



# RECEIVING TUBE MANUAL

## Electrons and Electrodes

The radio tube is a marvelous device. It makes possible the performing of operations, amazing in conception, with a precision and a certainty that are astounding. It is an exceedingly sensitive and accurate instrument—the product of coordinated efforts of engineers and craftsmen. Its construction requires materials from every corner of the earth. Its use is world-wide. Its future possibilities, even in the light of present-day accomplishments, are but dimly foreseen, for each development opens new fields of design and application.

### ELECTRONS

A radio tube consists of a cathode, which supplies electrons, and one or more additional electrodes, which control and collect these electrons, mounted in an evacuated envelope. The envelope may be a glass bulb, or it may be the more compact and efficient metal shell.

The importance of the radio tube lies in its ability to control almost instantly the flight of the millions of electrons supplied by the cathode. It accomplishes this with a minimum of control energy. Because it is almost instantaneous in its action, the radio tube can operate efficiently and accurately at electrical frequencies much higher than those attainable with rotating machines.

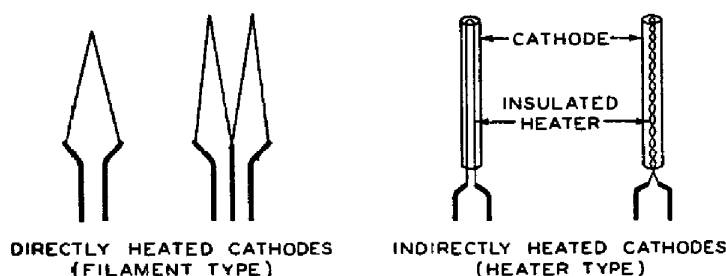
All matter exists in the solid, liquid, or gaseous state. These three forms of matter consist entirely of minute divisions known as molecules. Molecules are assumed to be composed of atoms. According to a present accepted theory, atoms have a nucleus which is a positive charge of electricity. Around this nucleus revolve tiny charges of negative electricity known as **electrons**. Scientists have estimated that these invisible bits of electricity weigh only 1/46 billion, billion, billion, billionths of an ounce, and that they may travel at speeds of thousands of miles per second.

Electron movement may be accelerated by the addition of energy. Heat is one form of energy which can be conveniently used to speed up the electron. For example, if the temperature of a metal is gradually raised, the electrons in the metal gain velocity. When the metal becomes hot enough to glow, some electrons may acquire sufficient speed to break away from the surface of the metal. This action is utilized in the radio tube to produce the necessary electron supply.

### CATHODES

A cathode is an essential part of a radio tube, since it supplies the electrons necessary for tube operation. In general, heat is the form of energy applied to the cathode to release the electrons. The method of heating the cathode may be used to distinguish between the different forms of cathodes. For example, a directly heated cathode, or filament-cathode, is a wire heated by the passage of an electric current. An indirectly heated cathode, or heater-cathode, consists of a filament, or heater, enclosed in a metal sleeve. The sleeve carries the electron-emitting material on its outside surface and is heated by radiation and conduction from the heater.

A filament, or **directly heated cathode**, may be further classified by identifying the filament or electron-emitting material. The materials in regular use are tungsten, thoriated-tungsten, and metals which have been coated with alkaline-earth oxides. Tungsten filaments are made from the pure metal. Since they must operate at high temperatures (a dazzling white) to emit sufficient electrons, a relatively large amount of filament power is required. Thoriated-tungsten filaments are drawn from tungsten slugs which have been impregnated with thoria. Due to the thorium, these filaments liberate electrons at a more moderate temperature (a bright yellow) and are, therefore, much more economical of filament power than are pure tungsten filaments. Alkaline earths are usually applied as a coating on a nickel alloy wire or ribbon. This coating, which is dried in a substantial layer on the filament, requires only a very low temperature (a dull red) to produce a copious supply of electrons. Coated filaments operate very efficiently and require relatively little filament power. However, each of these cathode materials has special advantages which determine the choice for a particular application.



Directly heated filament-cathodes require comparatively little heating power. For that reason, they are used in almost all the tube types designed for battery operation because it is, of course, desirable to impose as small a drain as possible on the batteries. Examples of the battery-operated filament types are the 30, 31, 32, 33, and 34. A-c operated types having directly heated filament-cathodes are the 2A3 and 45.

**Heater, or indirectly heated cathodes**, comprise an assembly of a thin metal sleeve coated with emitting material and a heater contained within and insulated from the sleeve. The heater is made of tungsten wire and is used only for the purpose of heating the sleeve and its coating to an electron-emitting temperature. The tungsten wire is operated at a moderate temperature and supplies the energy for heating the sleeve.

The heater-cathode construction is well adapted for use in radio tubes intended for operation from a-c power lines. The use of separate parts for emitter and heater functions, the electrical insulation of the heater from the emitter, and the shielding effect of the sleeve may all be utilized in the design of the tube to prevent the a-c heater supply from causing hum. From the viewpoint of circuit design, the heater-cathode construction offers advantages in connection flexibility due to the electrical separation of the heater from the cathode. Another advantage of the heater-cathode construction is that it permits a rectifier tube to be designed with closer spacing between the cathode and plate, and an amplifier tube with closer spacing between the cathode and grid. In a rectifier tube, this results in less voltage drop in the tube and improved regulation; in an amplifier tube, it results in an increase in the gain obtainable from the tube. Because of the advantages of the heater-cathode construction, almost all present-day tubes designed for a-c operation have heater-cathodes.