INTRODUCTION

SUPERCONDUCTIVITY is the name given to a remarkable combination of electric and magnetic properties which appears in certain metals when they are cooled to extremely low temperatures. Such very low temperatures first became available in 1908 when Kamerlingh Onnes at the University of Leiden succeeded in liquefying helium, and by its use was able to obtain temperatures down to about 1°K.

One of the first investigations which Onnes carried out in the newly available low-temperature range was a study of the variation of the electrical resistance of metals with temperature. It had been known for many years that the resistance of metals falls when they are cooled below room temperature, but it was not known what limiting value the resistance would approach if the temperature were reduced towards 0°K. Onnes, experimenting with platinum, found that, when cooled, its resistance fell to a low value which depended on the purity of the specimen. At that time the purest available metal was mercury and, in an attempt to discover the behaviour of a very pure metal, Onnes measured the resistance of pure mercury. He found that at very low temperatures the resistance became immeasurably small, which was not surprising, but he soon discovered (1911) that the manner in which the resistance disappeared was completely unexpected. Instead of the resistance falling smoothly as the temperature was reduced towards 0°K, the resistance fell sharply at about 4°K, and below this temperature the mercury exhibited no resistance whatsoever. Furthermore, this sudden transition to a state of no resistance was not confined to the pure metal but occurred even if the mercury was quite impure. Onnes recognized that below 4°K mercury passes into a new state with electrical properties quite unlike those previously known, and this new state was called the "superconducting state".

It was later discovered that superconductivity could be destroyed (i.e. electrical resistance restored) if a sufficiently strong magnetic field were applied, and subsequently it was found that a metal in the superconduc-

ting state has very extraordinary magnetic properties, quite unlike those known at ordinary temperatures.

Up to the present time about half of the metallic elements and also a number of alloys have been found to become superconducting at low temperatures, that is to say below about 25°K. Recently (1987), however, it has been discovered that some ceramic metallic oxides become superconducting at much higher temperatures, i.e. at about 100°K (see Chapter 14).

Those materials which exhibit superconductivity when sufficiently cooled are called superconductors. For many years it was thought that all superconductors behaved according to a basically similar pattern. However, it is now realized that there are two kinds of superconductor, which are known as type-I and type-II. Most of those elements which are superconductors exhibit type-I superconductivity, whereas alloys generally exhibit type-II superconductivity. The two types have many properties in common but show considerable differences in their magnetic behaviour. These differences are sufficient for us to treat the two types separately. The first part of this book deals with type-I superconductors and the second part with type-II superconductors.