traversed by a current and deflected in the field. Its deflexion was observed by an attached mirror in the usual way.

Another form of thermoelectric receiver has been devised by J. A. Fleming *(Phil. Mag.,* December 1906) as follows:—It consists of two glass vessels like test tubes one inside the other, the space between the two being exhausted. Down the inner test tube pass four copper strips having platinum wires at their ends sealed through the glass. In the inner space between the test tubes one pair of these platinum wires are connected by a fine constantan wire about ∙02 mm. in diameter. The other pair of platinum wires are connected by a tellurium-bismuth thermo-couple, the junction of which just makes contact with the centre of the fine wire. The outer terminals of this junction are connected to a galvanometer, and when electric oscillations are sent through the fine wire they cause a deflexion of this galvanometer (fig. 48). The thermal detectors are especially useful for the purpose of quantitative measurements, because they indicate the true effective or square root of mean square value of the current or train of oscillations passing through the hot wire On the other hand, the coherer or loose contact detectors are chiefly affected by the initial value of the electromotive force acting on the junction during the train of oscillations, and the magnetic detectors by the initial value of the current and also to a considerable extent by the number of oscillations during the train. Hence the coherer type of detectors are called potential detectors whilst the thermal are called integral current de­tectors, the current detectors depending entirely or to some extent upon the damping of the train of oscillations, that is to say, upon the number of oscillations forming a train.

The fifth type of wave detector de­pends upon the peculiar property of rarefied gases or vapours which tinder some circumstances possess a unilateral conductivity. Thus J. A. Fleming invented in 1904 a detector called an oscillation valve or glow lamp detector made as follows:@@1 A small carbon filament incandescent lamp has a platinum plate or cylinder placed in it surrounding or close to the filament. This plate is supported by a platinum wire sealed through the glass. Fleming discovered that if the filament is made incandescent by the current from an insulated battery there is a unilateral conductivity of the rarefied gas between the hot filament and the metal plate, such that if the negative terminal of the filament is connected outside the lamp through a coil in which electric oscillations are created with the platinum plate, only one half of the oscillations are permitted to pass, viz., those which carry negative electricity from the hot filament to the cooled plate through the vacuous space. This phenomenon is connected with the fact that incandescent bodies, especially in rarefied gases, throw off or emit electrons or gaseous negative ions.

Such an oscillation valve was first used by Fleming as a receiver for wireless telegraph purposes in 1904 as follows:—In between the receiving antenna and the earth is placed the primary coil of an oscillation transformer; the secondary circuit of this trans­former contains a galvanometer in series with it, and the two together are joined between the external negative terminal of the carbon filament of the above-described lamp and the insulated platinum plate. When this is the case oscillations set up in the antenna will cause a continuous current to flow through the galvano­meter, the lamp acting as a valve to stop all those electric oscilla­tions in one direction and only permit the opposite ones to pass (fig. 49). Wehnelt discovered that the same effect could be pro­duced by using instead of a carbon filament a platinum wire covered with the oxides of calcium or barium, which when incandescent have the property of copiously emitting negative ions. Another form of receiver can be made depending on the properties of mercury vapour. A highly insulated tube contains a little mercury, which is used as a negative electrode, and the tube also has sealed through the glass a platinum wire carrying an iron plate as an anode. A battery with a sufficient number of cells is connected to these two electrodes so as to pass a current through the mercury vapour, negative electricity proceeding from the mercury cathode to the iron anode. The mercury vapour then possesses a unilateral con­ductivity, and can be used to filter off all those oscillations in a train which pass in one direction and make them readable on an ordinary galvanometer. In addition to the above gaseous rectifiers of oscillations it has been found that several crystals, such as car­borundum (carbide of silicon), hessite, anastase and many others possess a unilateral conductivity and enable us to rectify trains of oscillations into continuous currents which can affect a telephone. Also several contacts, such as that of galena (sulphide of lead) and

plumbago, and molybdenite and copper possess similar powers, and can be used as detectors in radio-telegraphy. See G. W. Pierce, *The Physical Review,* July 1907, March 1909, on crystal rectifiers for electric oscillations.

*Syntonic Electric Wave Telegraphy.—*If a simple receiving antenna as above described is set up with an oscillation-detect­ing device attached to it, we find that it responds to incident electric waves of almost any frequency or damping provided that the magnetic force of the wave is perpendicular to the antenna, and of sufficient intensity. This arrangement is called a non-syntonic receiver. On the other hand, if a closed oscilla­tion circuit is constructed having capacity and considerable inductance, then oscillations can be set up in it by very small periodic electromotive forces provided these have a frequency exactly agreeing with that of the condenser circuit. This last circuit has a natural frequency of its own which is numerically measured by 1∕2π√(CL), where C is the capacity of the con­denser and L is the inductance of the circuit. The problem of syntonic electric wave telegraphy is then to construct a transmitter and a receiver of such kind that the receiver will be affected by the waves emitted by the corresponding or syntonic transmitter, but not by waves of any other wave-length or by irregular electric impulses due to atmospheric electricity. It was found that to achieve this result the trans­mitter must be so constructed as to send out prolonged trains of slightly damped waves. Electric-radiative circuits like thermal radiators are divided into two broad classes, good radiators and bad radiators. The good electric radiators may be compared with good thermal radiators, such as a vessel coated with lamp black on the outside, and the bad electric radiators to poor thermal radiators, such as a silver vessel highly polished on its exterior. When electric oscillations are set up in these two classes of electric radiators, the first class send out a highly damped wave train and the second a feeble damped wave train provided that they have sufficient capacity or energy storage and low resistance. A radiator of this last class can be constructed by connecting inductively or directly

an antenna of suitable capacity and inductance to a nearly closed electric circuit consisting of a condenser of large capacity, a spark gap and an inductance of low resistance. When oscillations are excited in this last circuit they communicate them to the antenna provided this last circuit is *tuned* or syntonized to the closed circuit, and the radiating antenna has thus a large store of energy to draw upon and can therefore radiate prolonged trains of electric waves. The above state­ments, though correct as far as they go, are an imperfect account of the nature of the radiation from a coupled antenna, but a mathematical treatment is required for a fuller explanation.

@@@1 See J. A. Fleming, *Proc. Roy. Soc.,* 1905, 74, p. 746. Also *British Pat. Spec.,* No. 24580 of 1904.