OPERATOR'S MANUAL

METRON ACCUSONIC 1 & 3 MHz ULTRASOUND THERAPY UNIT

MODEL AC 450

Prepared by
Metron Medical Australia P/L
Version 2.2 May 1998

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The Metron Accusonic 1 & 3 MHz Ultrasound Therapy Unit bears the above marking in accordance with the requirements of Council Directive 93/42/EEC.

Should you as the purchaser and/or user of this product wish to make any comment about the product or the manner in which it may be used our Authorised Representative within the European Union may be contacted as follows:

Metron Medical
Attention: Mrs Sue Marks
P.O. Box 5399
Southend-On-Sea
ESSEX SS1 3RY UNITED KINGDOM

WARRANTY STATEMENT

Metron Medical Australia Pty Ltd., will warrant this device/instrument/appliance (excluding accessories) against defects in manufacture for a period of two years from the date of purchase.

Accessories including patient leads, cables and electrodes will be covered under this warranty for a period of three months from the date of purchase.

- PROVIDING -

The instrument has not been serviced by persons not authorised by Metron Medical Australia Pty Ltd., and has not been misused or tampered with and has been used on the correct voltage as branded on it.

- THIS WARRANTY EXCLUDES -

Parts of the device/instrument/appliance failure of which in the opinion of the dealer of manufacturer is a result of misuses or abuse or any other reason not directly attributed to fault in manufacture. Batteries are excluded from this warranty except where it can be demonstrated that any battery failure was caused by a malfunction in the Microsonic. This warranty also excludes glass or ceramic portions.

- IN THE EVENT OF FAILURE -

The complete device/instrument/appliance should be returned to the dealer from which it was purchased or to the nearest authorised service agent, together with a full report, freight paid and insured.

- UNDER NO CIRCUMSTANCES -

Shall Metron Medical Australia Pty Ltd., or their agents or dealers be liable in any manner whatsoever for any compensation or damages to any person occasioned by this device/instrument/appliance for any loss, injury or any damage occasioned by or as a result of the misuse or abuse of this device/instrument/appliance.

- LOSS IN TRANSIT -

The warrantor does not accept any responsibility for loss or damage to the device/instrument/appliance in transit.

Any express or applied conditions, statements or warranty, statutory or otherwise (save specifically provided above) is hereby excluded.

Metron Medical Australia Pty. Ltd.

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EC DECLARATION OF CONFORMITY

Metron Medical Australia Pty Ltd
57 Aster Avenue
Carrum Downs, Australia, 3201

declares that the medical devices described hereafter:

Metron Accusonic and Metron Accusonic 1 & 3
Ultrasound Therapy Units

Models: AS 250 & AC 450

are in conformity with the essential requirements and provisions of Council Directive 93/42/EEC

are subject to the procedure set out in Annex II of Directive 93/42/EEC under the supervision of Notified Body Number 0120, SGS Yarsley International Certification Services Ltd, Portland Road, East Grimstead, W Sussex RH19 4ET.

Melbourne, 25 November 1998

R. H. Hopkins
Technical Director

On Behalf Of
Metron Medical Australia Pty Ltd

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1. SPECIFICATIONS

MAINS SUPPLY REQUIREMENTS:

Voltage	100/110/120/200/220/240 Volts AC
Frequency	50/60 Hz
Power	60 VA

FUSES:

Primary external 100 V Series	2 of 1 A 5 x 20 mm DA205 Delay
or	
Primary external 200 V Series	2 of 500 mA 5 x 20 mm DA205 Delay
Secondary internal	2 of 2 A 5 x 20 mm M205

MAINS STEP-DOWN TRANSFORMER:

Manufactured to Australian Standard AS 3208 (1981) "Approval and Test Specification for Transformers in Electromedical Equipment" and tested to meet the requirements of international safety standards.

Secondary voltages	30 Volts C.T. 15 Volts @ 2A

ULTRASOUND OUTPUT:

Frequency	1.1 MHz +/- 10%
Output power in continuous mode	15 Watt +/- 10% maximum
Power/intensity display	accurate to +/- 10% of reading for output in excess of 1 Watt.
Effective Radiating Area	Nominally 5.0 square cms.
Frequency	3.0 MHz +/- 10%
Output power in continuous mode	2.4 Watt +/- 10% maximum
Power/intensity display	accurate to +/- 10% of reading.
Effective Radiating Area	Nominally 0.8 square cms.
Beam Non-Uniformity Ratio	Nominally 5:1

Ultrasound Modulation

Modulation modes	continuous or pulsed
Pulsed modulation:	
Pulse frequency	100 Hz
Pulse period	10 milliseconds
Pulse width	0.5, 1.0, 2.0 milliseconds
Pulse duty cycle	1:19, 1:9, 1:4 respectively

Treatment Timer

Maximum treatment time	19 minutes
At time expiration	time display shows zero and a four second audible alarm sounds.

Contact Control

Function	to detect poor acoustic coupling between ultrasonic treatment applicator and patient detected.
At detection of contact loss	the indicator on applicator illuminates red and after 1 second the treatment timer is halted, treatment time display flashes and ultrasonic output power is reduced from that selected to 1 Watt for 1MHz and 0.2 Watt for 3MHz.
At detection of contact	the treatment timer is restarted and ultrasonic output power is restored to the selected value.
Purpose/rationale	to ensure the patient receives the required ultrasound dose and to prevent damage to ultrasonic treatment applicator by the heat generated in ultrasonic transducer if it was operated unloaded.

ELECTRICAL SAFETY:

Manufactured to Australian Standards:

AS 3100	(1985)- Definitions and General Requirements of Electrical Materials and Equipment
AS 3208	(1981) - Approval and Test Specification Transformers in Electromedical Equipment
AS 3200.1	(1990) - Approval and Test Specification Medical Electrical Equipment Part 1: General Requirements
AS 3211	(1986) - Approval and Test Specification Ultrasonic Therapy Equipment

Patient Circuit:	Treatment applicators
Patient Circuit:	BF
Device Classification:	Class I Equipment

DIMENSIONS:

Width	370 mm
Height	130 mm
Depth	410 mm

WEIGHT:

Packed	7 Kg
Unpacked	6.5Kg

ENVIRONMENTAL CONDITIONS:

Operating:	Temperature Range	10 - 40 °C
	Relative Humidity	30% - 90%
Transport & Storage:	Temperature Range	0 - 70 °C
	Relative Humidity	10% - 100%

2. INTRODUCTION

Congratulations on the purchase of a Metron Accusonic Ultrasonic Therapy Unit. We are confident that it will provide many years of excellent performance.

This Operator's Manual presents all the relevant operator information for the Metron Accusonic Ultrasonic Therapy Unit. Refer to the Metron Accusonic Technical Manual for maintenance, calibration and repair information.

The Accusonic is a microcomputer controlled instrument. It comprises of the control unit and the ultrasonic treatment applicator. The control unit generates an electrical signal which is applied to an ultrasonic transducer. The ultrasonic transducer, bonded to the inside of the treatment applicator, converts the electrical signal into sound energy. This energy radiates from the flat applicator surface via acoustic coupling gel into the patient.

The control unit provides for operator setting of treatment time, continuous/pulse modulation modes and ultrasound output power/intensity. When used at 1MHz or 3MHz a contact control circuit monitors the integrity of acoustic coupling between the ultrasonic treatment applicator face and patient. If poor acoustic coupling is detected, the operator is alerted visually by illumination of the red warning light, the treatment time is halted and the ultrasound power is reduced to 1 Watt for 1MHz and 0.2 Watts for 3MHz. If good acoustic coupling is detected, the red light turns green, the treatment time counts down and ultrasound power is maintained until the timer displays zero. This feature ensures that the patient receives the required ultrasound dose and prevents damage to the ultrasonic treatment applicator by heat generated in the ultrasonic transducer when it is operated unloaded at high power levels.

3. QUALITY ASSURANCE

It is recommended that a program of regular and appropriate quality assurance including calibration and electrical safety inspections be instituted for this equipment. Calibration should be performed at 12 month intervals. Information on the type and frequency of electrical safety testing may be obtained from locally published Standards.

In Australia, the relevant Standards published by the Standards Association of Australia are:

AS 2500 (1986) - Guide to the Safe Use of Electricity in Patient Care

AS 3200.1 (1990) - Approval and Test Specification, Medical Electrical Equipment, Part 1: General Requirements

AS 3211 (1986) - Approval and Test Specification, Ultrasonic Therapy Equipment

AS 3551 (1988) - Acceptance Testing and In-Service Testing, Electromedical Equipment

A hospital Biomedical Engineering Department or a third party service organisation nominated by the manufacturer or distributor should be capable of performing the necessary calibration, testing and documentation. A program of electrical safety inspections is recommended to confirm continued operator and patient safety. Local statutory requirements for electrical safety inspections may also apply.

4. OPERATING WARNINGS

4.1 Electromagnetic Interference

The Accusonic complies with IEC 601-1-2: 1993 but this does not guarantee that other equipment in the vicinity will not be affected by the electromagnetic emissions from this unit., Similarly, other equipment in the vicinity may effect the operation of the Accusonic.

It is recommended that all equipment used near this unit complies with the relevant electromagnetic compatibility requirements for that equipment and to check before use that no interference is evident or disruptive. Increasing the distance between offending devices, and keeping interconnecting leads as short as possible will help reduce the effect.

4.2 Inflammable Gases and Anaesthetics

The Accusonic is **NOT SUITABLE** for use in the presence of inflammable gases and anesthetics

4.3 Open Wounds or Broken Tissue

The Accusonic treatment applicators have not been designed to be used on open wounds or broken skin. Use in the presence of these conditions is not recommended and is not an intended use of the device.

4.4 Prevention of Cross Infection

Even though the patient treatment applicators do not contact open wounds or broken skin it is still possible for them to carry infections by the mere fact that they contact bare skin.

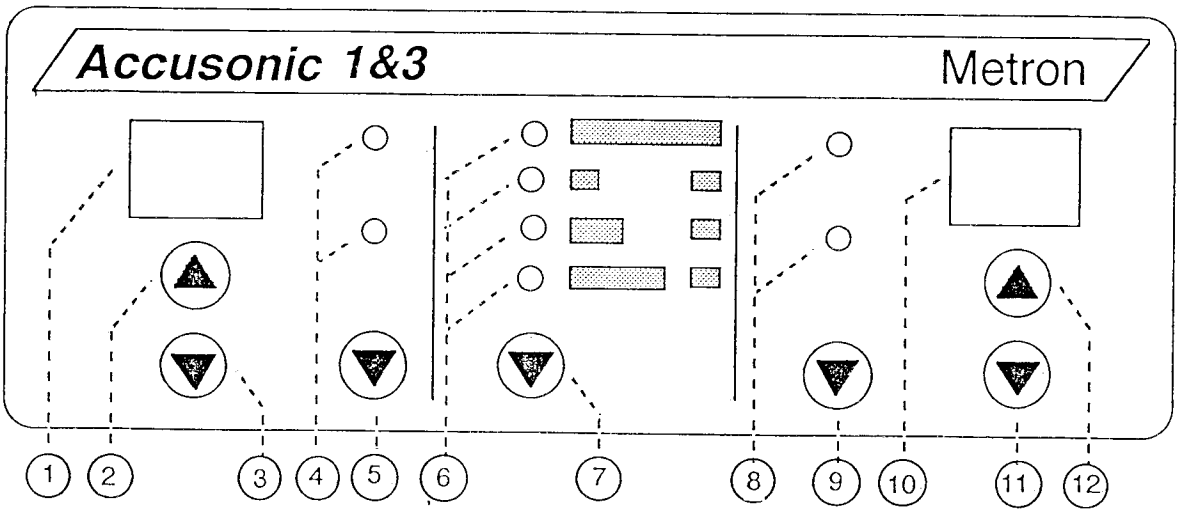
The applicators should be thoroughly cleaned after a treatment session with one patient is completed prior to a new session beginning with another patient. The treatment applicators are not suitable for autoclaving. See Section 5.6 for more specific cleaning details.

4.5 Damage to the Therapy Device

If when the unit is unpacked, or if it is mishandled at any stage of its life, and there appears to be physical damage to the machine it should not be used. Use should only commence or continue after it has been thoroughly checked by an appropriately qualified technician to ensure its functional and safety performance has not been impaired.

5. OPERATING INSTRUCTIONS

5.1 Front Panel - Controls and Indicators



1. Timer Display
2. Timer Up
3. Timer Down
4. 1MHz/3MHz Indicator
5. 1MHz / 3MHz Selector
6. Mode Indicator
7. Mode Selector
8. Output Scale Indicator
9. Output Scale Selector
10. Output Display
11. Output Down
12. Output Up

Note The following symbol is used on the front panel and is defined as follows:

This symbol indicates that the instructions for use should be consulted before operation is attempted.

5.2 Front Panel - Functions of Controls and Indicators

5.2.1 Treatment Timer

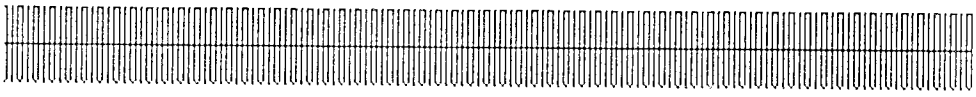
When the power is switched on, the timer display is reset to zero. Each single, momentary depression of the timer switches causes the timer display to respectively count up or down in one minute steps. The maximum timer setting is 19 minutes. Continuous depression of either switch causes the timer display to continuously auto-count. The timer will cycle from 19 to zero minutes after counting up to 19 and from zero to 19 minutes after counting down to zero.

The timer will not proceed to count down until a non-zero ultrasound output is selected. When the treatment time expires, the timer display will show zero and a two second audible alarm will sound.

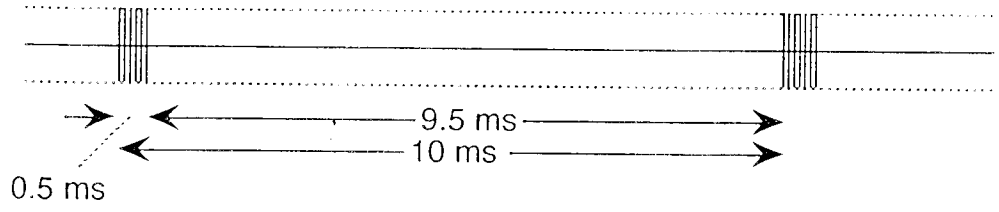
5.2.2 Continuous/Pulsed Mode Switch

When the power is switched on, the modulation mode display is reset to "Cont." (Continuous). Each single depression of the mode selector causes the modulation mode display to be cycled one place through the four selections available. The available modulation envelope selections are:

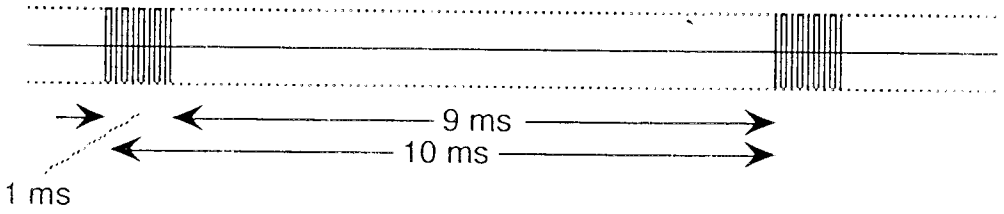
(a) **Cont.** - Continuous



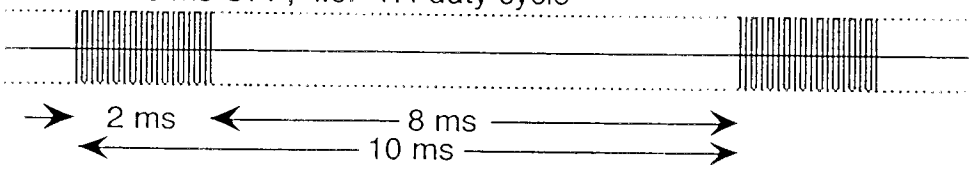
(b) **1:19** - 0.5 ms ON/9.5 ms OFF, i.e. 1:19 duty cycle



(c) **1:9** - 1 ms ON/9 ms OFF, i.e. 1:9 duty cycle



(d) **1:4** - 2 ms ON/8 ms OFF, i.e. 1:4 duty cycle



5.2.3 Ultrasound Output

When the power is switched on, the output display is reset to zero. Each momentary depression of the output switches causes the output display to respectively count up or down in 0.2 W/cm^2 or 1 Watt steps. The maximum setting is 3.0 W/cm^2 or 15 Watts @ 1MHz and 2.4 Watts @ 3MHz. Holding down these switches causes the output display to continuously auto-count. The output will not cycle from maximum to zero when counting up nor from zero to maximum when counting down. This is a safety feature designed to prevent accidental selection of maximum ultrasound output.

The output display shows the ultrasound intensity or power in the continuous modulation mode: thus when pulse modulation is selected, the display does not change. When the ultrasound output is automatically reduced during contact loss, the display does not change.

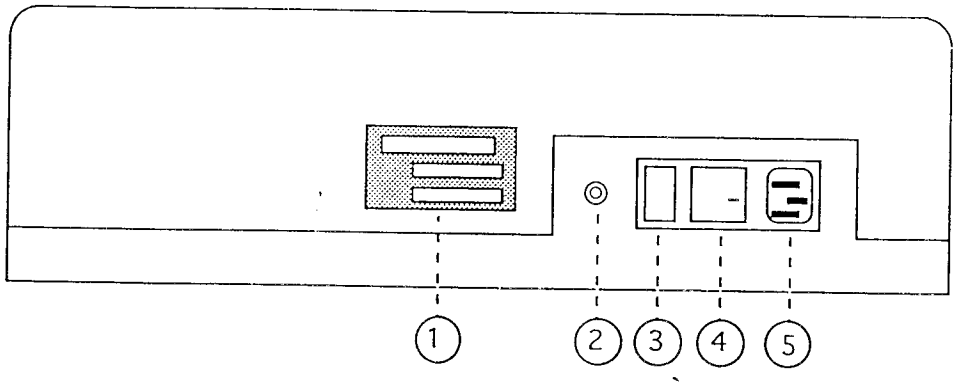
5.2.4 Output Scale Selection

When the power is switched on, the output display scale is reset to W/cm^2. Each momentary depression of the output display selector causes the output display scale to switch between W/cm^2 and Watts.

5.2.5 Output Frequency Selection

When the power is switched on the frequency will automatically set to 1MHz and by depressing the frequency down icon 3MHz may be selected.

5.3 Rear Panel



1. Equipment identification label
2. Muscle stimulator input socket
3. Mains fuses 0.5 Amp delay (200V Series) or 1Amp delay (100V Series)
4. Mains power on/off switch Mains fuses
5. Mains inlet connector

5.3.1 Mains Fuses

External mains fuses are installed to protect the Accusonic from damage if certain internal faults occur. Fuses do age and sometimes fail unnecessarily. Fuse failure should not, however, be interpreted as a fault in the fuse only. If the mains fuses fail, the Accusonic should be inspected by a qualified technician. Ensure that mains fuses are replaced with the same type and rating as stated on the equipment identification label.

5.3.2 Mains Inlet Connector

The mains inlet connector is an IEC appliance connection and contains the mains power switch and fuse holder. The mains cable supplied with the Accusonic should be fitted with an approved plug suitable for connection to local mains power outlets. Ensure that the mains power outlet is properly earthed.

IMPORTANT: It is important that the Accusonic be operated from a mains supply which has a nominal supply voltage equal to that indicated on the label on the Accusonic rear panel. Safety and performance specifications are only valid if these voltages are the same.

5.3.3 Equipment Identification Label

This label provides information on equipment identification, mains supply requirements, mains fuse rating and type and ultrasound output. Ensure that the Accusonic operating voltage is correct for the local mains supply voltage.

5.3.4 Muscle Stimulator Connector

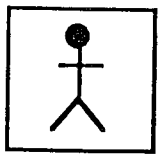
The muscle stimulator connector (2) allows the output from a muscle stimulator to be connected to the Accusonic by simply plugging the muscle stimulator into the socket. The 1 MHz ultrasound treatment applicator then acts as an active electrode for patient electrical stimulation.

Caution: Any muscle stimulator used with the Accusonic Ultrasound unit should meet the relevant electrical safety standards applicable to electromedical equipment. If in doubt, refer to the manufacturer or authorised distributor for the stimulator. To maintain the integrity of the BF classification of the Accusonic applied part only those stimulators with BF classified outputs should be used in conjunction with the Accusonic

5.4 Symbols

Several symbols are used on the enclosure of the Accusonic which are defined as follows:

This symbol indicates that the instructions for use should be consulted before operation is attempted.



This symbol indicates that the applied parts (treatment applicators) of this equipment are rated as Type "BF" which means that the patient connections are suitable for placement on the external surface of the body.

5.5 Using a Muscle Stimulator with the Accusonic Therapy Unit

The output from a muscle stimulator can be connected to the Accusonic Ultrasound by by plugging the muscle stimulator active output into the red rear panel socket on the Accusonic as described in 5.3.4 above.

5.5.1 Combined Ultrasound Treatment and Muscle Stimulation

To obtain a combined output, both the Accusonic Ultrasound and the muscle stimulator must be switched on. In this mode, both the ultrasound energy and the muscle stimulation current are delivered to the patient by the 1 MHz ultrasound treatment applicator. The level of ultrasound power is set as described above in 5.2.3, and the output voltage of the muscle stimulator is set in accordance with the instructions for that unit.

Please Note: The passive pad or return electrode of the muscle stimulator must be attached to the patient in the normal manner for this treatment to be effective.

When the Accusonic Ultrasound Unit is operated with a muscle stimulator in this way, the output is the same as the combined output from a "3 in 1" unit.

5.5.2 For Muscle Stimulation Only

When using as a muscle stimulator only, do not operate the timer or output controls on the Accusonic Ultrasound. These should be off.

The passive pad from the muscle stimulator is attached to the patient as usual, and the muscle stimulator is operated as normal in accordance with the instructions, however, the active head is now the 1 MHz treatment applicator of the Accusonic Ultrasound unit. The treatment applicator will now function as the active electrode of the stimulator and should be used in exactly the same way as the normal muscle stimulator active electrode.

Caution: Not all ultrasound gels are suitable for use as a coupling media for electrical stimulation. The ability to transmit electrical current will depend on the electrical conductivity of the gel. Use only gels which are labeled as being suitable for electrical stimulation and ultrasound application.

5.6 Cleaning & Preventative Maintenance

5.6.1 Cleaning - Unit & Treatment Applicators

There is no requirement for routine cleaning of the Accusonic other than to ensure that all ventilation holes are kept clear of debris and any spillage of conductive gels, etc, particularly on the front of the unit and near the mains inlet connector on the back of the unit be removed as soon as possible.

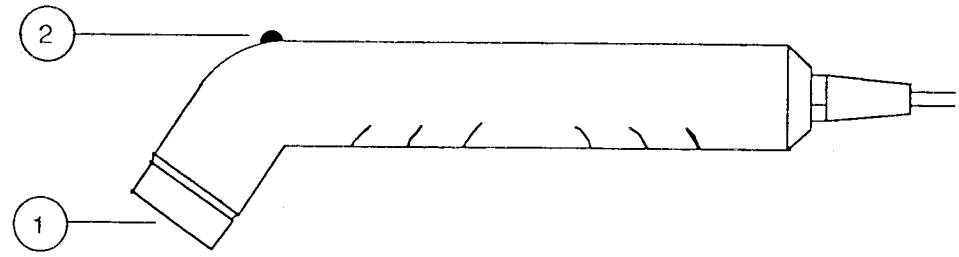
The treatment applicators should be kept free from gel buildup. Regular cleaning with a damp cloth soaked in a mixture of mild soap and water is recommended.

5.6.2 Preventative Maintenance

There is no preventative maintenance that needs to be performed on the Accusonic other than occasional cleaning as detailed in clause 5.6.1 preceding. It is however recommended that routine calibration verification and electrical safety testing be carried out on the Accusonic at least once every twelve months. Information on the type and frequency of electrical safety testing may be obtained from Australian Standard AS 3551 or from relevant locally published standards.

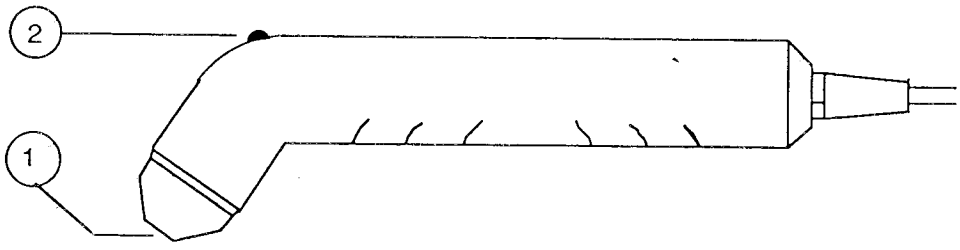
5.7 Treatment Applicators

5.7.1 1MHz Applicator



1. Circular face from which ultrasound radiates
2. Contact indicator:
   Green light indicates ultrasound power on / contact
   Red light indicates contact loss

5.7.2 3MHz Applicator



1. Circular face from which ultrasound radiates
2. Contact indicator:
   Green light indicates ultrasound power on / contact
   Red light indicates contact loss

5. ULTRASONIC THERAPY

6.1 Introduction

Ultrasonic therapy is an effective method of treating various ailments. The technique is simple and the treatment is safe to both patient and therapist, providing that reliable equipment is used.

Satisfactory results have been obtained in the treatment of neuritis, neuralgia, degenerative joint diseases, arthritis, indolent ulcer of the leg, acute inflammatory processes, prostatis and angiospasm.

Although the medical applications of ultrasound are recent, the principles date back many years. Ultrasound was first used for underwater echo sounding in 1917 and the first biological effects were observed on fish. Since then, research into biological effects has produced a number of clinically important results.

Shortly before the Second World War, development and design of ultrasonic therapy units had progressed sufficiently to enable an extensive series of observations on human patients. In the years following, extensive studies of the biological effects of ultrasound were conducted. These fundamental studies laid the groundwork to ensure that modern ultrasonic therapy units can be used without hazard by a competent practitioner.

6.2 What Is Ultrasound?

Depression of a piano key causes a hammer to strike a string which vibrates and produces sound waves. The human ear is sensitive to sound waves between the frequencies of 20 and 17,000 Hz (1 Hertz or Hz = 1 cycle per second). Sound waves with frequencies higher than the upper limit of hearing are described as ultrasound.

Ultrasound waves obey the same fundamental laws of acoustics as do sound waves: they therefore require some conducting medium. Ultrasound waves are suited to therapeutic applications because they can be beamed, like the light from a torch, and because of their ability to selectively heat deeply located tissue. Ultrasonic waves carry much greater energies than sonic waves of the same amplitude because of their high frequency. It is possible to generate ultrasonic waves of very high frequencies. For therapeutic purposes, the most effective frequencies are in the region of 1,000,000 Hz (1MHz) up to 3,000,000 (3MHz).

6.3 How Are Ultrasound Waves Generated?

An ultrasonic therapy unit comprises two main parts; an electronic high frequency electrical signal generator and the ultrasonic treatment applicator. The high frequency electrical oscillations excite a piezoelectric transducer which oscillates mechanically producing ultrasonic waves which radiate from the ultrasonic treatment applicator (refer Ward (1986).

The ultrasound frequencies of the Metron Accusonic Ultrasonic Therapy Unit are 1.1 MHz. & 3.0 MHz. In the continuous modulation mode at maximum intensity the average effective power is 3.0 Watts per square centimetre on either treatment applicator. The ultrasonic waves may be continuous or pulsed with pulse durations of 0.5, 1.0 and 2.0 milliseconds.

6.4 How Do Ultrasound Waves Act?

On the basis of present knowledge, the following physical actions can be cited as important factors in ultrasonic therapy:

* Generation of heat in tissue occurring by absorption of ultrasonic energy.
* Specific mechanical actions which are attributed to the forces associated with regions of alternating pressure separated by one half of a wavelength in tissue. This is sometimes described as a micro-massage effect.

In organisms these physical actions produce the following physiological effects:

* The blood and lymph supply of the tissues is considerably improved, much more than could be expected through superficial heating such as with infrared treatment or hot packs.
* Cellular metabolism is demonstrably increased by improved blood and lymph flow, mechanical vibration and heating.
* In inflamed tissue, acidity is returned more rapidly to normal.
* Spasms of pain are relieved through the action of ultrasound on the sympathetic nervous system.

6.5 Is There Any Hazard In Ultrasonic Therapy?

Every effective therapy, whether pharmacological or physical, has an inherent danger if not correctly applied or if administered by persons other than expert. Ultrasound energy can produce injury. When used correctly the Metron Accusonic will not produce undesirable effects and treatment is entirely painless. The operator is not exposed to stray ultrasound radiation from the treatment applicator on the Metron Accusonic. The treatment applicator is completely shielded with the exception of the circular face. No ultrasound radiates from the handle.

6.6 What Are Contraindications For Ultrasonic Therapy?

Operators are warned against the use of ultrasonic therapy:

* Near the heart.
* Over the eyes.
* Over the uterus during pregnancy.
* In the region of the reproductive organs.
* Directly over the spinal column (post-laminectomy), visceral plexi and large autonomic ganglia.
* Over areas of malignancy.
* Where the skin has no sensation.
* Over growing bone ends in children.

Operators are cautioned in the use of ultrasonic therapy:

* The applicator should be moved continuously over the treatment site throughout

* Areas where metal such as a prosthesis or pacemaker is embedded in tissue may form a reflective surface to the ultrasound causing unintended irradiation of tissue and excessive heating.
* Damage to tissue may occur from excessive ultrasound dosage. Periosteal pain is an indication of excessive ultrasound intensity. If this occurs, the applicator should be moved more quickly, the bony prominences avoided or the ultrasonic intensity reduced.

6.7 When Is Pulsed Ultrasound Administered?

Ultrasound is an effective therapy when administered either in pulsed or in continuous mode. Pulsed ultrasound ensures the heat generated in tissue is minimised while most of the effect of micro-massage is obtained. Pulsed ultrasound is recommended in all cases where a high ultrasound intensity is indicated and where periosteal pain may occur. Investigations indicate that pulsed ultrasound is an invaluable technique in the treatment of the nervous system.

6.8 Method And Techniques Of Ultrasonic Therapy

The following description of technique and dosage of ultrasound have been compiled from various reports, unpublished communications and from our own observations.

6.8.1 Patient-applicator contact

Good acoustic coupling between the ultrasonic treatment applicator and the treatment site is most important and is monitored by the Metron Accusonic. Air is a poor conducting medium of ultrasound. A good ultrasonic conducting medium of acoustic coupling gel between the applicator and treatment site is essential for efficient transfer of ultrasonic energy. A liquid film of gel must be maintained between the applicator and the treatment site throughout the course of the therapy. During long periods of treatment, the gel should be renewed periodically. It is best to use too much rather that too little gel - estimation of the correct amount will come with experience. The applicator face should be kept parallel to the surface being treated.

6.8.2 Underwater treatment

Underwater treatment, although more complicated than direct treatment, affords many advantages in certain cases. It facilitates even and efficient sound transmission and is indicated where the surface to be treated is so uneven or small that good contact with the applicator can only be made with difficulty, or not at all. Underwater treatment can be used for treating small joints, areas of ulceration or areas sensitive to pressure.

In underwater treatment the part of the body concerned is immersed in a vessel filled with warm water. The water should always be degassed by boiling, a condition which frequently cannot be fulfilled in practice. In contrast with direct contact treatment, the applicator is held 1 to 5 cm or 0.5 to 2 inches from the body surface during underwater treatment. Treatment must be terminated as soon as bubbles are noticed adhering to either the skin or the applicator. The air in the bubbles is a poor conductor of ultrasound.

6.8.3 Massaging or static sounding

In massaging treatment the applicator is applied with moderate contact pressure and movement over the desired area. The applicator is held lightly between the fingers. Tight gripping will cause fatigue and turning of the applicator. The applicator should be moved as slowly as possible in order to maintain sufficient exposure. When moving over bony surfaces such as knees, the applicator should be moved sufficiently rapidly to ensure that the patient does not experience periosteal pain. Pulsed ultrasound is preferred for massaging treatment.

Massage should be administered with moderate pressure over the skin in a slow rhythmic manner with a pattern of movement which may have to be varied depending on the size and shape of the field to be treated. Stroking, with one stroke overlapping by half the width of the applicator is used. The stroke length is about 2.5 to 5 cm or 1 to 2 inches. The applicator is moved gradually in the direction perpendicular to the stroke in a field of about 25 to 100 square centimetres or 2 to 4 square inches at any one time. This technique has the advantage that the moving applicator provides for uniform heating. Also, if the field is not too large, the temperature increase resulting from the first movement of the applicator over an area is not dissipated when the applicator returns to the same place; thus, the temperature is gradually elevated to a therapeutically useful value. Moving the applicator in a spiral path with small overlapping circles, allows treatment of wider fields with relatively uniform distribution of the ultrasound. A rate of approximately one circle per second is suggested.

6.8.4 Pulsed ultrasound

Pulsed ultrasound differs from continuous ultrasound in that heat localisation and accumulation is avoided. It is suitable for high intensity treatment of a joint particularly when it lies close to the skin and where periosteal pain should be avoided and for heat sensitive neuritis and sensitive tissue.

6.9 Ultrasound Dosage

Estimation of ultrasound dosage is gained with experience. The following factors should be considered:

* Two important factors in dosage are the ultrasound intensity and the duration of treatment. The product (intensity x duration) determines the total ultrasound energy delivered. On this basis one might expect that a treatment at 1 Watt/cm^2 for 4 minutes would have the same effect as a treatment of 2 Watt/cm^2 for 2 minutes: this is not the case! A treatment of short duration at high intensity is not equivalent to a treatment of long duration at low intensity because of the heat dissipating mechanisms of biological tissue. Greater temperature elevation will result from the short duration, high intensity treatment. Ward (1986) chapters 8 and 10 discusses ultrasound dosage and effects.

* It is important to ascertain the smallest dose which will produce an optimum result. The treatment times and intensities quoted here are only general recommendations. The correct dosage for each case depends on the individual reaction to the therapy. Treatment should begin with smaller doses than those which seem to be indicated. Following are some simple guidelines for ultrasound dosage.

Further recommendations are to be found in Wadsworth and Chanmugam (1983), chapters 5 and 12.

6.9.1 Rules for ultrasound dosage

Commence with an average intensity of 1 watt/cm^2 and an average treatment time of 3 to 4 minutes. Determine the correct dosage for the individual case according to the following three criteria:

* Nature of disease -

  Chronic, indolent processes generally tolerate and require a more massive action, i.e. a higher initial intensity and duration (treatment time) than acute conditions.

* Seat of disease -

  Due to adsorption, the ultrasound intensity decreases with depth. After penetrating a tissue layer of thickness 3.5 cm the intensity might have reduced to one half of its initial value (depending on the nature of the tissue). At a depth of 7 cm, the intensity would be reduced to a quarter of its initial value. Accordingly, a deep lesion in an obese patient will be treated with a higher initial intensity.

* Area to be treated -

  The larger the treated surface, the longer the exposure must be. This will provide sufficient energy for each area of treatment.

With any new therapeutic agent the matter of dosage receives considerable attention on the part of those who have done research and experimental work. In ultrasonic therapy the following general principles are well established:

* Pain is an indication of over dosage.
* Ultrasonic therapy is a safe procedure of dosage is kept below the pain threshold.
* A five minute treatment over a given area is normally sufficient.
* Therapeutic intensities of 0.5 to 3.0 Watts/cm^2 have been used with good results, the lower intensities in acute conditions and the higher in chronic.
* When ultrasound is applied to the nerve root area in addition to the affected area, the intensity over the nerve root area should not exceed 0.5 Watts/cm^2 and application should be made with a circular or stroking motion.

6.9.2 Pulsed ultrasound dosage

When pulsed ultrasound is used, the total energy of the ultrasound is a fraction of that for continuous ultrasound by virtue of the same amplitude but reduced duty cycle. If no compensation is made for the energy loss due to the long interval between pulses, the heating of tissue will be much less. When a micro-massage effect is required with a minimum of heating, pulsed ultrasound treatment is indicated.

The short time of each pulse is sufficient to elicit a biological action and the time between pulses of less than 1/100th of a second (10 milliseconds) is short enough such that the biological response does not decay to zero. Before the biological reaction has diminished significantly, the next ultrasound pulse has been delivered and the treated area is restimulated.

6.9.3 Suggestions for treatment

The table below is only a selected guide to the indications and details of ultrasound therapy. A presentation such as this should not substitute for an operator's practical experience. Those who wish to become acquainted with the characteristics of ultrasound therapy should consult texts such as Ward (1986) and Wadsworth and Chanmugan (1983). Cases should be selected carefully on the basis that only those responding well and quickly should be given ultrasound therapy. This will enable the operator to gain experience and proficiency to widen the scope for indications.

Conditions in which ultrasound therapy is most promising are indicated as follows:

CONDITION	TREATMENT TIME (mins.)	NUMBER OF TREATMENTS
Arthritis	5 - 7	10 - 15
Arthritis of large joints	10 - 12	10 - 20
Arthritis of small joints	10 - 12	10 - 20
Distortions and contusions	3 - 5	3 - 6
Epicondylitis Styloditis	5 - 7	10 - 15
Lumbago	4 - 5	2 - 6
Myalgia	4 - 5	2 - 6
Periarthritis	5 - 10	10 - 15
Plexus Neuralgia	3 - 6	6 - 10
Spondylitis	8 - 15	15 - 20
Tendovaginitis	3 - 7	5 - 8

6.10 3 MHz versus 1 MHz Ultrasound

When ultrasound travels through the human body, the amount of energy absorbed, and consequently the amount of heat produced, is different in different tissues. The rate of energy absorption is indicated by the penetration depth. A high penetration depth implies a low rate of energy absorption and a low penetration depth implies a high rate of energy absorption.

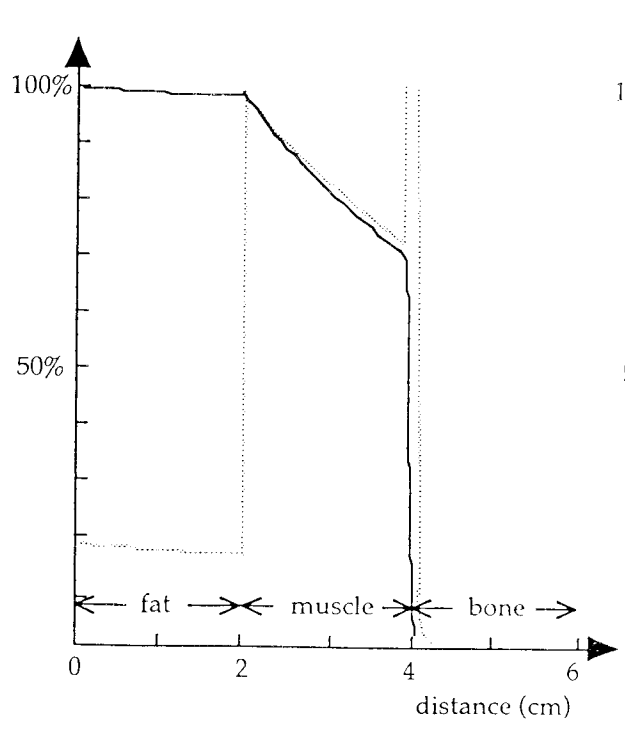
Ultrasound is therapeutically useful because of its high penetration depth in fatty tissue and lower penetration depth in muscle: ultrasound energy is absorbed at a greater rate in muscle and consequently the heating rate is higher.

The table below, taken from Ward (1986), shows the penetration depth of 1 MHz ultrasound and 3 MHz ultrasound in fat, muscle and bone tissues:

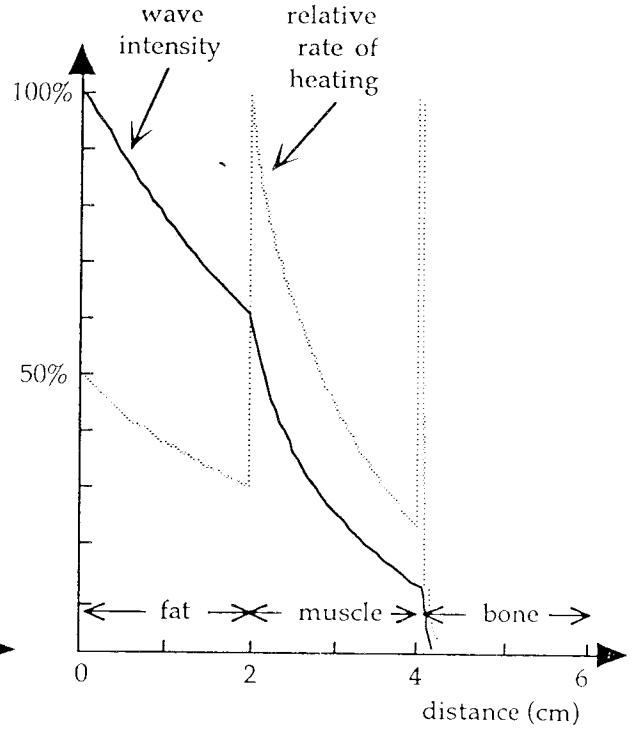
ultrasound frequency	penetration depth in fat	penetration depth in muscle	penetration depth in bone
1 MHz	22.0 cm	4.0 cm	0.058 cm
3 MHz	3.8 cm	1.1 cm	0.006 cm

It is clear from the table that in each tissue 1MHz ultrasound has a higher penetration depth than 3 MHz ultrasound. This means that 1 MHz ultrasound penetrates more deeply in tissue. It also means that the heat production in a given volume is less.

Values of penetration depth can be used to calculate the ultrasound energy and rate of heating at different depths in the body. The diagrams below show the calculated ultrasound intensity and pattern of relative heating in a tissue combination consisting of two centimetre layers of fat, muscle and bone.



1 MHz ultrasound



3 MHz ultrasound

Consider first 1 MHz ultrasound. The ultrasound intensity drops very slowly in fatty tissue, resulting in a very low relative rate of heating. It is absorbed more rapidly in muscle, resulting in greater heating. The pattern of heating in the fat/muscle combination is therapeutically desirable but the heating rate of the superficial bone is not: here the rate of heating shows a sharp, intense peak. Although not shown on the diagram, the relative rate of heating is some forty times higher than in muscle. It is this which gives rise to periosteal pain and the risk of burns in the periosteum. The only way

to avoid the problem is to keep the total ultrasound intensity low, which also reduces the effectiveness of heating of the fatty tissue and muscle layers.

At a frequency of 3 MHz, penetration depth values are lower in each tissue, resulting in more rapid absorption of ultrasound energy. Only a fraction of the wave energy remains to heat the bone and consequently the peak in the heating pattern in the superficial bone tissue is much smaller than with 1 MHz ultrasound. As the graph shows, a much higher percentage of the ultrasound energy is absorbed in the fatty tissue and muscle.

It is for this reason that 3 MHz ultrasound is preferred when treating soft tissue overlying bone in most regions of the body.

1 MHz ultrasound has the advantage when the soft tissue volumes are large as, for example, when the patient is large and obese or when treating bulky muscle groups such as the quadriceps of athletes. 3 MHz ultrasound is preferred when the fatty tissue and muscle layers are a few centimetres or less in thickness.

7. REFERENCES

Wadsworth, H. and Chanmugam, A.P.P., *Electrophysical agents in therapy,* Science Press (1983).

Ward, A. R., *Electricity, Fields and Waves in Therapy,* Science Press (1986).