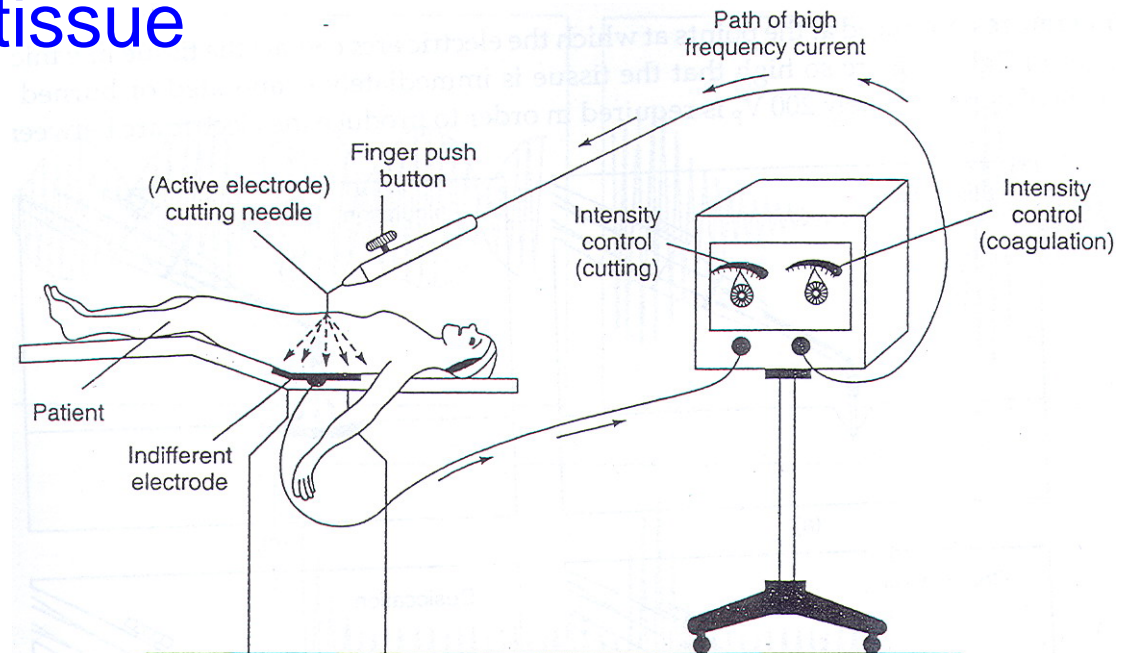


# **Electrosurgical Unit (ESU) “Diathermy Machine”**

# Principle of Electrosurgical Unit

- ❖ An ESU is an AC source that operated at a radio frequency (RF) in the range between **300 kHz** and **3 MHz**
- ❖ It depends on the heating effect of a high frequency electrical current which flows through the sharp edge of a wire loop or band loop or a point of a needle into the tissue

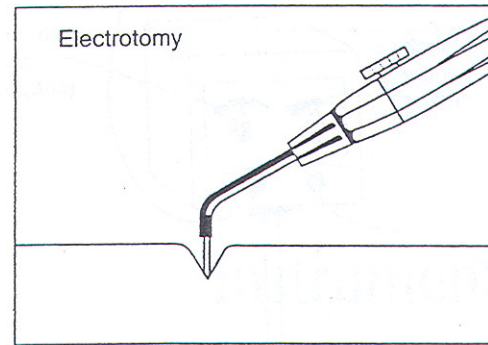
Principle of surgical diathermy machine



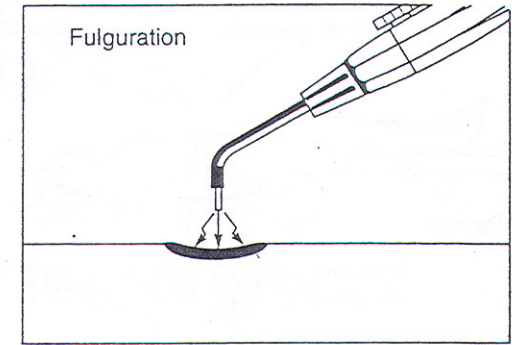
# Principle of Electrosurgical Unit

❖ It used for:

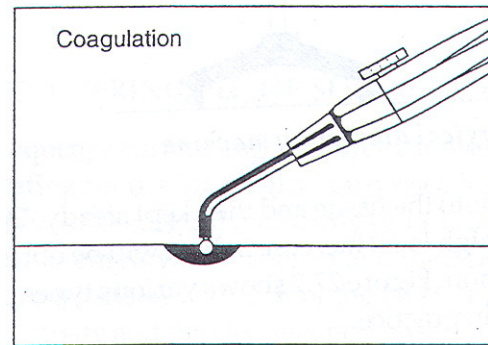
- Cutting (a)
- Coagulation (c)
- Fulguration (b)
- Desiccation (d)



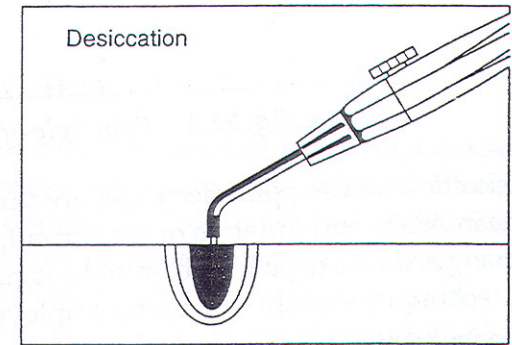
(a)



(b)



(c)



(d)

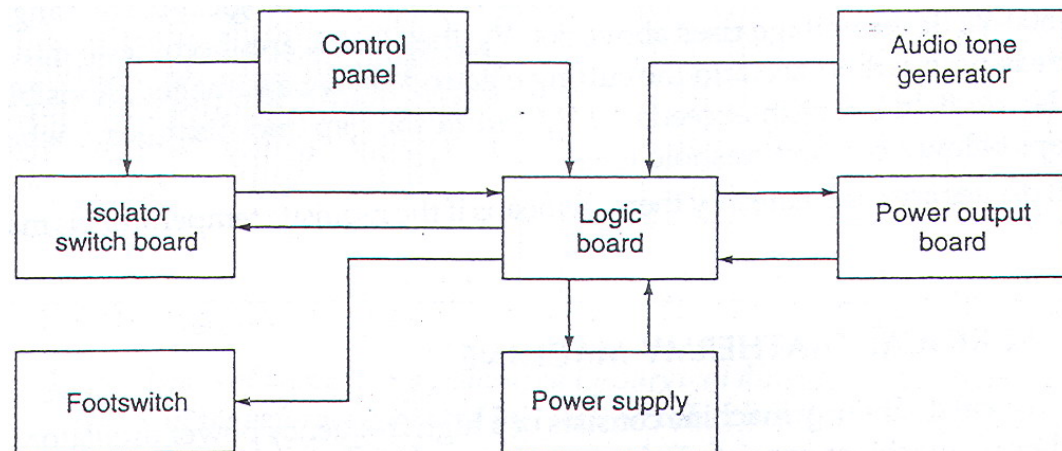
Various types of electro-surgery techniques

# Surgical diathermy machine

- ❖ An ESU consists basically of a high frequency power oscillator
  - Spark-gap oscillator: damped high frequency current which is specifically suitable for the coagulation of all kinds of tissues
  - Solid-state oscillator: undamped high frequency current which is suitable for making clean cutting

# Solid-state ESU

- ❖ The heart of system is the logic and control part which produce the basic signal and provides various timing signals for the cutting, coagulation and haemostasis modes of operation
  - Frequency range is from *250 kHz* to *1 MHz*
  - In the cutting it delivers *400 W* in *500 Ω* load at *2000 V*
  - In the coagulation it delivers *150 W*
  - The output circuit in ESU is generally isolated and carefully insulated from low frequency primary and secondary voltage by mean capacitors

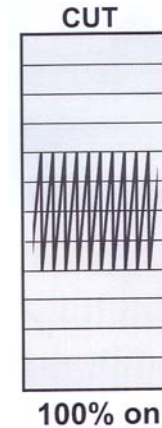


Block diagram of solid-state ESU

# ESU waveforms

## ❖ Waveform in cutting mode:

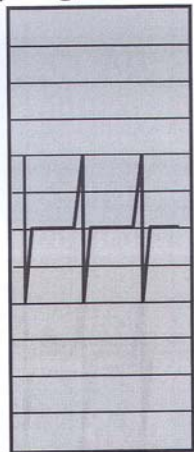
➤ 100 % on



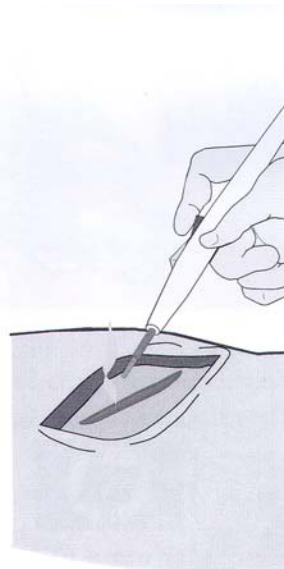
## ❖ Waveform in coagulation mode:

➤ 6 % on and 94 % off

COAG  
(Fulguration)

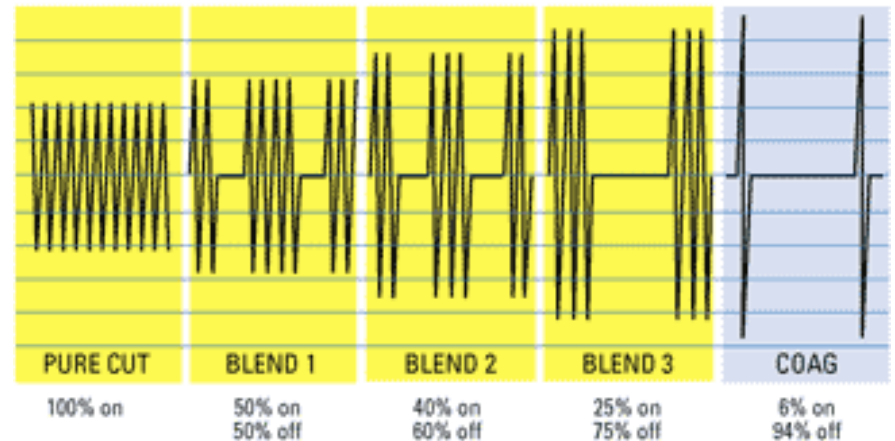


6% on  
94% off



Low Voltage

High Voltage



Typical example

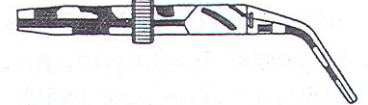
# ESU Electrodes

- ❖ Electrodes are connected to the RF power generator
- ❖ Switching on the high frequency current can be done with a **finger-tip switch** in the electrode or a **foot switch**
- ❖ Active electrode: small size (many mm in thickness, 1mm, and wideness, till 10 mm)

(a) Needle electrode



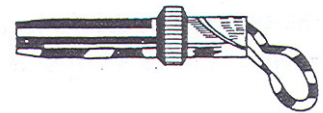
(b) Angulated lancet electrode



(c) Wire loop electrode



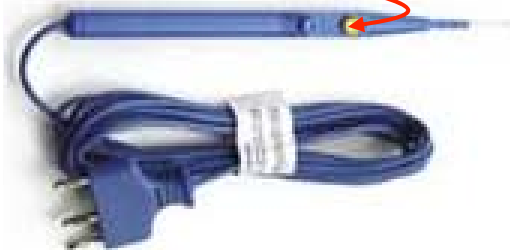
(d) Angulated band loop electrode



(e) Straight lancet electrode

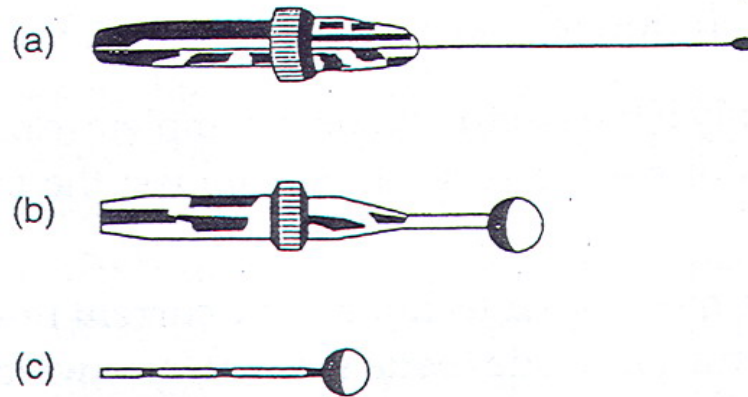


Cutting electrode used with diathermy machine



# ESU Electrodes

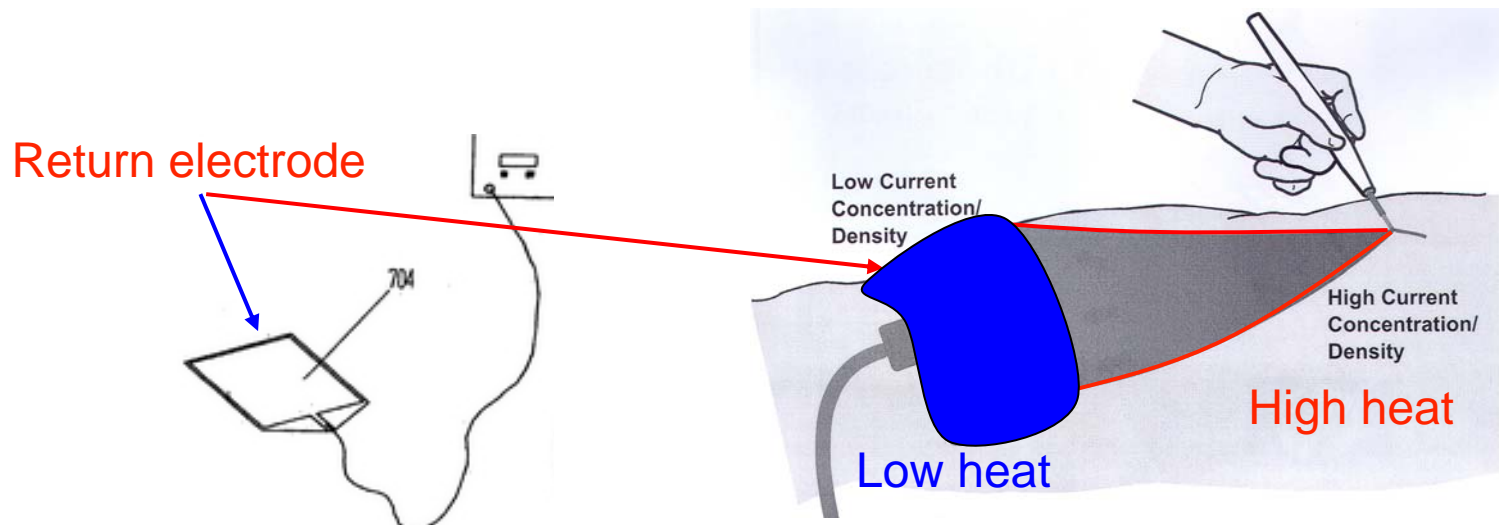
❖ Active electrode for coagulation:



Coagulation electrodes of different shapes and size

# ESU Electrodes

- ❖ Passive (Neutral, Return ) electrode: (disposable or reusable)
  - The function of the patient return electrode is to remove current from the patient safely
  - A return electrode burn occurs when the heat produced, over time, is not safely dissipated by the size or conductivity of the patient return electrode
  - Two points are of practical importance:
    - ✓ Sufficiently large contact area.
    - ✓ High electrical conductivity between the body and electrode



# Active Electrode Resistance

- ❖ The amount of power delivered to the tissue for a given ESU voltage depends on the active electrode-to-skin resistance

$$R_E$$

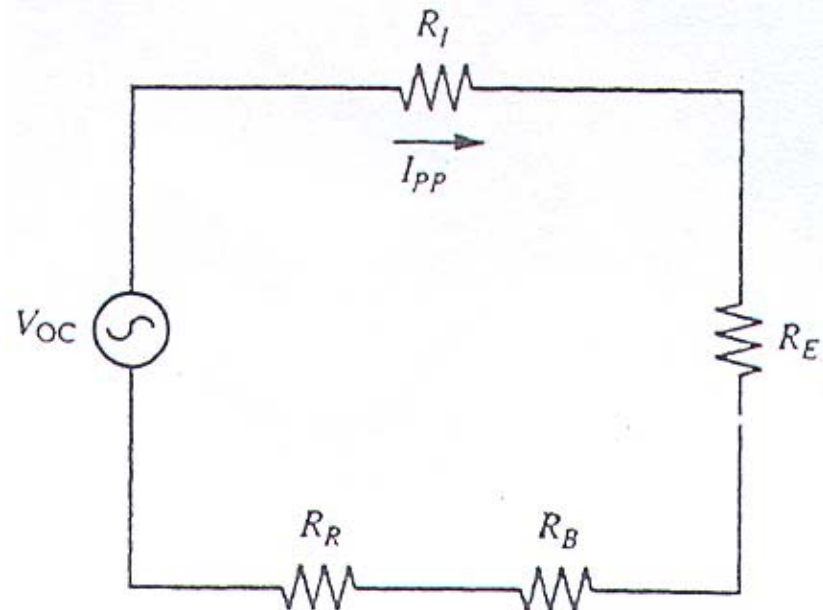
- ❖  $R_E$  varying depend on how much of the electrode actually contacts the tissue (changed or controlled by surgeon)

- $R_I, R_E$ : Internal resistance
- $R_B$ : Body resistance
- $R_R$ : Return electrode resistance

- ❖ The power dissipated by each of this resistances determines the cut, coagulation, warming or burning effect

- ❖ The maximum power delivered to the patient occurs when:

$$R_E = R_I + R_B + R_R$$

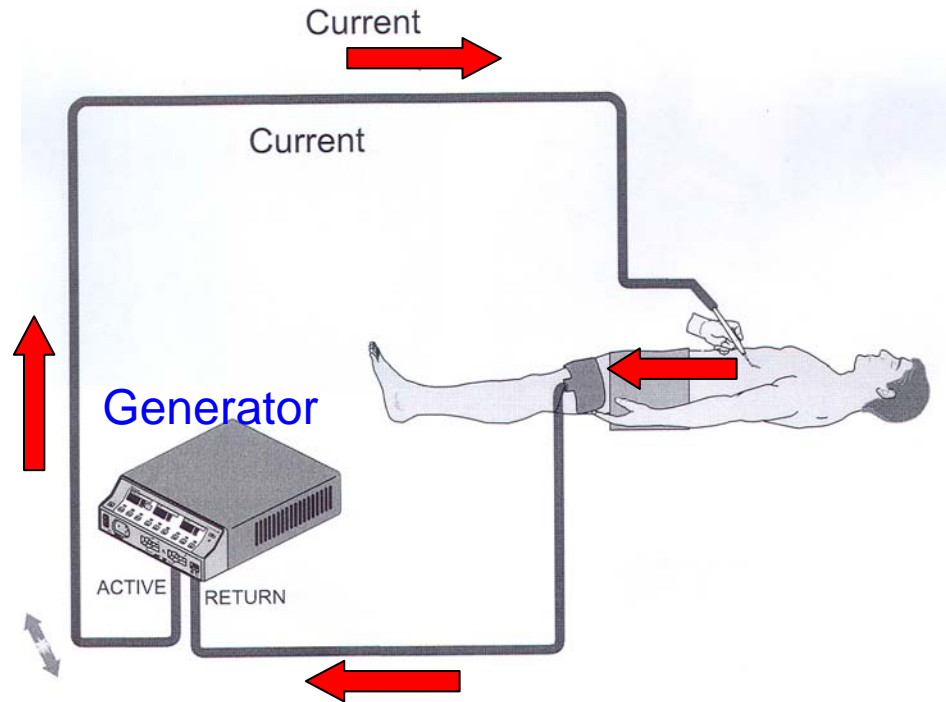


An ESU electrical equivalent circuit

# Electro-Surgery Techniques

- ❖ Mono-polar technique: the current flows from the generator to the active electrode through the patient to the neutral electrode (return electrode) from which it returns to the generator

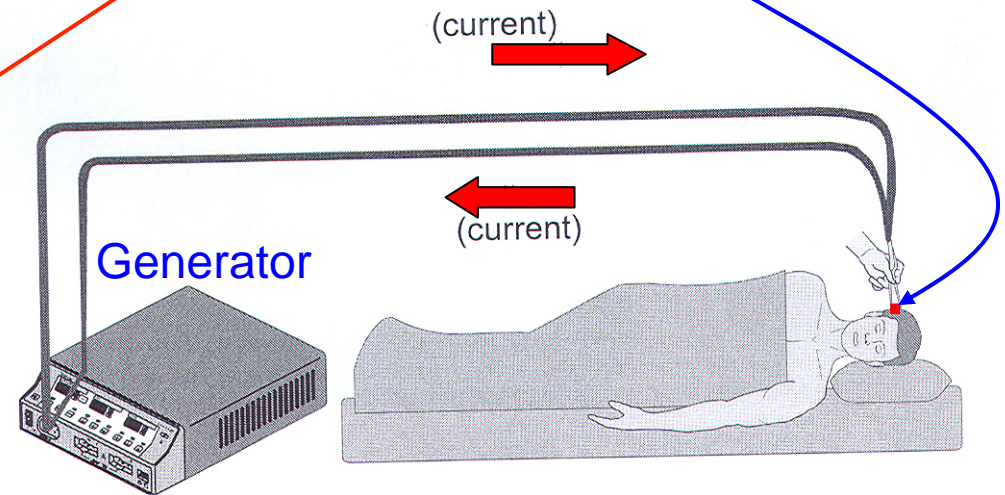
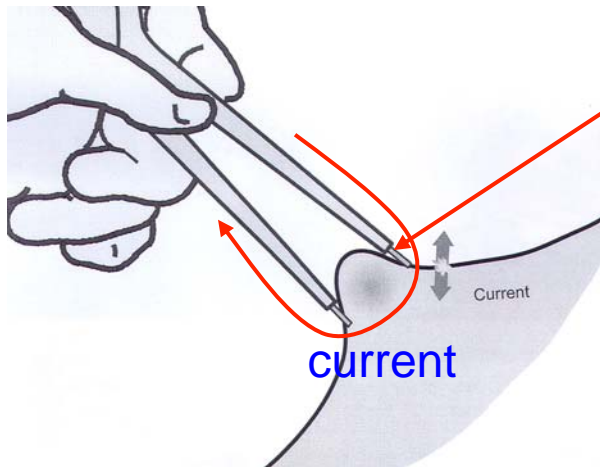
➤ **Generator** → **Active Electrode** → **Patient** → **Patient Return Electrode** → **Generator**



# Electro-Surgery Techniques

- ❖ Bi-polar technique: two electrodes are used. The current flows through the tissue between the tips of the two electrodes and returns to the generator without passage the patient

➤ **Generator** → **Active Electrode** → **Electrodes tips** → **Generator**



# Safety aspects in electro-surgical unit

- ❖ Burns: caused by excess current density
- ❖ High frequency current hazard
- ❖ Explosion hazards: sparks with ether, alcohol, explosive anesthetic gas,...