EE 4BD4 Lecture 25

Electrosurgery

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Overview

- An electrosurgical unit (ESU) delivers high frequency electric current, 100kHz to 5 MHz, to tissue through a small “active” electrode, with the current returning to the device through a large “passive” electrode
- To provide a mechanism for both cutting tissue and cauterization resulting in “bloodless” surgery
- Can also supply this current through endoscopic or laparoscopic equipment
- Degree of heating depends on tissue resistivity and current density

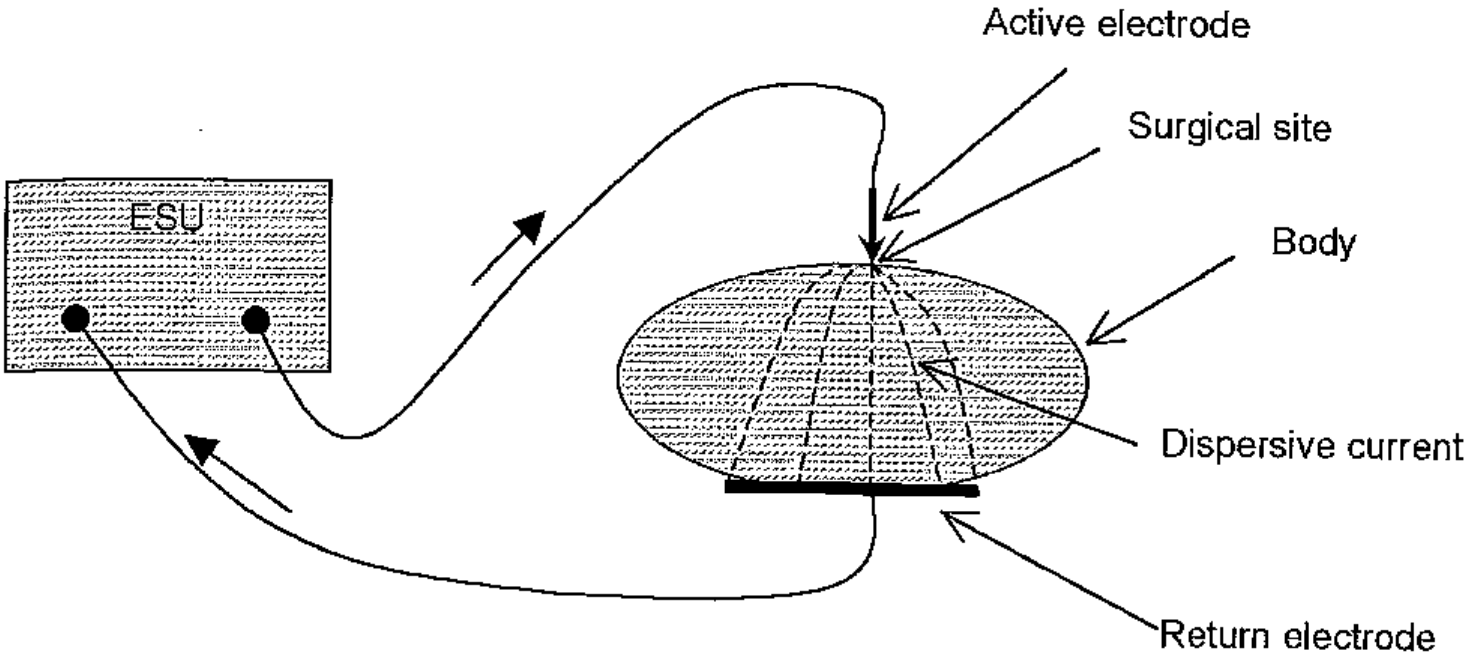

Figure 24–1. Electrosurgery Setup.

Table 24–1.
Tissue Effect of RF Current Density.

Current Density	*Tissue Effect*
> 50 mA/cm^2	Reddening of tissue
> 80 mA/cm^2	Pain and blistering
> 100 mA/cm^2	Intense pain
> 400 mA/cm^2	Second-degree burn

Modes of Operation

- Desiccation – low RF current causes destruction and of cells – may have steam and bubbles with tissue turning brown
- Cutting – separating electrode about 1 mm from tissue and maintaining 100 V between electrodes. RF current jumps gap creating plasma with cells exploding – 500 kHz continuous sine wave with high power output
- Fulguration – touch tissue ,withdraw several mm, no cells exploding but heat causes necrosis charring tissue, current goes deeper into tissue, medium power

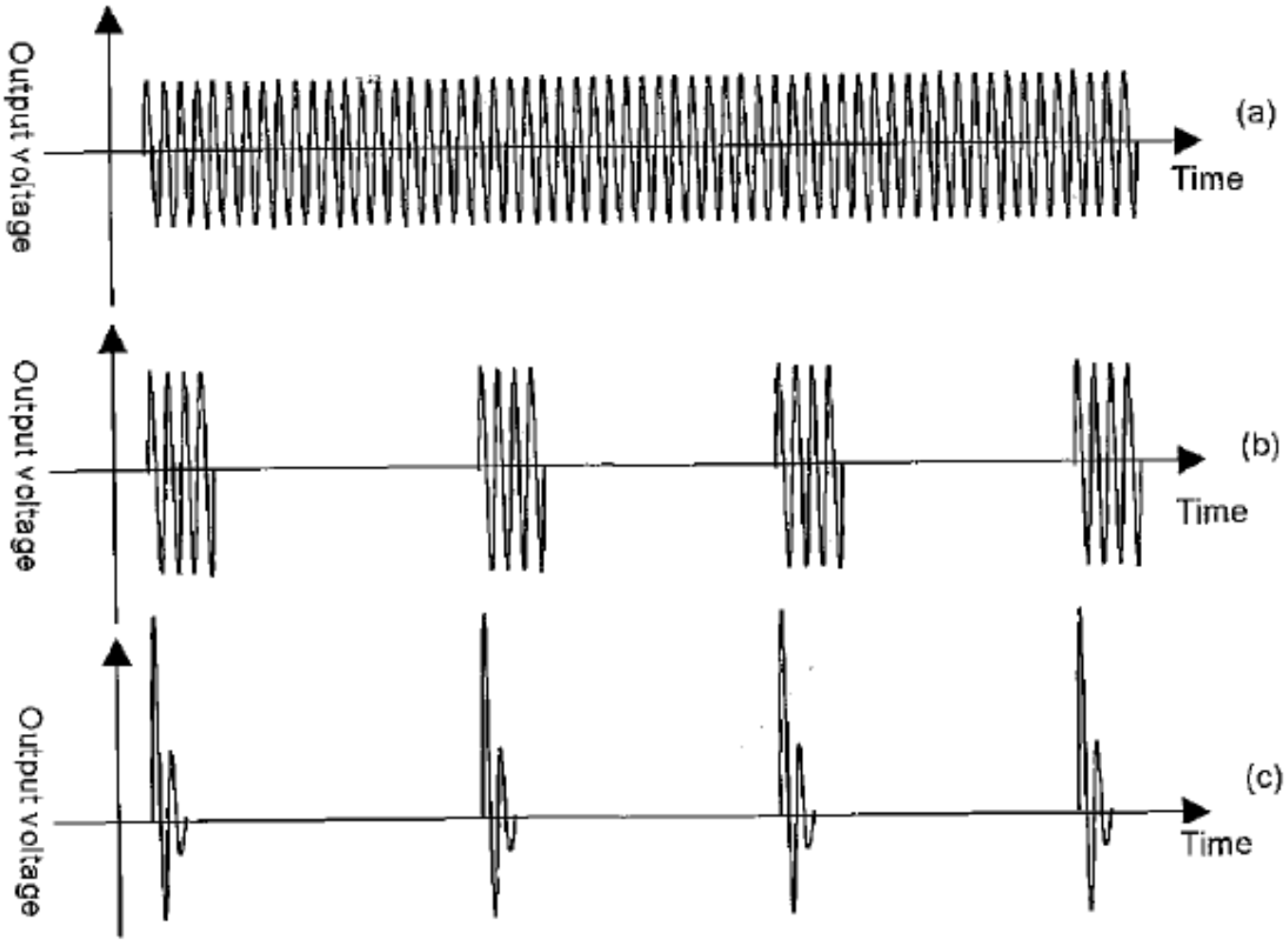

Figure 24-2. ESU Output Waveforms. (a) Cut, (b) Blended, (c) Coagulation.

Electrosurgical Active Electrode ("Pencil")

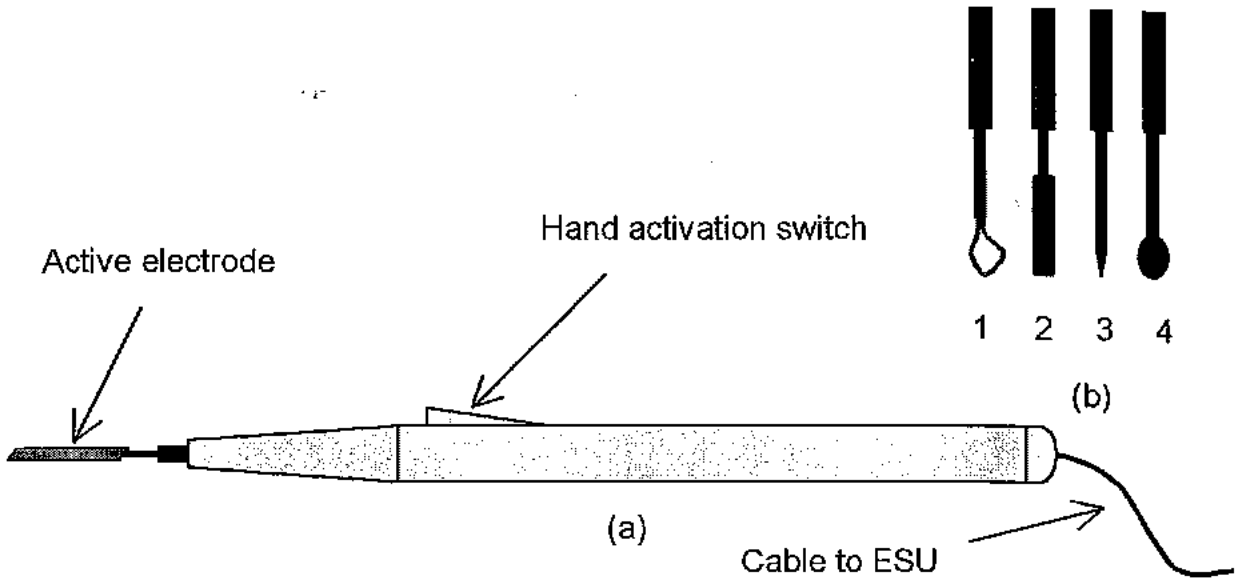

Figure 24–4. (a) Hand-Switched ESU Pencil with a Flat Blade Electrode; (b) Monopolar Tips: 1) Loop, 2) Flat Blade, 3) Needle, 4) Ball.

Operating Modes

- Crest factor is peak voltage/rms voltage

Table 24–3.
Characteristics of ESU Operation Modes.

	Effect	*Waveform*	*Voltage*	*Power*	*Crest Factor*
Monopolar					
Cut	Pure incision plus slight hemostatic effect	Continuous unmodulated sine wave to lightly modulated sine wave	Low	High	~1.41 to 2
Coagulation	Desiccation or fulguration	Burst of damped sine wave	High	Low	~9
Blended	Cut and coagulation	Burst of medium duty factor sine wave	Medium	Medium	Between cut and coagulation
Bipolar					
Coagulation	Desiccation	Continuous unmodulated sine wave	Lowest	Lowest	1.41

Bipolar Operation

- Used for very localized dessication as in the figure to avoid blood loss when vessel is cut

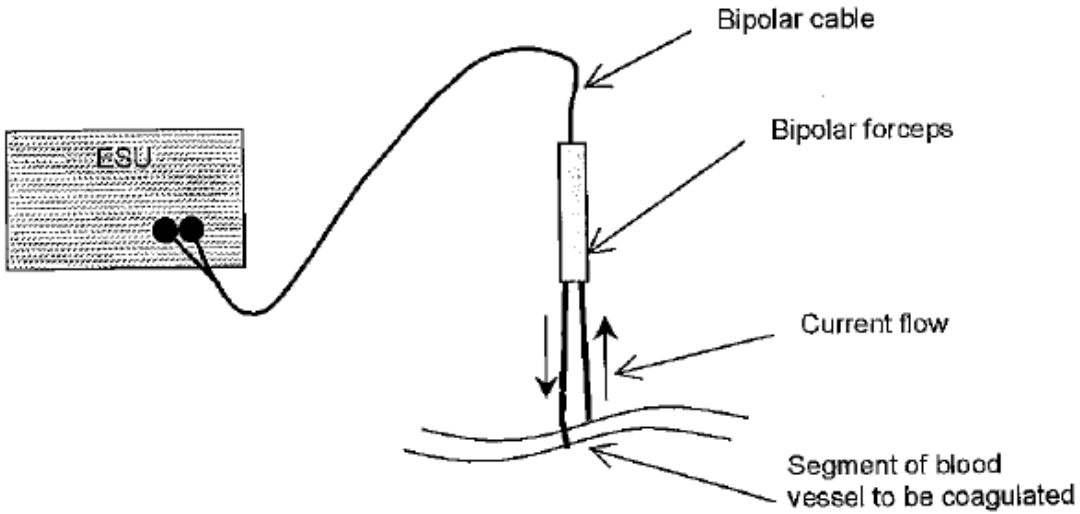

Figure 24–3. Bipolar Mode of Electrosurgery.

Return Electrode for Monopolar

- Maximum current density to avoid tissue damage is 50 ma/cm^2
- Need large surface electrode (e.g. 100 cm^2)
- Ordinary flat plate under patient caused burns
- Now gel electrode pads

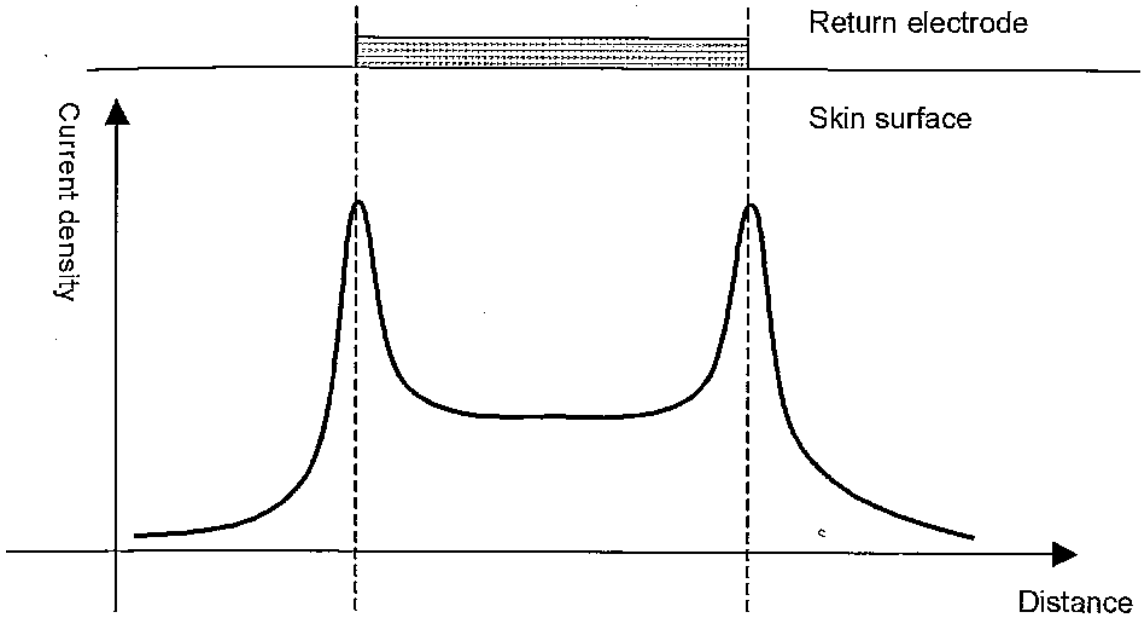

Figure 24–5. Current Density Crossing the Return Electrode–Skin Interface.

Standards for Return Electrode

- ANSI/AAMI HF18 states overall tissue-return electrode resistance shall be below 75 Ω
- No part of tissue in contact with return electrode shall have more than 6^{O} C temperature increase when the ESU is activated continuously for up to 60 sec with output up to 700 mA

Return Electrode Monitor

- REM checks contiuity of electrode cable using low frequency (140 kHz 3ma typical) signal
- High resistance (>20 Ω) triggers alarm
- REQM Return Electrode Quality Monitor uses a double return path and checks cable plus electrode contact using same waveform
- Resistance > 135 Ω or < 5 Ω indicate poor contact or electrolyte/pad bridging

REM and REQM

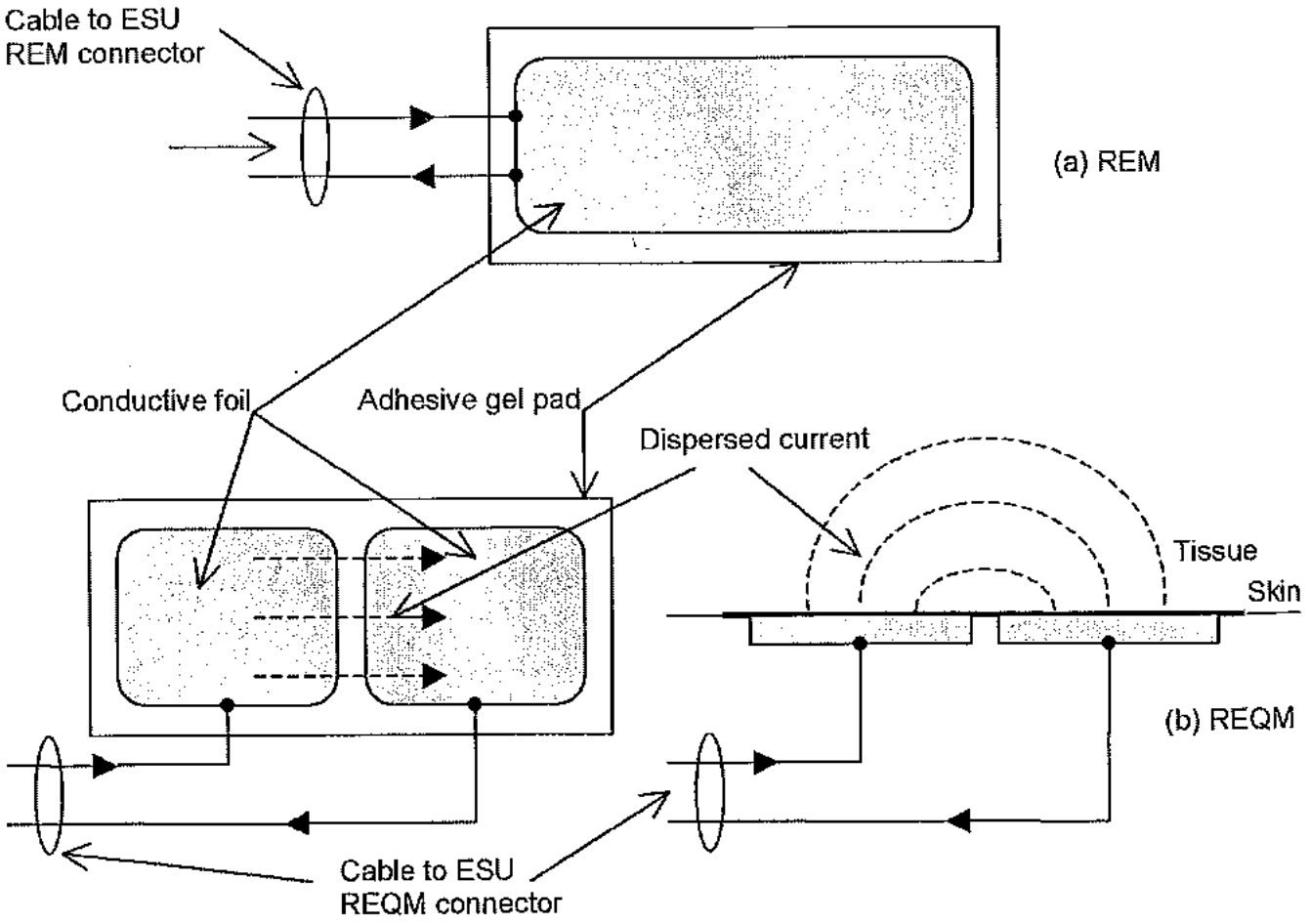

Figure 24–6. Return Electrode and Return Electrode Quality Monitors.

Functional Block of ESU

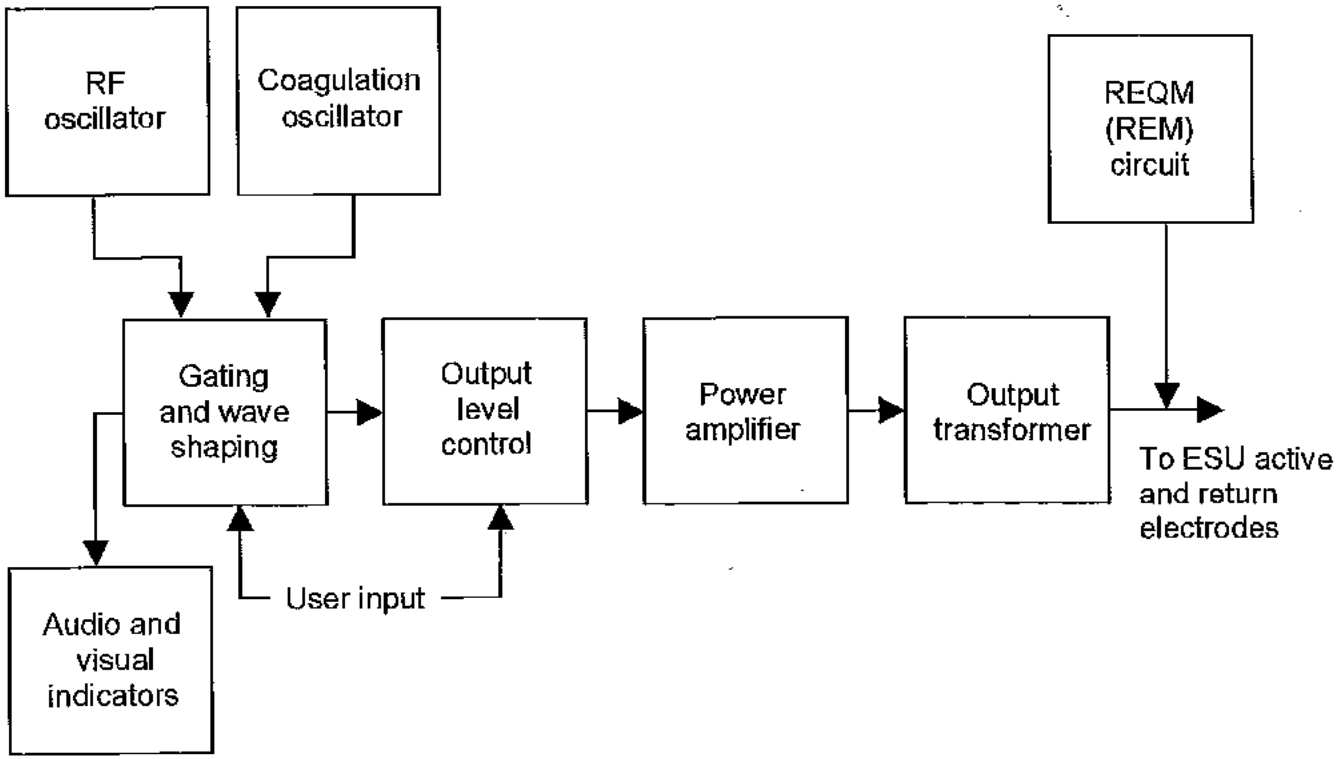

Figure 24–8. Functional Block Diagram of an ESU.

Output Stage

- Output can go to 1000 watts, 9000 V (peak to peak open circuit) and 10 amps

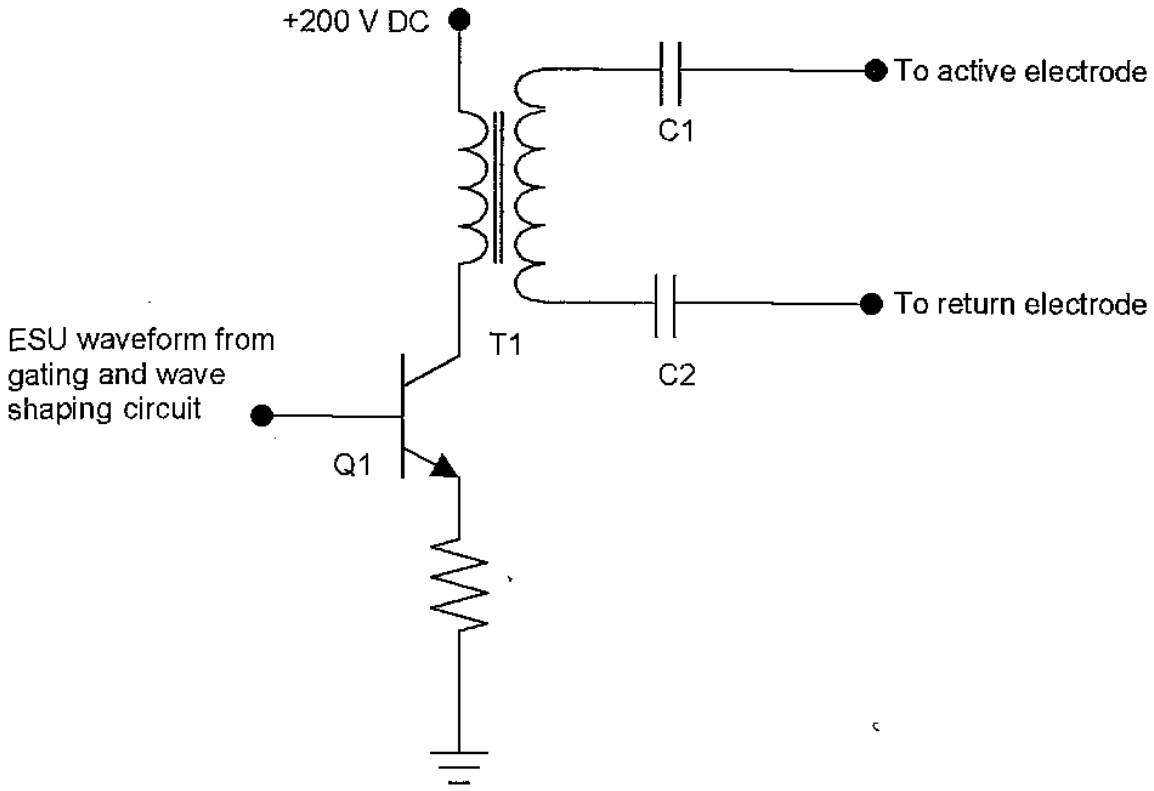

Figure 24–9. ESU Output Circuit.