CHAPTER I

INTRODUCTION AND HISTORICAL REVIEW

The magnetic property (1,2) of the nucleus have stimulated the interest of physicists ever since they were first postulated to explain the hyperfine structure of spectral lines. It was supposed that the nucleus is, in general, a small magnet whose interaction with the atomic electrons split the energy levels of the atom. The atomic line spectra, which arise from the transitions between different energy states, are then shifted if the atomic nucleus possesses the magnetic moment.

In the form of an atomic beam, there were two experimental techniques that pointed the way to study nuclear magnetic property. The first of these was the extension, by Estermann and Stern of the original Stern - Gerlach experiment, to study the magnetic deflection of atomic and molecular beams (2, 3). In 1937, the magnetic moment of proton was first determined in this way. The second technique was introduced by Rabi and his co-workers in 1939 and is called the molecular beam resonance (2). In the Estermann - Gerlach experiment a collimated beam of nuclei is split by an inhomogeneous magnetic field into components corresponding to the different spin states of the nuclei, i.e., to different values of spin I. Rabi's method involves a refocusing technique in which the deflected beam is subjected to a second inhomogeneous field which causes the nuclei to retrace the deflection caused by the first field. If during its passage through the two fields a nucleus changes its spatial orientation, for example if it undergoes transition to another spin state, it will not be refocused, and the essential feature of the molecular beam resonance method is that it permits the detection of nuclear spin transitions. Normally, the number of nuclei which undergoes transitions during the passage through the two fields is negligible. However, if prior to refocusing, the deflected beam is passed through a homogeneous magnetic field and simultaneously irradiated with electromagnetic radiation transitions between spin states will occur provided the frequency of the radiation corresponds to the energy difference between the spin states. It transpires that for the strength of a homogeneous field employed in these experiments the correct frequency lies in the radio frequency region. The exact radio frequency which will cause the efficiency of refocusing to fall to a minimum is a function of the spin I, the magnetic moment μ, and the strength of the homogeneous field H, so that if I is known the value of μ can be determined.

The resonant exchange of energy between the (2 I + 1) energy levels of a nuclear magnetic moment in a magnetic field should not be restricted to the matter in the form of molecular beams, but should also occur for matter in its ordinary solid, liquid or gaseous states. This had in fact been pointed out by Gorter in 1936, who unsuccessfully sought the resonance for the lithium nuclei in crystalline lithium fluoride and for the protons in crystalline potassium alum.

In 1942 Gorter and Broer attempted to find the nuclear magnetic resonance absorption for lithium in solid lithium chloride and for fluorine in solid potassium fluoride at low temperatures. The experiment was unsuccessful. Four years later, in 1946 the first successful nuclear magnetic resonance experiments were reported by two independent groups, namely Purcell, Torrey and Pound at Harvard, and Bloch, Hansen and Packard at Stanford University. Purcell and his colleagues found first of all the resonance absorption for the protons in solid paraffin, and detected it by measuring the additional loss which is caused in the tuned circuit supplying rf power. For this purpose the tuned circuit was placed in one arm of a balanced rf bridge. Bloch and his colleagues found their first resonance for the protons in water. The reorientation of the nuclear moments by the resonant electromagnetic field induces an emf at the resonant frequency in a coil, whose axis is perpendicular to the steady homogeneous magnetic field, wound round the small tube of water. The induction of this emf indicated the condition of resonance. This method of detection was named "nuclear induction".

At the present time, nuclear magnetic resonance is finding wide application in physics, chemistry and biology. It is an important method that is used in research to find out the nuclear properties, the structures of matters and other related subjects.

The present investigation deals with the construction and the operation of a nuclear magnetic resonance spectrometer first discussed by Pound and Watkins (4).