8. Sensors and generators

In the tube collection there are several sensors designed for applications in some kinds of physics measurements or detection. Other devices were designed to generate white noise or radiations. The most relevant categories are listed below.

8.1 – Current limited diodes

Current limited diodes, usually with filamentary tungsten cathode, are commonly used as current sensors, since they return a plate current proportional to the current flowing in the filament. Above few tens anode volts, in a filamentary cathode diode the plate current depends upon the actual cathode temperature by the Richardson law.

Fig. 8.1.1 – Current limited diodes used in power supply current stabilization circuits.

Current limited diodes were also used as white noise sources. Of course, in this case the design was optimized for an uniform noise over the widest band.

Fig. 8.1.2 – Some current limited diodes designed for use as noise generators. The CV2341, in the middle, was designed to be directly interfaced to a 75 ohm coaxial line.

8.2 – Gas noise generators

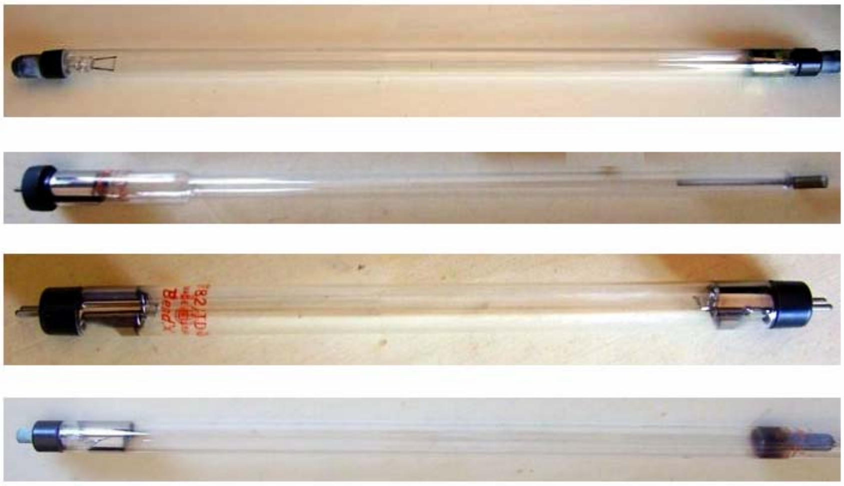

Fig. 8.2 – Some gaseous noise sources.

8.3 – Displacement, vibration sensors

Some tubes were devised to sense the position of a rod protruding from the envelope. The rod, through a flexible diaphragm, moved an electrode inside the envelope. In the case of the twin diode Ramberg sensor, the rod moved the block of two anodes with respect to the common cathode. In the RCA 5734 'Vibrotron', the rod moves the anode of a triode, changing its transconductance.

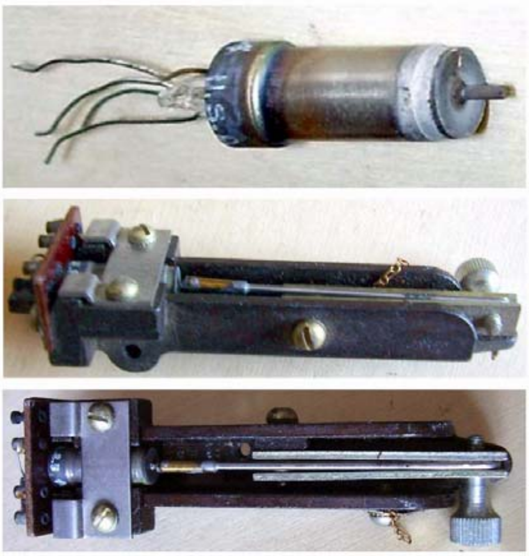

Fig. 8.3 – The RCA 'Vibrotron' and two views of a rare phono pick-up designed around 1950, based upon this tube.

8.4 – Magnetic field sensors

Some tubes were designed to operate as magnetic sensors or even as switches. Their operating principle resembles the operation of a magnetron, electrons being forced by the magnetic field to follow more and more curved trajectories, up to the cutoff. Usually their structure is a cylindrical diode with filamentary or unipotential cathode. Some types were also used into laboratories to demonstrate the Hull effect.

Fig. 8.4 – The General Electric 2B23 was intended to operate as magnetically controlled switch. The Ferranti GRD7 was a lab tube, used to demonstrate the Hull effect deriving from external magnetic fields on a symmetrical diode.

8.5 – Mass sensors

These tubes are intended to operate as mass detectors in spectrometers. One end of the tube is open, to allow the introduction of the sample molecules to be analyzed. The tube is then evacuated and ions of the sample are accelerated and deflected by the electrode system immersed in a magnetic field. Deflection is inversely proportional to the mass of the ions. Usually electrodes are made of metals as iridium for low adsorbtion of foreign molecules and easy cleaning at high-temperature.

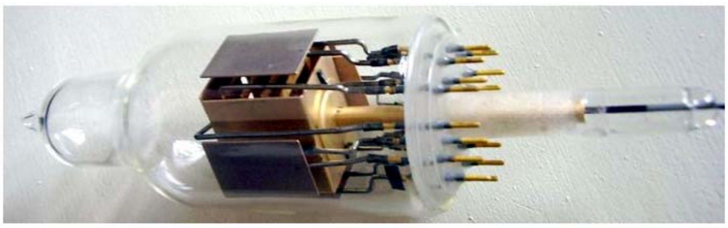

Fig. 8.5 – A still sealed experimental Omegatron

8.6 – Radiation nuclear

Nuclear detectors include both radiation and particle sensors. In this section we only find complete sensors devices as Geiger counters and scintillators. Photomultipliers, even if widely used in radiation sensors to detect the light from scintillators, are listed in a different section.

Fig. 8.6 – Samples of Geiger tubes.

8.7 – Radiation RF

Since the early experiments with radio waves, either filamentary lamps and neon bulbs were used as detectors of RF fields. Some families of specialized RF detectors were then introduced in the years, including indicators, for visual evaluation of RF power, and sensors, to convert RF fields in electrical values as resistances or voltages. We find thermocouples, bolometers, incandescent lamps, sometimes usable as bolometers and neon indicators.

Fig. 8.7 – Some samples of RF bolometers.

8.8 – Radiation sensors, visible, IR, UV

Here we find several devices sensitive to IR, visible or UV, ranging from simple photocells, to photoresistors and photomultipliers, used to detect even the smallest radiations.

Fig. 8.8.1 – Standard and custom photocells. The last device is a cadmium-sulphide photoresistor.

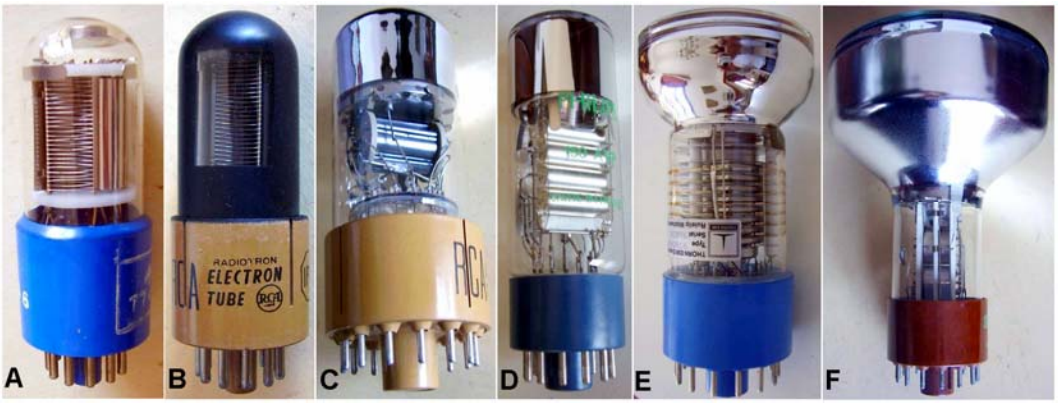

Fig. 8.8.2 – Samples of photomultipliers, with side and top window and with different dynode structures.

8.9 – Radiation sources, visible, IR, UV

Fig. 8.9 – Samples of different radiation sources. From left we see a thermal test bulb, a hollow cathode monochromatic light source, a crater lamp, used to generate the tiny scanning beam in the early facsimile sets, and four stroboscopic light sources.

8.10 – Vacuum sensors

Many tube manufacturers also listed high vacuum sensors, offering the same devices they designed for internal use in their own plants. We find several operating principles, depending upon the magnitude of the vacuum to measure: thermocouples, temperature-sensitive resistors or Pirani sensors, hot-cathode ionization gauges, the most sensitive ones, and cold-cathode ionization gauges. Sensors were usually designed to be heated at high temperature for cleaning and degassing. Many use hard glass, such as Pyrex or Nonex. Electrodes are supported by glass arbors, since no mica spacers can be used. Base is missing in sensors intended for high-temperature degassing cycles.

- The Pirani sensor is based upon a temperature-sensitive filamentary resistor, in which a small amount of current flows. Filament temperature, and hence its resistance, depends upon the convection cooling by molecules of surrounding gas. Fine tungsten wire is commonly used in these sensors, that are very similar to incandescent lamps, even if they are operated at temperatures below some 500ºC. By the way, a similar principle was used in some little known attitude sensors, the 'Convectrons', made by Bendix.

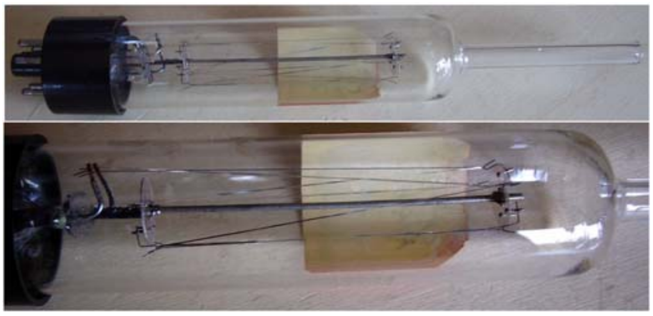

Fig. 8.10.1 - Two images of Raytheon CK-1300 Pirani or hot filament vacuum sensor.

- Thermocouple: while in the Pirani sensor a single filament acts both as heater and as temperature sensor, in the thermocouple the two elements are separated. This kind of sensor has in the same envelope the heater and the thermocouple assembled side by side. Hence this device has two current inputs and two voltage outputs.

Fig. 8.10.2 - The Sylvania R1100 is a thermocouple type vacuum sensor.

Hot-cathode ionization sensor is very similar to a vacuum triode. It measures the ion current in the collector, which decreases with vacuum increase. The grid is biased positive with respect to filament, attracting and accelerating electrons emitted by the filament. The anode, biased negative, acts as collector for ions derived from impacts of electrons on gas molecules. In the Bayard-Alpert sensor the geometry of electrodes is modified for better efficiency. Filament is mounted outside the grid helix and anode is a small filamet in the middle.

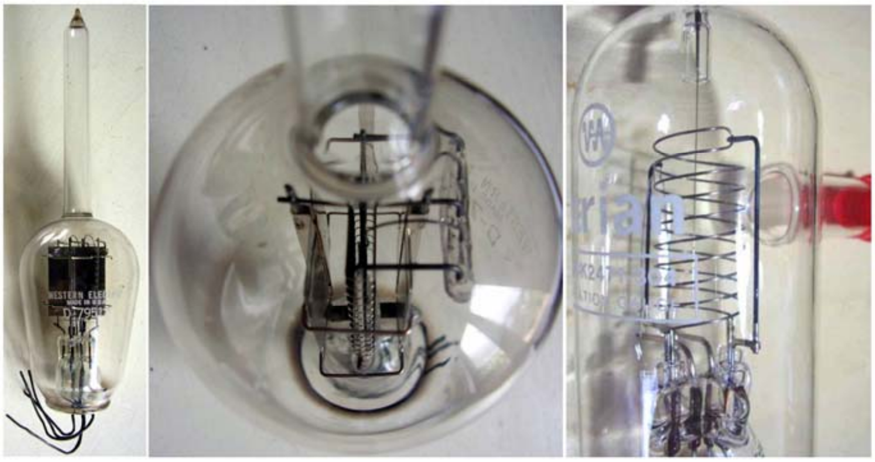

Fig. 8.10.3 - Hot cathode ionization sensors. Left and center photos of a Western Electric D-79512 sensor, based upon the electrode structure of their popular 205B power triode mounted in a high-temperature Nonex bulb. On the right a Bayard-Alpert sensor with external grid.

Cold cathode ionization sensors. The Penning sensor, by the name of its inventor Frans Michel Penning, operates in a magnetic field. Here the ionization takes place because of the quite high voltage applied to electrodes.

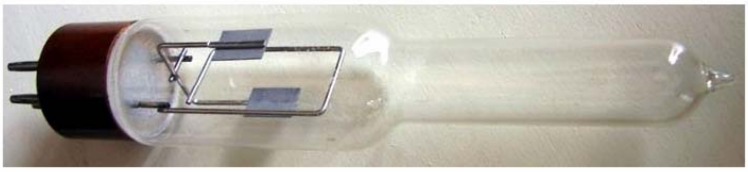

Fig. 8.10.4 - The Philips CIG22 is a cold cathode Penning sensor.