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DEVICE FOR INDICATING THE CEASING OF SUPER-CONDUCTIVITY

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Fig.1

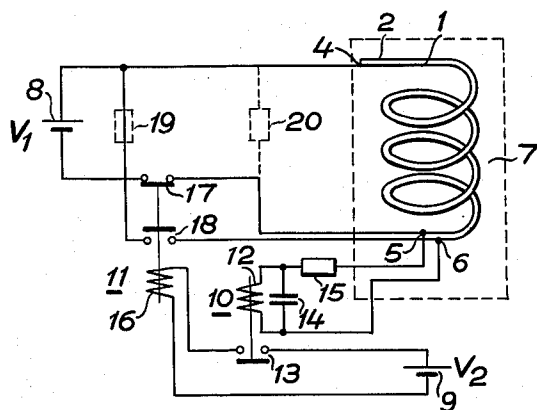


Fig.2

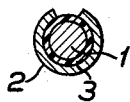
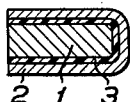


Fig.3



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1

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3 Claims. (Cl. 317—9)

Certain materials have the property, at low temperatures in the neighbourhood of the absolute zero point, of becoming super-conducting, implying that the resistivity at a certain critical temperature suddenly sinks to zero. The critical temperature for lead is about 7° K and for mercury 4° K. In recent times this property has been utilised by using super-conductors in the magnetising winding of very large magnets with large field strength. Such magnets are suitably built without an iron circuit. The necessary magnetising power becomes equal to zero since the super-conductor has no resistance, but of course a certain amount of power is consumed in keeping the super-conductor at the necessary temperature. As a rule the cooling is performed by means of liquid helium.

Problems arise, however, if for some reason an increased temperature occurs at some point on the super-conductor and the super-conductivity as a result ceases to exist at this point. If steps are not taken to disconnect the super-conductor quickly, it will melt at the fault point. The process becomes explosive since the very large magnetic energy of the magnet coil (of the order of 100 mws.) will be discharged in a short time in the non-super-conducting zone, which will be very short as the heat generated by current losses in the zone will not have time to spread to other parts of the coil.

The present invention relates to a protective device sensing the cessation of super-conductivity in a super-conductor which encloses a flux generated by a current through the super-conductor. According to the invention, a non-super-conducting conductor is electrically connected to one end of the super-conductor to follow the super-conductor closely but is electrically insulated therefrom and between the non-connected end points of the two conductors a voltage-sensing means is connected, said voltage sensing means being so arranged that at a predetermined voltage difference between the last-mentioned end points it initiates protective action by first connecting together the end points of the non-super-conducting conductor, possibly across a suitable discharge resistor, and thereafter breaking the super-conductor current circuit.

Since the super-conductor, when it is super-conducting, has no resistance and the other conductor carries no current and both conductors are influenced by the same flux, the voltage difference normally sensed by the voltage-sensing means is zero. If the super-conductivity ceases at some point of the super-conductor, a voltage drop is obtained across the super-conductor which gives a voltage difference e between the non-connected end points of the two conductors. The presence of this voltage difference e thus means that a fault exists in the super-conductor and the voltage-sensing means is arranged to break the super-conductor current circuit.

It is important that the conductors follow each other as intimately as possible so that due to a great many different leakage fluxes the voltage e will not be generated on the occasion of faults other than a fault in the super-conductor. For this reason the non-super-conductor is suitably arranged to enclose wholly or partly the super-conductor.

In spite of this arrangement of the two conductors it

2

is impossible to eliminate the circular flux between the conductors, which, on the occasion of changes in the current through the super-conductor, may induce a voltage of the magnitude e across the voltage sensing means. It is therefore advisable to provide the device with a delaying means, which is intended to obstruct the protective action when the voltage-sensing means senses a predetermined voltage difference e of only short duration. The time delay chosen is so long that the voltage-sensing means does not initiate action for the different irrelevant disturbances which may occur, but not so long that the voltage-sensing means cannot initiate action before a fault in the super-conductor causes its destruction.

The invention will now be described in greater detail, by way of example with reference to the accompanying drawings, in which FIGURE 1 is a circuit diagram of a device in accordance with the invention and FIGURES 2 and 3 show how the non-super-conducting conductor may be arranged around the super-conductor.

In FIGURE 1, the numeral 1 indicates a super-conducting conductor and 2 a non-super-conducting conductor which have been wound to form a coil. The conductors 1 and 2 are electrically connected at 4 and between their ends 5 and 6 a voltage-sensing means is connected. The coil is enclosed by a cooling system 7 filled with e.g. liquid helium. The super-conductor is fed from a voltage source 8. The voltage-sensing means includes, inter alia, a time delay relay 10 and is operatively connected to a switching device in the form of a contactor 11. The contactor 11 receives its operating voltage from a voltage source 9. The time delay relay includes a coil 12 and a closing contact 13, and the contactor consists of a coil 16, a breaking contact 17 and a closing contact 18.

The device functions in the following manner. On the occasion of a fault in the super-conductor 1 a voltage difference e arises between the points 5 and 6. The contact 13 then closes with a certain delay determined by the dimensions of a capacitor 14 and a resistance 15. When the contact 13 is closed a current flows through the coil, whereupon first the contact 18 is closed and thereafter the contact 17 is opened. This means that the end points of the non-super-conducting conductor 2 are first connected across a resistor 19 and that the current circuit of the super-conductor is thereafter broken. The current in the super-conductor may be broken very quickly since it may be transferred to conductor 2. It may however be necessary to insert a damping resistor 20 in order to take care of the little energy which remains in the leakage field between the conductors 1 and 2.

FIGURES 2 and 3, show possible ways of enclosing the super-conductor 1 within the non-super-conducting conductor 2, there being a layer 3 of electrical insulation between the conductors. Having regard to the very large dynamic forces which act on a conductor in a magnet coil of the magnitude mentioned above, the embodiment according to FIGURE 3 is perhaps mechanically the more suitable.

I claim:

1. In a circuit including a super-conductor, means for protecting said super-conductor in case of cessation of super-conductivity, said super-conductor having a first and second end terminals and enclosing a magnetic flux generated by a current through said super-conductor, said device including a non-super-conducting conductor arranged to follow said super-conductor closely but electrically insulated therefrom between said terminals, said non-super-conducting conductor having first and second end points, said first terminal being electrically connected to said first end point, a voltage sensing means connected between said second end terminal and said second end

point, a switching device in said super-conductor circuit, said voltage sensing means being operatively connected to said switching device to initiate protective action in response to a predetermined voltage difference between said second terminal and said second end point, said switching 5 device thereupon first connecting together said end points of said non-super-conducting conductor and thereafter breaking said current in said super-conductor.

2. In a circuit according to claim 1, said non-super-conducting conductor being arranged to enclose said super-conductor at least partly.

3. In a circuit according to claim 1, delaying means for preventing protective action when said voltage sensing

means senses a predetermined voltage difference of short duration.

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