ELECTROSURCICAL UNIT

Electric devices to assist in surgical procedures by providing cutting and homeostasis (stopping bleeding) are widely applied in the operating room. These devices are also known as *electrocautary apparatuses.* They can be used to incise tissue, to destroy tissue through desiccation, and to stop bleeding by causing coagulation of blood. The process involves the application of an RF arc between a probe and tissue to cause localized heating and damage to that tissue.

The basic electrosurgical unit is shown in Figure 1.

The high-frequency power needed to produce the arc comes from a high-power, high-frequency generator. The power to operate the generator comes from a power supply, the output of which may in some cases be modulated to produce a waveform more appropriate for particular actions. In this case, a modulator circuit controls the output of the generator. The application of high-frequency power from the generator is ultimately controlled by the surgeon through a control circuit, which determines when power is applied to the electrodes to carry out a particular action. Often the output of energy from the high-frequency generator needs to be at various levels for various jobs. For this reason, a coupling circuit is inserted between the generator output and the electrodes to control this energy transfer.

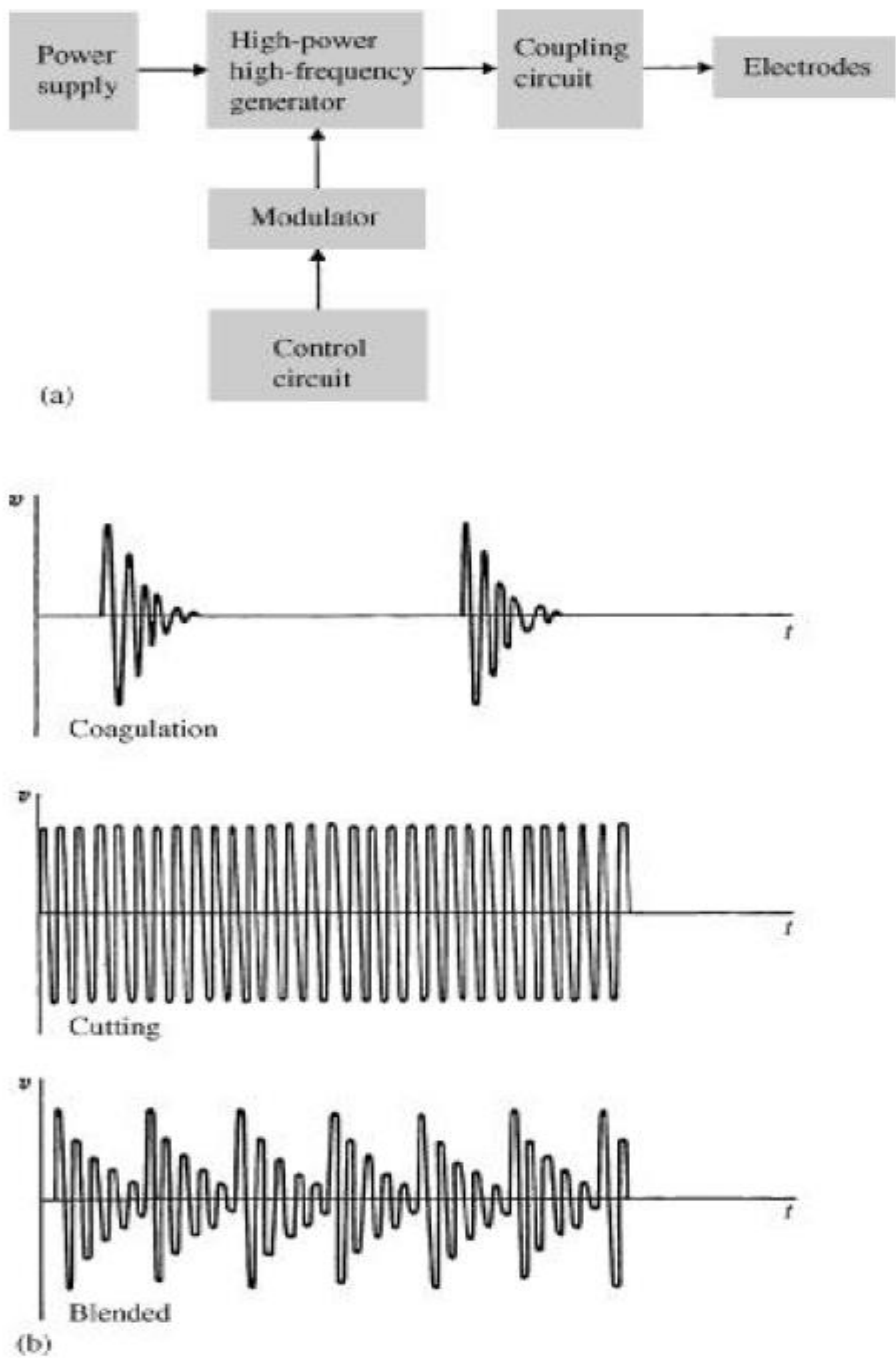

Figure 1 (a) Block diagram for an electrosurgical unit. High-power, high-frequency oscillating currents are generated and coupled to electrodes to incise and coagulate tissue, (b) Three different electric voltage waveforms available at the output of electrosurgical units for carrying out different functions.

The electric waveforms generated by the electrosurgical unit differ for its different modes of action. To bring about desiccation and coagulation, the device uses damped sinusoidal pulses, as shown in Figure 1(b). The RF sine waves have a nominal frequency of 250 to 2000 kHz and are usually pulsed at a rate of 120 per second. Open-circuit voltages range from 300 to 2000 V, and power into a 500 ohm loud ranges from 80 to 200 W. The magnitude of both voltage and power depends on the particular application, Cutting is achieved with a CW RF source, as shown in Figure 1(b). Cutting is done at higher frequency, voltage, and power, because the intense heat at the spark destroys tissue rather than just desiccating it as is the case with coagulation. Frequencies range from 500 kHz to 2.5 MHz with open-circuit voltages as high as 9 kV, Power levels range from 100 to 750 W, depending on the application.

The cutting current usually results in bleeding at the site of incision, and the surgeon frequently requires "bloodless" cutting. Electrosurgical units can achieve this by combining the two waveforms, as shown in Figure 1(b). The frequency of this *blended* waveform is generally the same as the frequency for the cutting current. For best results, surgeons prefer to operate at a higher voltage and power when they want bloodless cutting than when they want cutting alone.

Many different designs for electro surgical units have evolved over the years. Modern units generate their RF waveforms by means of solid-state electronic circuits. Older units were based on vacuum tube circuits and even utilized a spark gap to generate the waveforms shown in Figure 1(b).

Spark-Gap based electrosurgical unit:

As explained earlier, older types of surgical diathermy work on the “spark gap” principle. Fig. 2 gave the circuit diagram of a simple spark-gap type diathermy unit. The AC mains supply voltage is stepped up to several thousand volts by the mains transformer and applied to several spark gaps in series. Twice per cycle of the mains (on the + and - half cycles) sparks are produced. The capacitor is discharged through the gaps is an oscillatory fashion, the combination of L and C being chosen to oscillate at some 800 kHz. The output of the diathermy thus consists of bursts of damped radio-frequency waves at intervals of 10ms (one complete mains cycle takes 20 m sec at 50 Hz). A tapping on the output transformer allows the output current to be adjusted.

A typical maximum power output would be 250 W. The basic surgery arrangement is shown below in Fig. 4.

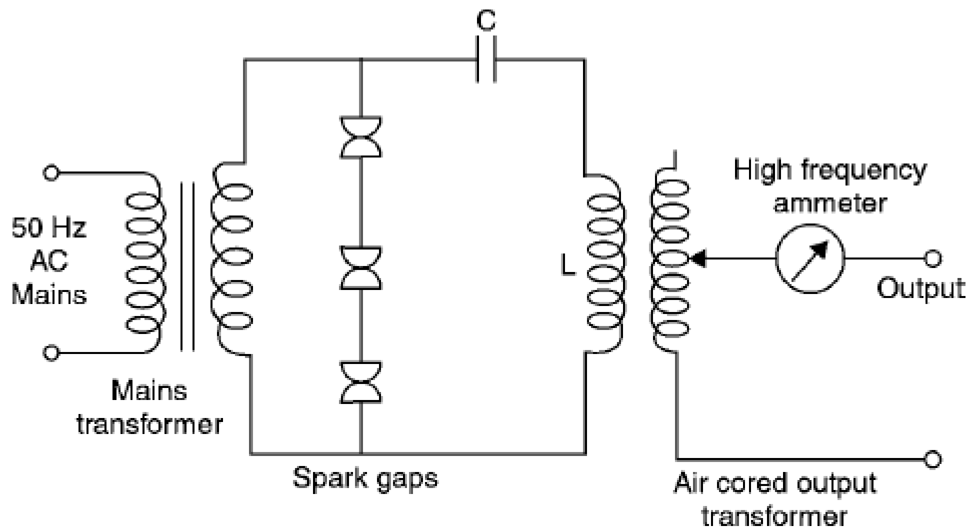

Figure 2. The circuit diagram of the spark-gap electrosurgical unit.

Spark-gap generators are very robust, but anesthetic explosion risks are greater with them, and they do generate a substantial proportion of harmonic frequencies. These can cause interference with communications and monitoring equipment. Valve and transistor oscillators seem to be preferred by surgeons, and any interfering radiation from them can be more easily suppressed by filter circuits because of the greater purity.

Typical electrosurgical units:

A block diagram of a typical electrosurgical unit is shown in Figure 3. The RF oscillator provides the basic high-frequency signal, which is amplified and modulated to produce the coagulation, cutting, and blended waveforms. A function generator produces the modulation waveforms according to the mode selected by the operator. The RF power output is turned on and off by means of a control circuit connected either to a hand switch on the active electrode or to a foot switch that can be operated by the surgeon. An output circuit couples the power generator to the active and dispersive electrodes- The entire unit derives its power from a power-supply circuit that is driven by the power lines. Electrodes used with electrosurgical units come in various sizes and shapes, depending on the manufacturer and the application. The active electrode is a scalpel-like probe that is shaped for the function for which it is intended.

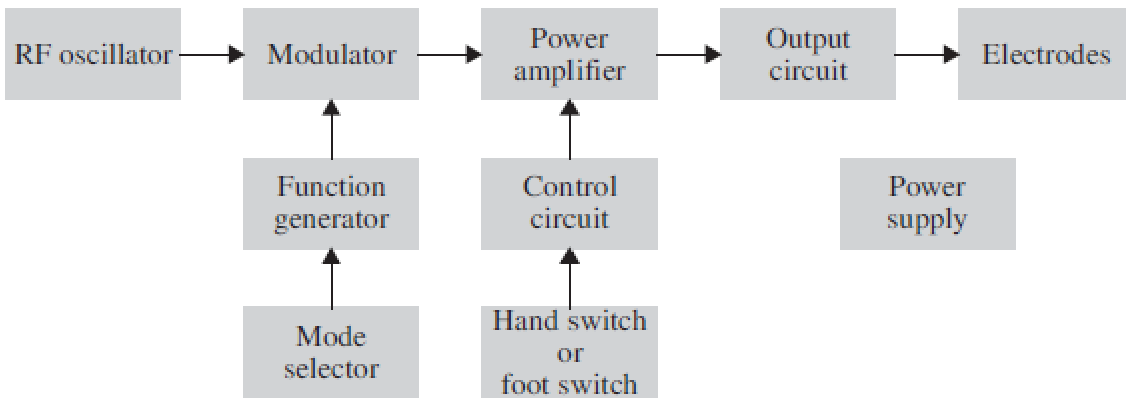

Figure 3. The block diagram of typical electrosurgical unit.

The simplest form consists of a probe that appears to be similar to a test probe used with an electronic instrument such as a multimeter or an oscilloscope, A pointed metallic probe fits into an insulating handle and is held by the surgeon as one would hold a pencil. The finger switch located on the handle is momentarily depressed when the surgeon wants to apply power to the probe.

Whereas the purpose of the active probe is to apply energy to the local tissue at the tip of the probe and thereby to effect coagulation, cutting, or both, the dispersive electrode has a different function. It must complete the RF circuit to the patient without having current densities high enough to damage tissue. The simplest dispersive electrode is a large, reusable metal plate placed under the buttocks or back of the patient. Most procedures use a 70 cm^2 disposable conductive adhesive polymer dispersive electrode placed on the thigh. Another type has a gel-soaked sponge backed by metal foil and surrounded by foam and pressure-sensitive adhesive. Another capacitive type has a thin Mylar insulator backed by foil and its entire face coated with pressure-sensitive adhesive. It is important that this electrode make good contact with the patient over its entire surface so that "hot spots" do not develop.

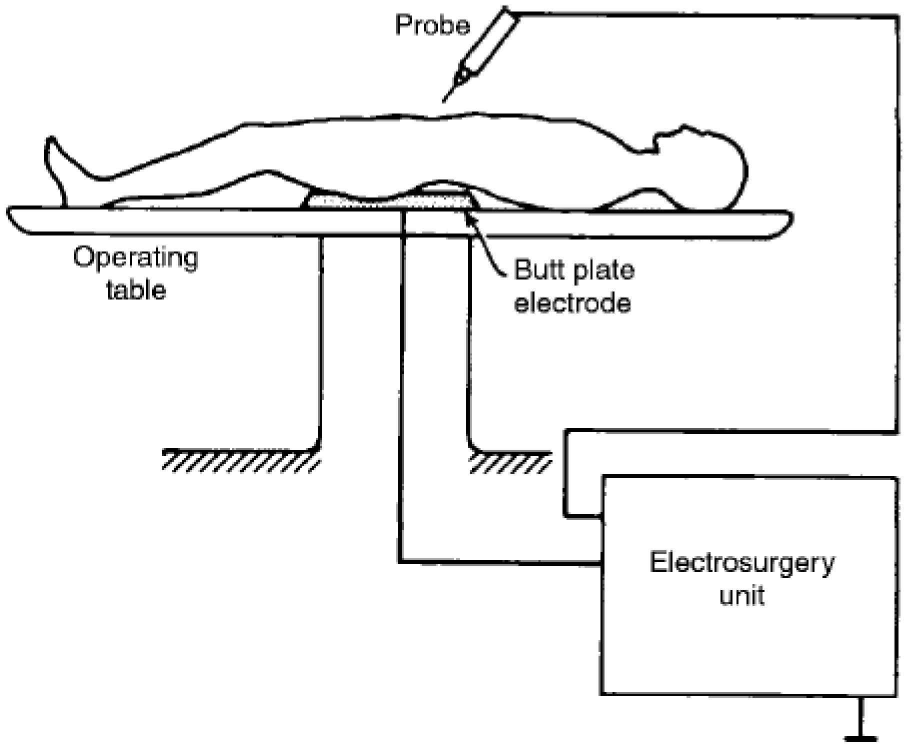

Figure 4. The basic arrangement of the electrosurgical unit.