1. INTRODUCTION

In general, electrical noise is a well understood phenomenon. The theory is well developed from the point of view of thermodynamics and statistical mechanics as well as by means of models that show us what the carriers are doing in special systems. Much experimental work has been done on electronic devices which supports the theories and gives us some ideas about the improvement of the considered systems, for example, in order to lower the noise level. For instance, generation-recombination noise can be lowered by using cleaner preparation techniques to avoid trapping centers. On the other hand, thermal noise cannot be reduced whatever method of preparation is used, because it is based on fundamental physics laws, and it is unavoidable. However, there is a type of electrical noise which is till now not well understood. This is the so-called Flicker noise (1/f noise in particular), which is characterized by a dependence of the power spectrum on a power law of the frequency and whose effects are important in low frequency ranges. We can find this kind of noise in electrical and non-electrical systems. For instance, it is present in all current-carrying condensed-matter systems as semiconductors, insulators, ionic conductors, liquid electrolytes, metals biopolymers, etc. Also it is present in solid-state devices as Schottky Barrier Diodes, infrared detectors, microphones, amplifiers, metal-oxide-semiconductors (MOS) transistors, etc. There are also non electrical systems which have Flicker noise. We can enumerate some of them: Flicker noise is present in the fluctuations of the phase and frequency of all known frequency standards determining, in general, the minimal error on frequency and time measurements. 1/f noise has also been found in axons as fluctuations of voltage across the membrane of the nodes of Ranvier \[ 1 \], in the spectral analysis of the rate of insulin intake by an unstable diabetic \[ 2 \], in the power spectrum of the fluctuations of the angular velocity of the earth's rotation below a certain limiting frequency \[ 3 \], in fluctuations of the relativistic neutron flux in the terrestrial magnetosphere, in fluctuations of seasonal temperature, in
the flow rate of sand in an hourglass, in the frequency of sunspots, in the flow rate of the Nile river over the last 2000 years and in the traffic flow in a motorway [4]. Of course, this enumeration is not exhaustive but gives us an idea of the great diversity of systems where this phenomenon is present. Recently very good reviews have been published on this subject [6-9].

This general character of Flicker noise and its similarity in a wide range of materials, has driven researchers to think in an universal underlying mechanism. On the other hand, this universal character might be a misleading feature because many different physical systems may lead to a given power spectrum. Of course it is difficult to think that the noise in a semiconductor is related to the fluctuations of the Earth's angular velocity. Also it is found that the most general models are poorly correlated with experiments whereas the most successful theories are the ones related to more specific systems [10].

In this work we shall make first a short review of the main features of this phenomenon and in the following sections we comment some models which produce power spectra giving a 1/f dependence.

2. SOME ELEMENTS OF NOISE THEORY

We shall concentrate ourselves in electric systems. A typical circuit for a simple noise measurement experiment consists of a constant dc voltage source and two resistances $R_c$ and $R_s$ (Fig.1). The voltage drop across the resistance $R_s$ is measured. In the steady state (when the current $I$ is constant) the sample voltage $V(t)$ is observed to fluctuate about its average value $<V(t)> = V_s$.

We define the autocorrelation function $C_v(\tau)$ by

$$C_v(\tau) = <V(t) V(t+\tau)> \quad (1)$$

Fig.1.- Circuit diagram

where the symbol $<>$ means averaging a long enough time interval. The spectral density or power spectrum of $V(t)$ is defined as the cosine transform of the voltage autocorrelation function $C_v(\tau)$.