DIATHERMY UNITS

HIGH FREQUENCY HEAT THERAPY:
The dipole molecules of the body are normally placed randomly. Under electric field, they rotate in the direction of the field lines so that the positively charged end of the dipole then orients itself to the minus pole and the negatively charge end to the plus pole. Since the polarity of the electric field alternates, the molecules realign continuously resulting in microheating.

With high frequency energy, deeper lying tissues e.g. muscles, bones, internal organs can be provided heat.

The high frequency energy for heating is obtained by
1. Short wave therapy unit using either condenser field or inductor field method.
2. Microwave
3. Ultrasonic waves.

ADVANTAGES OF DIATHERMY:
“Diathermy” means “through heating” or producing deep heating directly in the tissues of the body.

1. Externally applied heat sources like hot towels, IR lamps and electric heating pads often produce discomfort and skin burn long before adequate heat has penetrated to the deeper tissues. But with diathermy heat is produced within the body and not transferred through the skin.

2. The treatment can be controlled precisely since heat can be localized to region to be heated by careful placement of the electrodes and amount of heat can be closely adjusted through circuit parameters.

3. High frequency currents do not stimulate motor or sensor nerves and do not produce any muscle contraction hence no discomfort is caused to the subject.

4. Since the current is alternating, tissue currents of much greater intensity can be passed to produce direct heating in the tissues.

SHORT WAVE DIATHERMY:
The figure 5.4 shows the circuit diagram of a short wave diathermy unit. A step-up transformer (T1) with primary connected to mains supply, provides EHT for the anode of a triode valve and heating current for cathode of the triode valve. The coil AB in parallel with the condenser C1 forms a tank circuit. The coil CD generates positive feedback. Another coil (EF) and a variable condenser (C2) form the patient’s resonator circuit due to its coupling with the oscillator coil AB. The oscillator circuit and the patient’s resonator circuit are tuned with each other by adjusting variable condenser (C2) to achieve maximum reading on the ammeter.

The triode current conducts during positive half cycle and high frequency is generated only during this period. High frequency 27.12MHz and wavelength = 11m is produced continuously and hence more power is available if supply voltage is rectified before applying to the anode. The max. power delivered by these machines is 500W. The anode supply of the circuit is around 4000W.
A thermal delay in the anode supply prevents the passage of the current through this circuit until the filament of the valve attains adequate temperature. The patient circuit is then switched ON followed by a steady increase of current through the patient.

The current supplied to the patient can be regulated by
1. Controlling anode voltage
2. Controlling filament heating current
3. Adjusting grid bias by change of grid leak resistance (R)
4. Adjusting the position of resonator coil w.r.t oscillator coil.

**Automatic tuning:**

Any short wave therapy unit gives out desired energy to the patient only if the unit is correctly tuned to the electrical values of the part of the body. Therefore, the tuning must be carefully carried out at the beginning of the treatment and continuously monitored during treatment.

The tuning gets affected due to the unavoidable involuntary movements of the patient. The RF current in the patient circuit changes a capacitor to a voltage whose polarity and magnitude indicates detuning. This voltage moves a servomotor and adjusts the tuning capacitor so that resonance is restored.

**Application technique:**
1. Capacitor plate method
2. Inductive method

**Capacitor plate method or condenser method:**

The output of the short-wave diathermy machine is connected to the metal electrodes (called pads) positioned so that portion of the body to be treated is sandwiched between them Ref fig. 5.5 usually layers of towels are interspersed between the electrodes and the surface of the body, so that these pads or electrodes do not directly contact the skin.

The metal pads act as two plates while the body tissues between the pads, acts as dielectric. When the RF output is applied to the pads, the dielectric losses due to the vibration of ions and rotation of dipoles in the tissue fluids and molecular distortion in tissues, manifest as heat in the intervening tissues.

**Inductive method:**

The output of diathermy is connected to a flexible cable instead of pads (Ref. fig. 5.6). This cable is coiled around the arm, knee or any other portion of the patient’s body where plate electrodes are inconvenient to use.

When RF current is passed through the cable, an electrostatic field is setup between its ends and a magnetic field around its center. The electrostatic field results in deep heating and eddy currents set up by magnetic field, provides heating of superficial tissues. This technique is known as inductothermy.

**Advantages:**
When currents having very high frequencies, the motor or sensory nerves are not stimulated and there is no contraction of the muscles. Thus there is no discomfort to the patient.

**Disadvantages:**

Though most short-wave diathermy machines have output power control, there is no indication of the amount converted and absorbed heat within the body tissues. Therefore intensity of treatment depends on the subjective sensation of warmth felt by the patient.

**MICROWAVE DIATHERMY**

**Microwave:**

They are electromagnetic radiation with frequency range of 300 – 30000MHz and wavelengths varying from 10mm to 1m. They lie between short waves and IR rays in the electromagnetic spectrum.

The most used microwave frequency for therapeutic heating is 2450MHz corresponding to a wavelength of 12.25cm.

**Principle:**

Microwave diathermy involves irradiating the tissues of the patient’s body with microwave. The duration of irradiation ranges from 10 – 25 min. These waves pass through the intervening air space and are absorbed by the surface of the body. The heating effect is produced by the absorption. Microwave is produced using magnetron.

**Production of microwaves:**

A magnetron has a cylindrical cathode surrounded by an anode structure containing cavities opening into the cathode-anode space through slots. The output energy is picked up from the resonator system through a coupling loop forced into one of the cavities and is carried out of the magnetron, to a director through a cable.

The director has an antenna which transforms the current into electromagnetic radiation and a reflector which focuses the electromagnetic energy to the tissues of the patient. The tissue absorbs, reflects or refracts the electromagnetic energy according to the electrical properties of the tissues.

The tissues of the lower water content (i.e. subcutaneous) absorb less electromagnetic energy whereas the tissues of high water content (i.e. muscle) absorb more electromagnetic energy.

The output power of magnetron depends on anode voltage, magnetic field and magnitude and phase of the load impedance to which the magnetron output power is delivered.

A part of the energy fed to the magnetron is converted into heat in the anode, due to collision of the electrons with the anode. Hence output energy is less than the input energy and the efficiency of the magnetron is usually 40 to 60%. The heat produced is removed using water or air as means of cooling.
The figure 5.7 shows the schematic circuit diagram of microwave diathermy unit. The mains supply is applied to an interference suppression filter which helps to bypass the high frequency pick-up generated by the magnetron.

**Delay circuit:** The magnetron has to warm up for 3-4 min before power is derived from it. A delay circuit connects anode supply to the magnetron and a lamp lights up indicating that the apparatus is read for use after 4 minutes.

**Magnetron circuit:** The magnetron filament heating voltage is obtained directly from a separate secondary winding of a transformer. The filament cathode circuit has interference suppression filters. The anode supply to the magnetron can be DC or AC. DC voltage is obtained by a full wave rectifier followed by a voltage doubler circuit. A high wattage variable resistance, connected in series controls the current applied to the anode.

When using AC, the voltage is applied to the anode through a series is connected thyatron so that AC voltages of both tubes are equal in phase. By shifting the phase of the control grid voltage w.r.t the phase of the anode voltage, the amount of current through the magnetron and hence the output power can be varied. The phase shift is achieved using a capacitor resistor network.

**Safety circuit:** A fuse (500mA) is inserted in the anode supply circuit of the magnetron, to protect the magnetron from damage due to excessive flow of current. The considerable interference produced by the apparatus necessitates the use of large self-inductance coils in the primary supply. Since the cores become saturated due to the small dimensions, the coils are split up and fitted such that there is no magnetization.

**Advantage:**

1. The technique of application of microwave diathermy is very simple and does not require tuning for individual treatments. Since microwaves are transmitted from an emitter and directed towards the portion of the body to be treated directly.
2. Better therapeutic results are obtained by using microwave diathermy than short wave diathermy.
3. There is no pad shaped electrode.

**Limitations:**

1. Excessive dosage can cause skin burns and in all cases the sensation experienced by patient is primary guide for application.
2. Skin should be dry as these waves are rapidly absorbed by water.

**ULTRASONIC THERAPY UNIT**

The figure 5.8 shows the block diagram of the ultrasonic therapy unit.

**Timer:**

A mechanical spring loaded type time or a electronic timer is used to switch on the circuit so that ultrasound power is delivered to the patient for a given time. This timer allows time setting from 0-30 minutees.

**Half wave rectifier and full wave rectifier:**
The machine is operated in continuous or pulsed mode.

In pulsed mode, the oscillator supply is provided by passing mains supply through a half wave rectifier and oscillator get supply only for a half cycle. Hence output 1MHz is produced only for one half of the cycle and is pulsed.

In continuous mode, the oscillator supply is provided by passing mains supply through a full wave rectifier. Hence the supply voltage is at 100Hz (2 times the 50Hz) which causes the output 1MHz to amplitude modulated by this 100Hz.

**Timed oscillator:**

The timed oscillator produces the electrical oscillations of high frequency 0.75-3MHz. The output of the oscillator can be controlled by

(a) Using a transformer with a primary winding having multi-tapped windings and switching them as per the requirement.

(b) Controlling the firing angle of a triac placed in the primary circuit of the transformer and thereby varying the output of the transformer. The power output in the case of triac controlled machine can be continuously varied from 0-3W/cm².

**Power amplifier:**

The oscillator output is given to a power amplifier. Power amplification is achieved by replacing the transistor in a typical LC tuned colpitt oscillator by four power transistors placed in bridge configuration.

**Piezoelectric crystal:**

The power amplifier drives a piezoelectric crystal to generate ultrasound wave. The voltage is applied to the crystal through a metal electrode pressed against its back surface by a coiled spring. A front diaphragm is grounded and provides return path for the excitation voltage.

A metal face plate in front of the crystal vibrates the by the oscillations of the crystal and emits ultrasonic waves.

**Transducer:**

A cable connects the oscillator with a transducer. The length of the cable is of critical dimension and should not be altered. The acoustic vibration of the crystal causes mechanical vibration of a transducer head located directly in front of the crystal.

The crystal may be barium titanate or lead zirconate titanate crystal having 5-6cm² effective radiating area.

These mechanical vibrations then pass through a metal cap and into the body tissue through a coupling medium. The therapeutic ultrasonic intensity varies from 0.5 – 3.0 W/cm². Applicators range from 70 to 130 mm in diameter. The larger the diameter of the applicator, the smaller would be the angle of divergence of the beam and the less the degree of penetration.

**Effects of ultrasonics:**

1. Heating effect due to the ultrasonic energy absorption property of the tissues.
2. Direct mechanical effect (high speed vibration of micromassage used in the treatment of soft tissue lesions).
The thermal effects are dependent on the amount of energy absorbed, length of time of the ultrasound application and the frequency of the ultrasound generator.

**Dosage control:**

The dosage can be controlled by varying the

1. Frequency of ultrasound
2. Intensity of ultrasound
3. Duration of exposure

**Frequency of ultrasound:**

The absorption of ultrasonics by the tissues is frequency dependent. Higher the frequency, the quicker the energy loss and less is the penetration. A frequency below 1MHz, the ultrasonic energy beams diffuse and there is no efficient treatment. Therefore the frequency in the range of 800 KHz to 1MHz is most widely adopted.

**Intensity of ultrasound:**

The therapeutic ultrasonic intensity is varied from 0.5 – 3W/cm² of the transducer area that is in contact with the part of the body to be treated. The intensity is in terms of electric power converted into acoustic energy.

Some instruments have dose tabulator having a dose mark for every indication (disease). By setting pointer appropriately it is ensured that the apparatus is providing correct output intensity.

**Duration of exposure:**

The predominant effect of ultrasound is direct mechanical effect (micromassage) and not heating effect. The thermal effect is reduced by repeatedly interrupting the supply of energy through brief pauses.

**Application technique:**

For long areas, the probe is moved up and down for small areas, a circular motion if given to obtain uniform distribution of ultrasonic energy.

The probe is put in direct contact with the body through a couplant if the to-be-treated part is smooth and uninjured.

If there is wound or uneven part (joints etc) the treatment is done in warm water bath so as to avoid mechanical contact with the tissues which may damage the already injured surface. It should be ensured that the air bubbles are not present on probe or skin. The to-be-treated body is rubbed with alcohol or soaped. The probe is held at a distance of 1-2cm from the area under treatment and moved over the area to be treated. This method is not generally preferred because exact amount of dosage is difficult to control.

**Advantages:**

1. Ultrasonic energy enables this massage to be carried out to greater depth than is possible manually and in acute injuries when pressure cannot be exerted by hand because of intolerable pain caused to the patient.
2. Unlike the operation of a short wave therapy unit, tuning is not needed during treatment.

3. The operating frequency is also not very critical and may vary to the extent ±10%.

Use:

It is used where shortwave treatment failed and in cases where localizing of heat is required. It is very useful in curing of diseases of peripheral nervous system like neuritis, skeletal muscle system like arthritis and skin like ulcers.