REVIEW OF VARIOUS ACTIVE COOLING SYSTEM (ACS) CONFIGURATIONS

This review is based on results of experimental works and prototyping performed at R&D Lab MP Lighting for development new concept of Active Cooling System (ACS) granted by US Patent #8070324 and Canadian Patent #2770394.

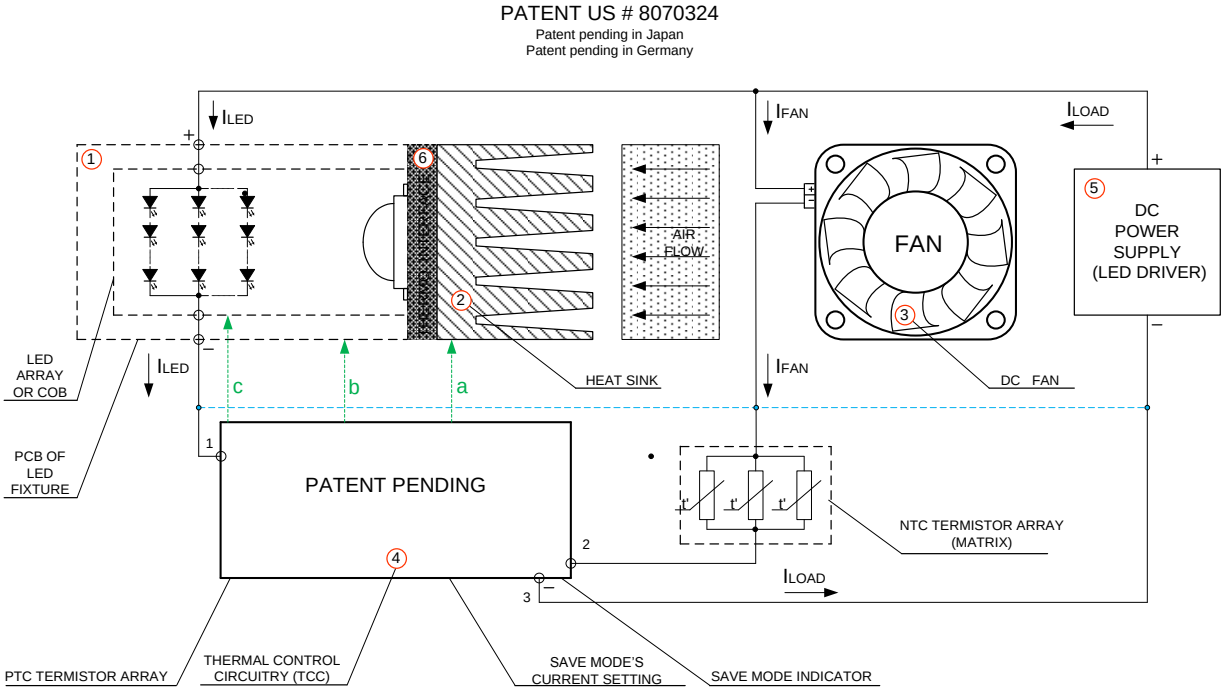

Fig. 1

The main innovation idea is using NTC thermistors not just for sensing of temperature of heat sink (like in traditional circuitry for FAN's speed control) but also for direct current control of the FAN 3 by means of connecting NTC thermistor array (matrix) directly in the power line between FAN 3 and POWER SUPPLY 5. This technical solution simplifies extremely the control loop (actually BOM consist of just one item – NTC thermistor), reduces size and weight of circuitry and increase the reliability of ACS in whole.

ACS itself consists of three main parts: heat sink 2, fan 3, and thermal control circuitry TCC 4 (see Fig 1).

The main function (as it was defined initially in patent #8070324) of the thermal control circuitry (TCC) 4 is sensing and regulating operation in the control loop between heat sink 2 and fan 3. However, the next stage of developing of ACS determined also that TCC could be used also for indicating (by miniature LED) the overheating LED fixture and switching to save mode accordingly, so that new patent application (as continued one) was done.

Moreover, in the next stages of development of ACS we could see that performance of TCC 4 ant its placement in the construction of LED fixture is the key point in practical realization and defines its technical parameters significantly. Now we can consider at least four versions of this realizations and each of them has own advantages and disadvantages in the terms of manufacturing, repairing and maintenance of the LED fixtures.

This review is dedicated to describe shortly various versions of configurations of ACS depending on ways of integration of TCC with basic parts: as PCB, or heat sink, or LED COB package even.

a) version

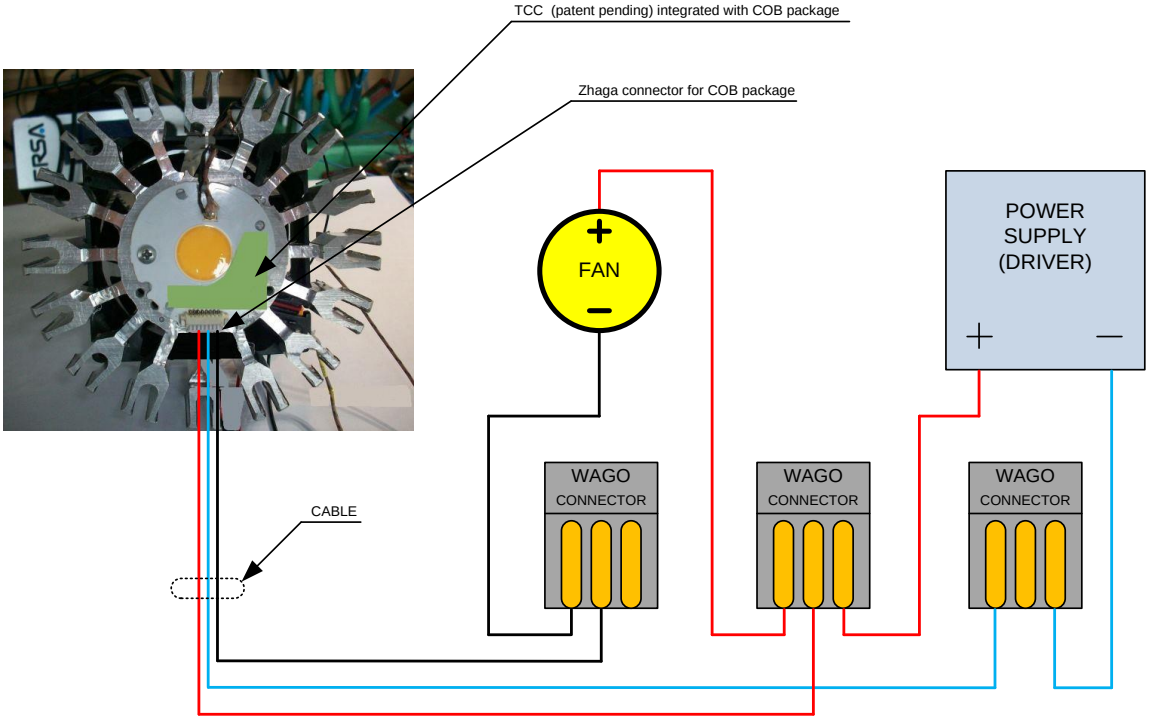

Fig.2

Version a)

In this configuration (Fig. 2) the electronic components of the thermo control circuitry (TCC) is integrated with LED COB package by soldering them on common PCB close to LED array of COB and external output of TCC is provided by Zhaga connector for LED COB. The external connections between LED light sources (LED COB), fan and power supply can be performed by means of WAGA connectors for Active Cooling System (ACS) completing.

As advantages of this configuration we can consider the follow features:

- the best of possible thermal coupling between source of heat – LED COB itself and TCC,
- high flexibility in the changing of ACS for various LED fixture: the same COB package can be used with different types fans and heat sinks just by means of external electrical connection (without de soldering/soldering) and mechanical fitting of COB package to new type of heat sink;
- relatively low volume of assembling work;

As disadvantage we can consider:

- the necessity 3 WAGO connector's usage.
- TCC belongs to LED COB and can not to be used separately as part of ACS
- relatively long time and organization efforts for integrating TCC in package with LED COB manufacturers on the cooperation base.
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This configuration could be recommended for well-established LED COB manufacturers.

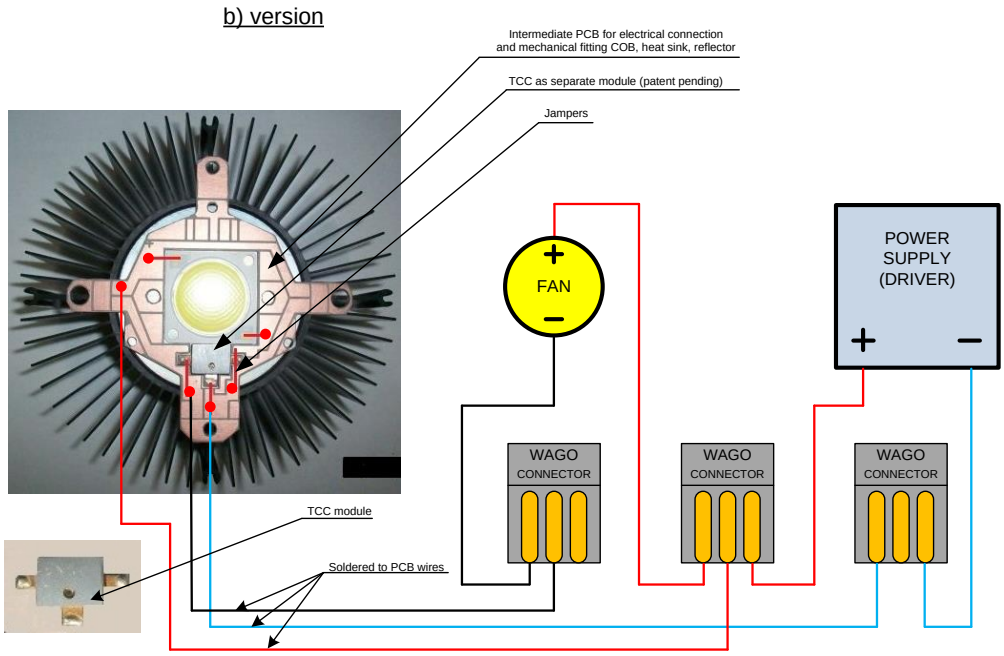

Fig.3

Version b)

TCC could be performed also as small (20 x 14 mm, for example) separate PCB in individual housing (as module or IC even in the future) and then could be placed on some intermediate PCB (Fig.3) together with LED COB package in the special nests which should be cut in accordance to their size and shape. Electrically T-shape TCC module has three terminals: left – “minus Fan”, center – “common minus”, right – “minus LED/COB/LED array”. To realise the electrical connections for this configuration of ACS we need to set at least 5 soldered jumpers (in the simplest way) on the pads of intermediate PCB: two between “+” and “-“ terminals of LED COB, and three between the terminals of TCC accordingly. Three wires should be soldered to intermediate PCB for external electrical connections (by WAGA connectors) to complete electrical diagram of ACS. In some modifications three different connectors could be set on intermediate PCB for external connections of ACS: two pins for the FAN, two pins for the POWER SUPPLY and three pins for TCC module. In another modification the electronic component of TCC could be soldered on intermediate PCB directly which reduces internal and external electrical connections (as jumpers, connectors). Mechanically, LED COB and TCC module could be fitted to the surface of the heat sink directly through the nests in the intermediate PCB accordingly.

As advantages of this configuration we can consider the follow features:

- the highest degree of functional flexibility for variations with different types if LED COB packages, heat sinks and FANs in the ACS structure;
- easy maintenance if we need to replace some main parts of ACS for LED fixture.

As disadvantage we can consider:

- relatively complicate structure (as intermediate PCB, electrical jumpers, connectors, wires, assembling works);
- the necessity to design and manufacturing individual TCC module (as T-shape, for example)

This configuration could be recommended for prototyping, manufacturing some engineering samples and early stages of volume manufacturing LED fixtures.

c) version

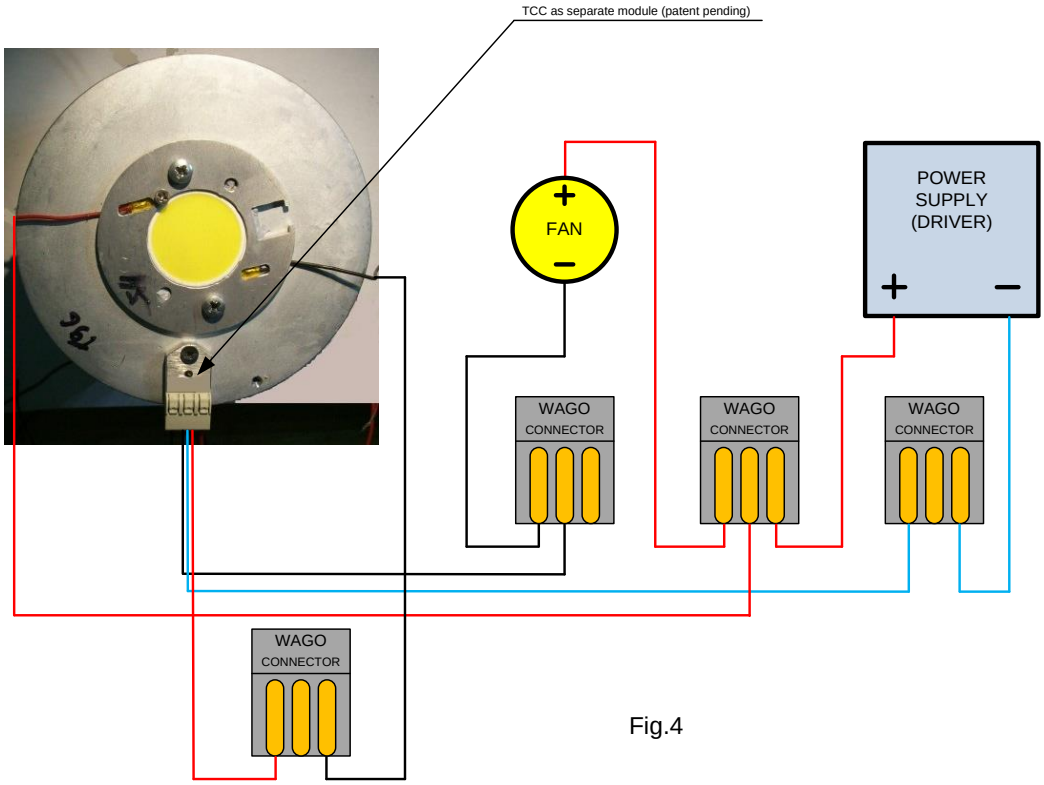

Fig.4

Version c)

In this configuration (Fig. 4) the electronic components of the thermo control circuitry (TCC) are soldered on small separate PCB (MCOB) together with 3-pin connector (TE connector, for example) and metal cover with small window for LED “ALARM” indicator. TCC module can be fitted mechanically by screw to heat sink or some another critical thermally metal element of the LED fixture.

As advantages of this configuration we can consider the follow features:

- the flexibility for choosing of placement of TCC on the heat sink and construction of LED fixture in general;
- solder less electrical connections between main parts of ACS for LED fixture which makes easy assembling work ;
- needless intermediate PCB (as version b) in the LED fixture assembly;

As disadvantage we can consider:

- relatively low grade of thermal coupling between TCC and source of heat (LED COB, for example);
- the necessity to increase amount of connectors in BOM of LED fixture
- the necessity to design and manufacturing individual TCC module with additional connector.

Another modification this version can be done to combine TCC PCB with all external 2-pins connectors of LED fixture: for COB, for FAN, for POWER SUBBLY; but it increases TCC dimensions.

d) version

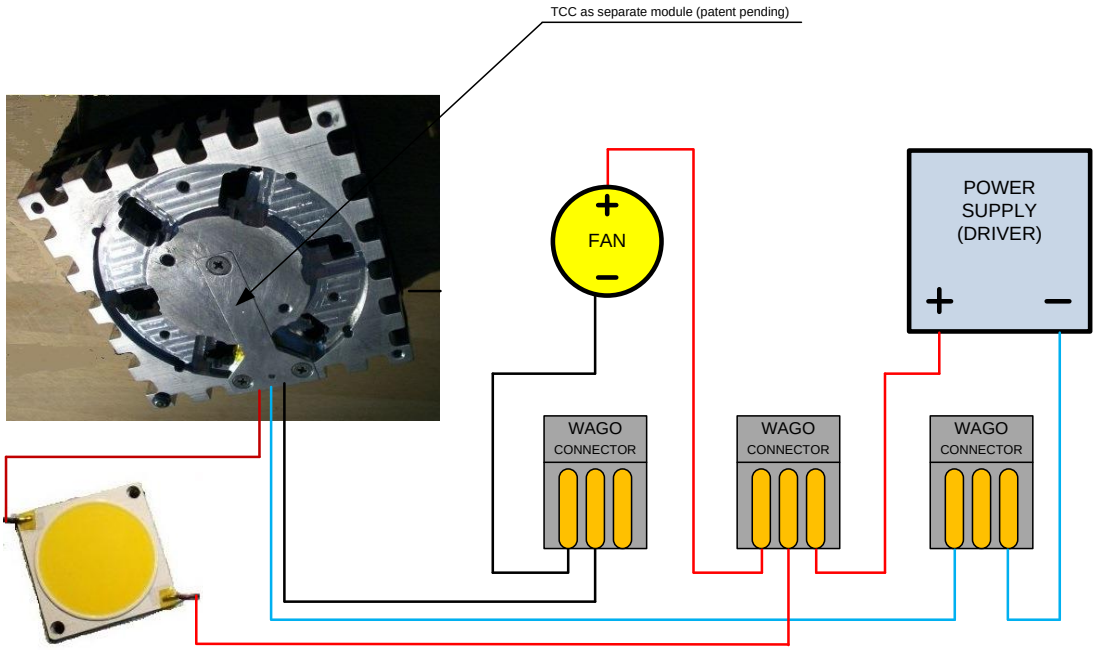

Fig.5

Version d)

TCC can be thermally coupled properly with heat source (as COB, for example) by placing into body of heat sink directly underneath LED COB package (Fig. 5). This version is presented cooling device with completed control loop (because TCC is becoming the integral part of heat sink and provides physical feedback by temperature for ACS) which can be named as Active Cooling Module (ACM). ACM can operate with various types of heat loads in the frame of specified cooling capability (power). In such a way not only LEDs but other electronic devices those heat emit, could be cooled just by fitting it's mechanically on the surface of heat sink of ACM.

As advantages of this configuration we can consider the follow features:

- the flexibility for application of ACM to different types of LED COB packages, PCB with LED array and another types electronics as thermal load;
- proper thermal contact between thermal load, TCC and heat sink ;
- needless to change configuration or electrical connection of ACM with different heat loads ;

As disadvantage we can consider:

- relatively complicated construction of heat sink;
- the necessity of additional machining of heat sink (nest for TCC PCB inside body);
- the necessity to design and manufacturing individual TCC PCB with special shape.

This configuration could be recommended for implementing as advanced product in manufacturing of cooling devices which based on combination of FAN and heat sink (FANSINK).

We can see here some pictures which are presented as illustration of operating TCC (performed in different versions) in “ALARM” mode with indicating of the overheating of LED fixtures.

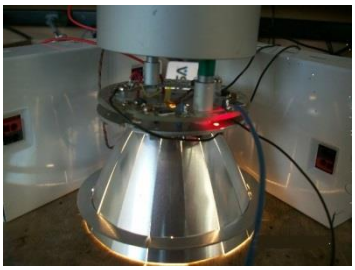

Fig.6

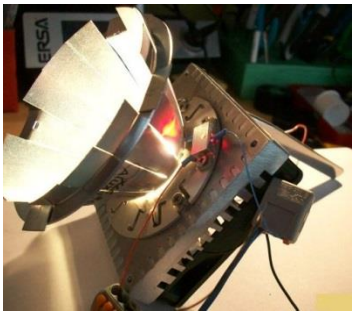

Fig.7

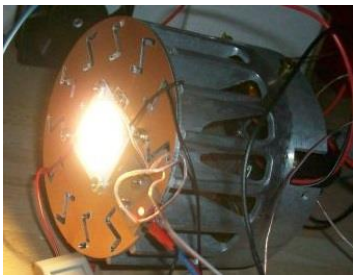

Fig.8

Fig.9

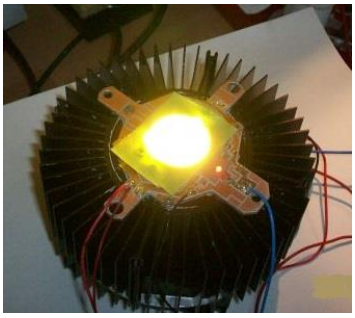

Fig.10