Response to the second report of the First Referee

The referee is not right, for the reasons given below. For clarity, I reproduce the referee's comments in quotation marks and italic font before my comments.

"The cooling process involving a finite cooling rate takes the system out of equilibrium and therefore cannot be described by equilibrium thermodynamics. As said in my report the correct way of describing the state of the system is in terms of the nonequilibrium Bogoliubov quasiparticle distribution and the variables of the superfluid. Then, it will become clear that the state of the system at the end of the cooling process (the time dependent change of the temperature of the heat reservoir) is out of equilibrium and therefore cannot be described by the thermodynamic variables as in the author's calculation. From this non-equilibrium state the superconductor will relax to equilibrium at temperature T2 within a microscopic relaxation time. "

The system is not in thermodynamic equilibrium while the temperature is changing at a finite rate. Nevertheless, its electromagnetic behavior can be described by Eqs. (26)-(29) with the London penetration depth \lambda_L(t) at time t. During the process the magnetic flux is changing, hence a Faraday field exists, hence a normal current exists. That is undeniable. And that is all I need to find that there is an inconsistency when I analyze the initial and the final states, after thermodynamic equilibrium is reached, with equilibrium thermodynamics, in Sect. VIII. The Joule heat Eq. (64) is non-zero if the cooling rate was not infinitesimally slow, that is undeniable. Note that I am considering the system in equilibrium initially at temperature T1, and again in equilibrium at temperature T2, after the cooling and after the system has relaxed to equilibrium "within a microscopic relaxation time" as the referee says. I am pointing out that the thermodynamic variables of the system are fixed in those two equilibrium states, i.e. they are the same whether the process was fast or slow, while the Joule heat generated is not. I am not making assumptions about the thermodynamic variables while the system is out of equilibrium.

"The heat reservoir and the superconductor coupled to it are not a "closed system" of finite extension. Rather, the heat reservoir by definition can absorb heat and entropy without changing its temperature, because it is much bigger than the system under consideration. This implies, in particular, that any heat generated by dissipation in the cooling process in the superconductor will be absorbed by the reservoir."

That is incorrect. The reservoir + superconductor are a closed system. The final state of the heat reservoir is completely defined by its initial state and the amount of heat it absorbed from the superconductor in the process. Whether the heat reservoir is large or small is irrelevant. I take it to be large only to avoid the additional issue of having to consider its change in temperature, but it would be easy to do so. So if the reservoir absorbs extra heat generated by dissipation, it will end up in a different final state (with slightly higher temperature, or more than slightly higher if it is a small reservoir), with higher entropy, in contradiction with thermodynamics, as I explain in the paper.

The details of "*interaction processes of the quasiparticles with the phonons of the heat bath*" mentioned by the referee do not affect my arguments in any way.

In summary, I hope the referee will consider the above comments that show that his/her objections are unfounded.