adjacent said transformer housing.

5. In a combination as in claim 2, a plurality of transformers each having a housing, said first conduit system including a liquid coolant pump.