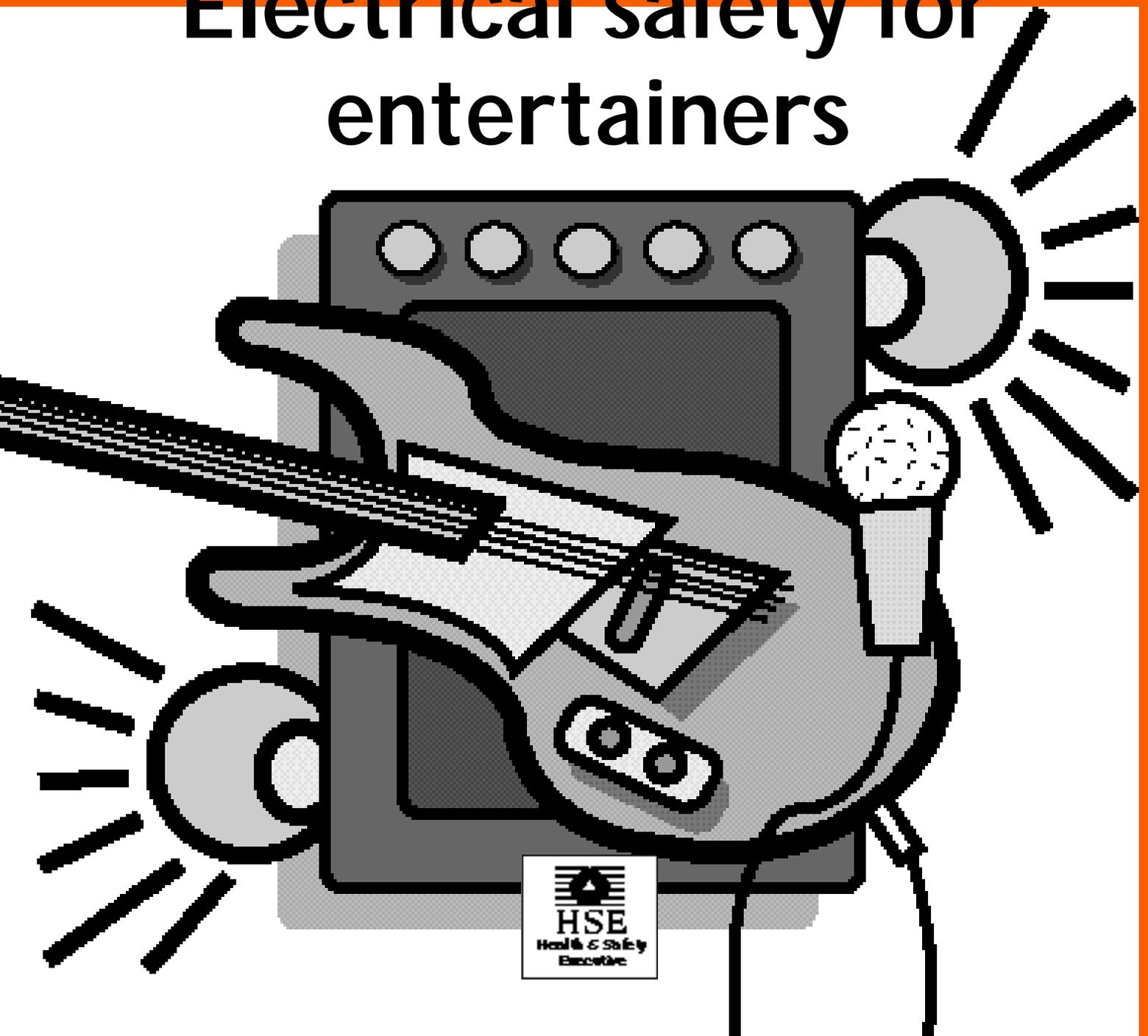
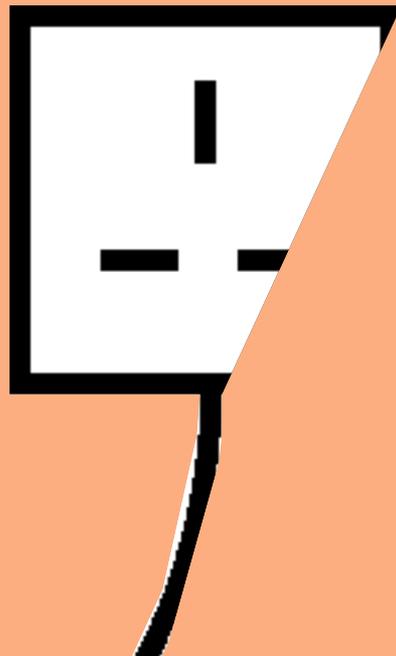


Electrical safety for entertainers



If you are an entertainer who uses electrical equipment for sound, lighting or other effects, this booklet is for you. It sets out basic measures you can take to help control the electrical risks from use of such equipment. As well as guidance for your safety, there are some notes at the end about the law.



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INTRODUCTION

Electric shocks can kill

Entertainers have been injured and even killed from electric shocks while performing or practising. Make sure your next performance is not your last.

Even a very small electric current flowing through your body can kill you. 50 milliamps (a 40 watt light bulb only takes about 150 mA) can cause pain, paralysis of chest muscles and, after a few seconds, upset the heartbeat and cause death (Figure 1).

The higher the current, the more dangerous and the quicker the effects.

Risks

If you damage electrical equipment, for example a cable, then bare live wires may be exposed.

Apparatus may be wrongly connected so that the outside metal parts become live.

Faulty, damaged or incorrectly used equipment can injure you. The risk of injury is increased if you are holding an instrument or microphone, as you may not be able to let go if it becomes electrified (live).

Even equipment which does not have a mains power supply itself can be dangerous. For example, on some systems audio equipment such as loudspeakers may have terminals at dangerous voltages.

Electrical equipment that overheats can cause fire.

Precautions

Maintenance, inspection, testing and repairs should only be carried out by someone who is suitably qualified and/or experienced such as an electrician.

Do not rely on other people's equipment being in a safe condition or properly connected. Check before you use it.

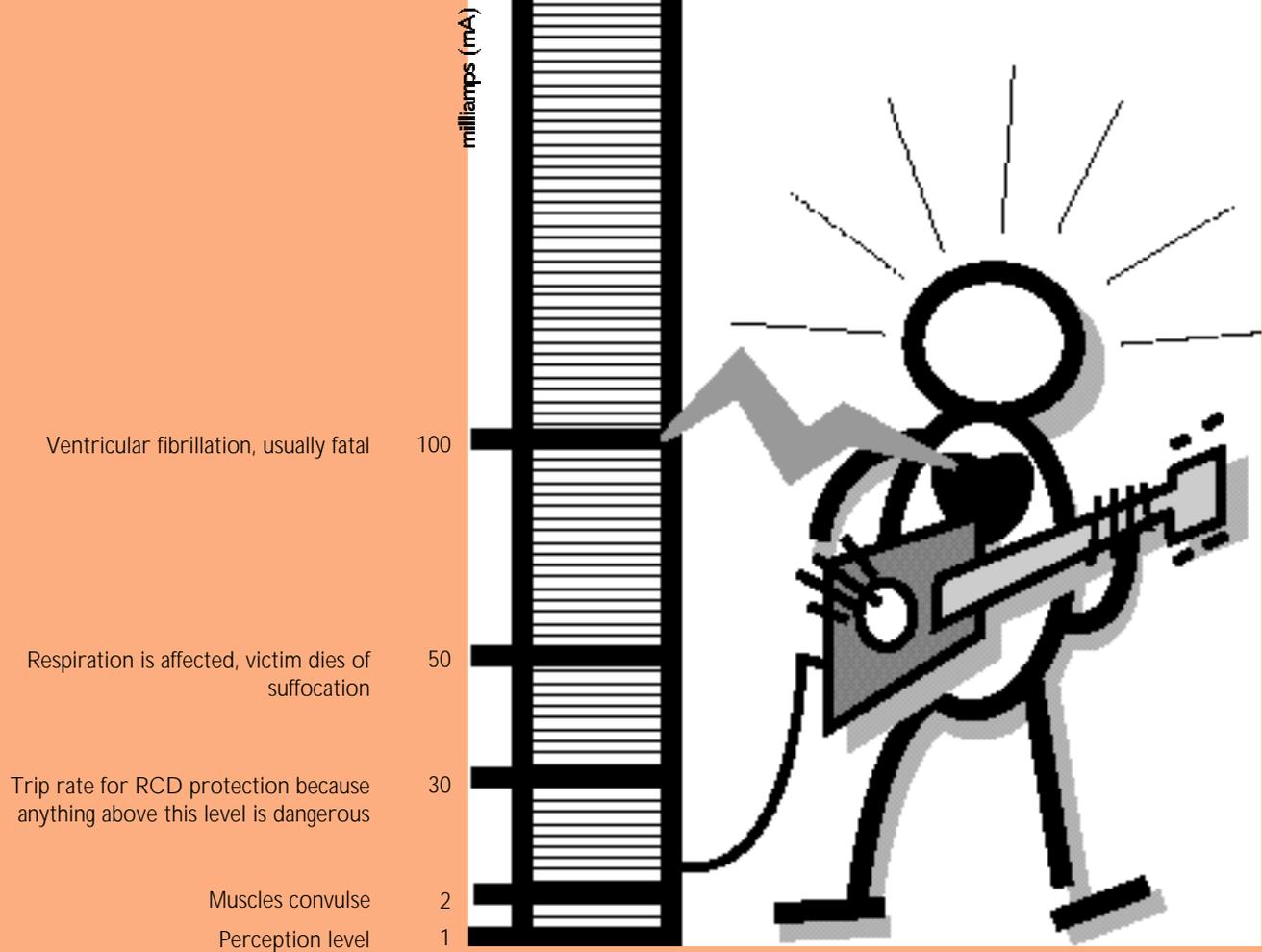
Do not connect or use incompatible items of equipment.

Use a residual current device (RCD) on the power supply to instruments, audio equipment and any other equipment which you or your colleagues may handle. RCDs are relatively inexpensive and widely available from retail outlets selling electrical goods.

Current necessary to light a 60 watt lamp
is sufficient to electrocute five people
simultaneously

250

Figure 1 **Relative magnitude and
effect of electric current**



Residual current devices

Good quality, well maintained equipment provides the best safety. However, it is recommended that RCDs are used because:

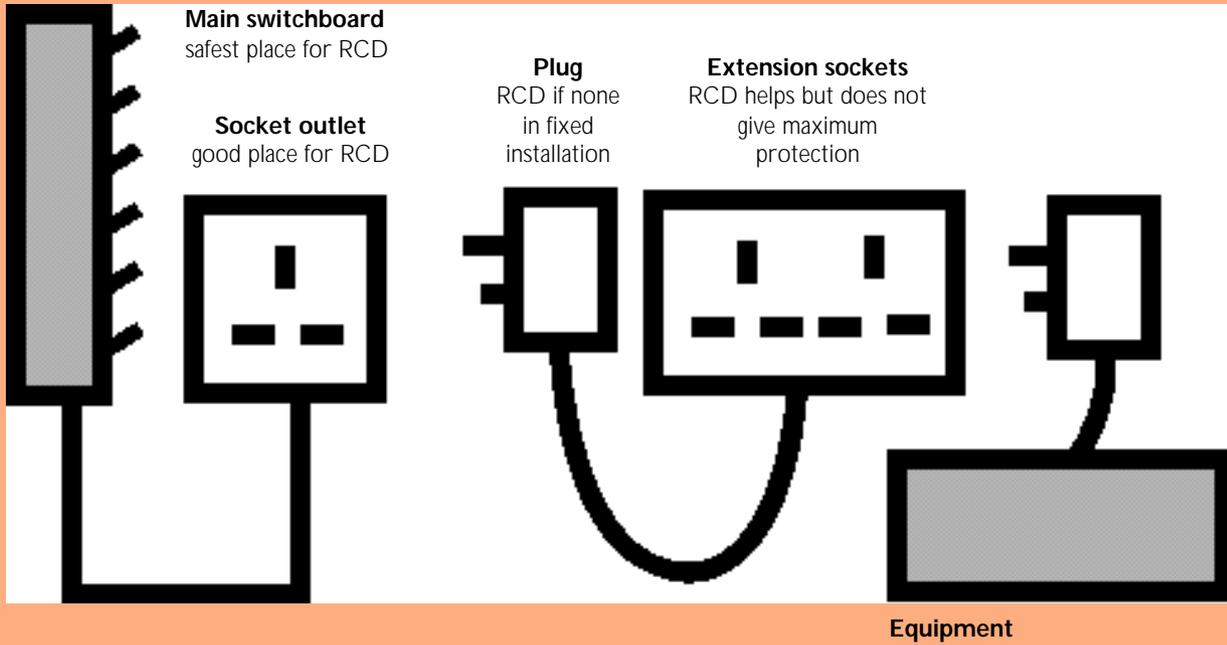
- they detect very small leakages of current to earth;
- they automatically and quickly cut off the electricity supply.

It is recommended that the sockets you use, particularly for audio equipment, are protected by RCDs suitable for personal protection. These are commonly referred to as 30 mA 30 ms devices. The best place for an RCD is at the main switchboard or at the socket outlet itself (Figure 2). If these are not already provided you can use an RCD fitted plug or RCD adapter, which is better than nothing.

Remember:

- It is important that you always keep your equipment in good condition.
- An RCD is a back-up to protect you if something goes wrong.
- If the RCD trips it is a sign that there is a fault that could be dangerous. Do not ignore this warning. Have it checked and get the fault fixed by someone competent to do so.
- Never bypass the RCD so that you can carry on using equipment which may be faulty, and possibly dangerous.

Figure 2 **Where should the RCD be?**



SOUND EQUIPMENT

Earth connections

Lack of good earth connections is the commonest electrical safety problem with sound equipment. Any item of equipment which is mains-powered should either be double-insulated (Figure 3) or correctly fitted with a protective (safety) earth.

If you are in any doubt about the connections of equipment, consult a competent electrician. Remember that an audio expert might not be expert in electrical safety.

Single items of equipment, if properly maintained, usually present few problems. However, if a number of items are connected together, it is possible that cable screens (the braided metal protective layer of the cable), together with protective earths, form loops resulting in 'mains hum' on the system.

If this happens, do **NOT** remove protective earth connections. Removal of earths is one of the common causes of entertainers receiving electric shocks, some of which have been fatal.

Good quality sound equipment should not cause hum, although in some cases you may need to disconnect the screen at one end (only) of interconnecting audio cables. In other cases rearranging the equipment, so that the wires do not criss-cross, can solve the problem. When obtaining new equipment, discuss your needs with the supplier. Some equipment has a facility for disconnecting the 'signal' earth from the safety earth without affecting safety.

Electricity supply

Sometimes it may be necessary to site a mixing desk at some distance from the power amplifiers, interlinked by multi-core signal cables. Microphones etc may have their own power supply (not phantom-powered from the mixing desk). It is preferable that all the different parts of the sound system are powered from the same phase of the electricity supply. If not, the risk of mains hum will be increased and people may be tempted to remove the earths from the equipment.

Connections

The terminals of amplifiers and the wiring and connections to loudspeakers may carry dangerous voltages (Figure 4). It is essential that wiring with adequate insulation is used, and that any connectors should be safe for use at the appropriate voltage and current.

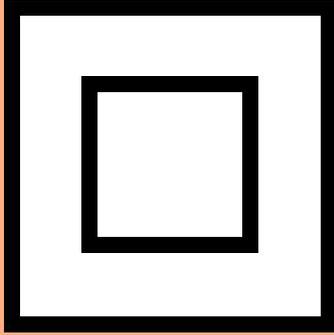


Figure 3 **Symbol for double-insulated equipment**

If this symbol is not on the equipment, it needs a protective earth (green/yellow) wire

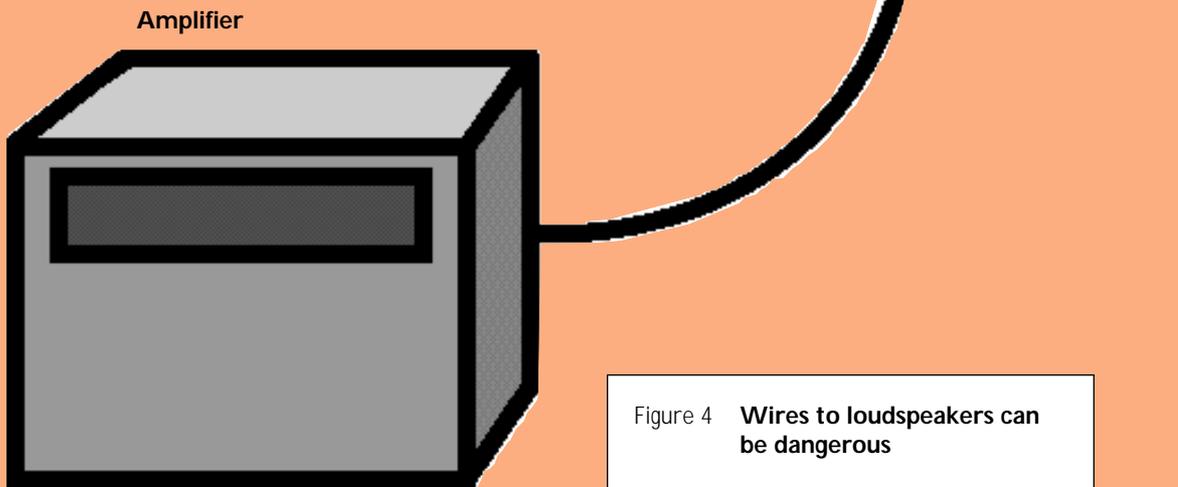


Figure 4 **Wires to loudspeakers can be dangerous**

Extension leads and plugs

Extension leads are frequently associated with electrical accidents, sometimes due to incorrect connection. Care should be taken with the connections, particularly if a different plug has to be fitted.

It is absolutely vital that the live, neutral and earth wires are connected correctly (Figure 5). If they are not, the apparatus may work but be lethal, perhaps in a way which would not be detected by a protective device, such as a fuse or RCD.

If you are not sure how to wire a plug, get someone who really does know to show you. It could be a matter of life or death (perhaps yours).

If a lead or plug is damaged, it should be taken out of service **AT ONCE** and replaced, not repaired.

Only fully extended extension leads are capable of carrying the full current capacity of the cable without overheating. So fully unwind leads feeding lighting to avoid the risk of fire. Also, do not use multiple adapters plugged into wall sockets, as they can easily get overloaded.

Ventilation

Make sure your amplifiers are properly ventilated. High power amplifiers can get very hot if the ventilation around them is blocked, for example by stacking other equipment on or near them. This could cause a fire. Most amplifiers are fitted with thermal protection devices as a precaution against fire and if this protection operates it will shut the system down (possibly during a performance).

Fuses

If your equipment is fitted with 13 amp (square pin) plugs, make sure that the correct fuse is fitted. The rating plate on

the equipment or the instruction book will tell you how much electrical power the equipment needs. 3 amp and 5 amp fuses are readily available for these plugs.

Under no circumstances should you bypass the fuse or replace it by wire, silver paper, or a nail, all of which are very dangerous.

Inspection and testing

However careful you are with your equipment, any apparatus which is moved from place to place can easily be damaged. It is therefore vital that all electrical apparatus, including extension boxes and cables, is visually inspected frequently. As a general guide you should inspect equipment, preferably before using it at a new location or alternatively when it is taken out of service for storage. If there is damage to any electrical part or if the equipment causes an RCD to trip, it should be taken out of service at once and replaced, or repaired by a competent person such as an electrician.

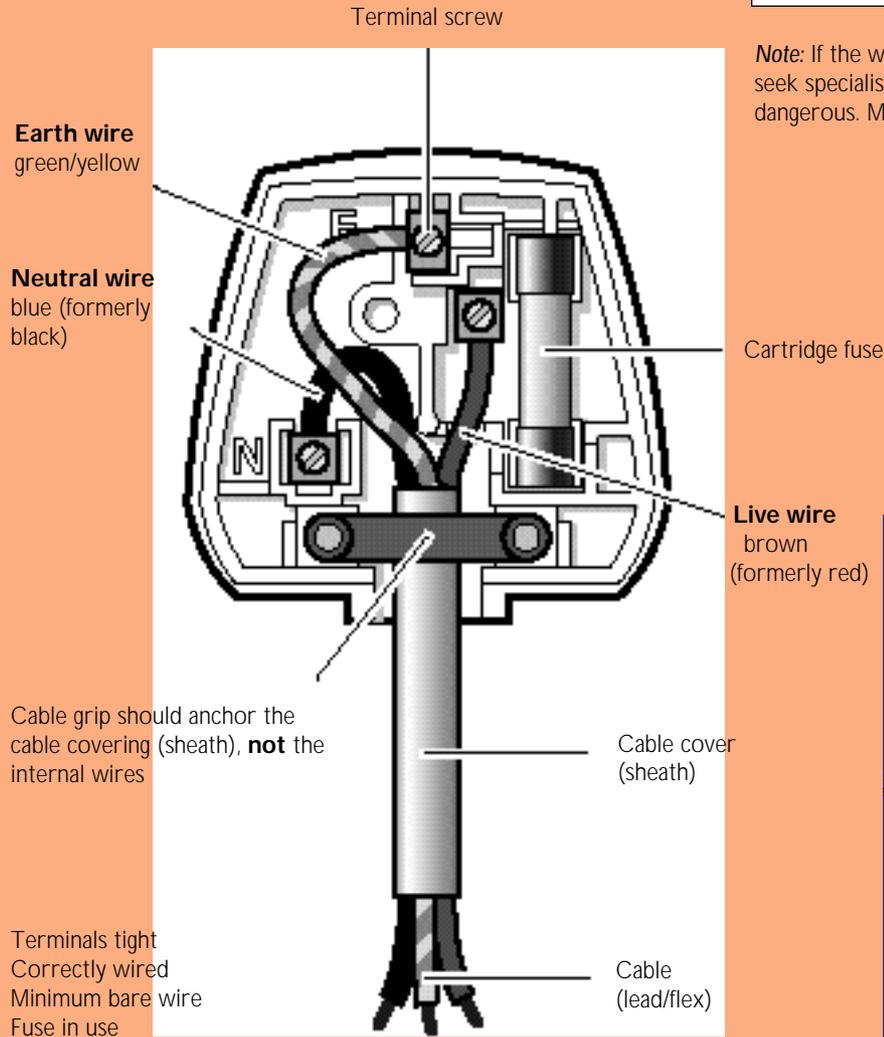
Typical routine checks for portable apparatus are shown in the checklist on page 18.

In addition, regular electrical tests may be appropriate. These will detect the faults that cannot be seen at inspection, such as lack of continuous earth. It is recommended that these tests are undertaken by a competent electrician, initially every five times the equipment is used. If you find that this frequency never identifies any damaged or faulty equipment, you could test it less often. Advice on in-service inspection and testing can be found in HSE booklet HS(G)107 *Maintaining portable and transportable electrical equipment*¹ and an IEE code of practice².

It is a good idea to keep a simple record either on a card or a label stuck to the equipment to show when it was last inspected (date) and tested (date and test readings).

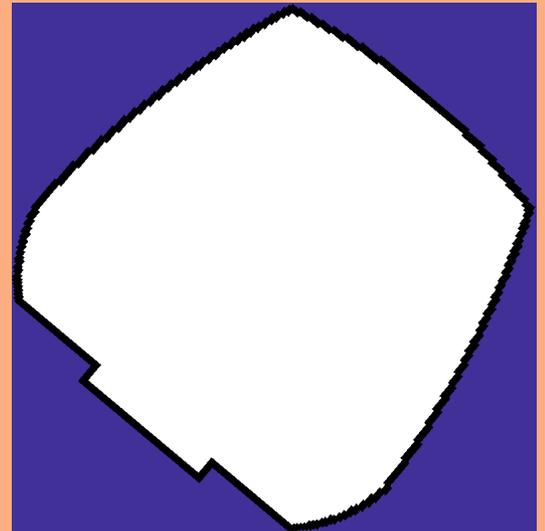
Repairs should only be made by someone who is competent to do so.

Figure 5 **Plugs: points to watch**



Note: If the wires are not brown, blue and green/yellow seek specialist advice: a wrong connection could be very dangerous. Make sure all the connections are tight

Put the cover back on securely



110-125 VOLT AMERICAN EQUIPMENT

If you have American equipment designed to work only on supply voltages of 110 to 125 volts, you will need a transformer to change the voltage (Figure 6). Incorrect use of such equipment can be dangerous and it is **strongly recommended** that you consult a competent person such as an electrician about the selection and use of transformers.

Do not use a single winding auto transformer as it can be incorrectly connected or can fail to danger (the electricity is still connected), without any indication. The first sign may be when you get an electric shock.

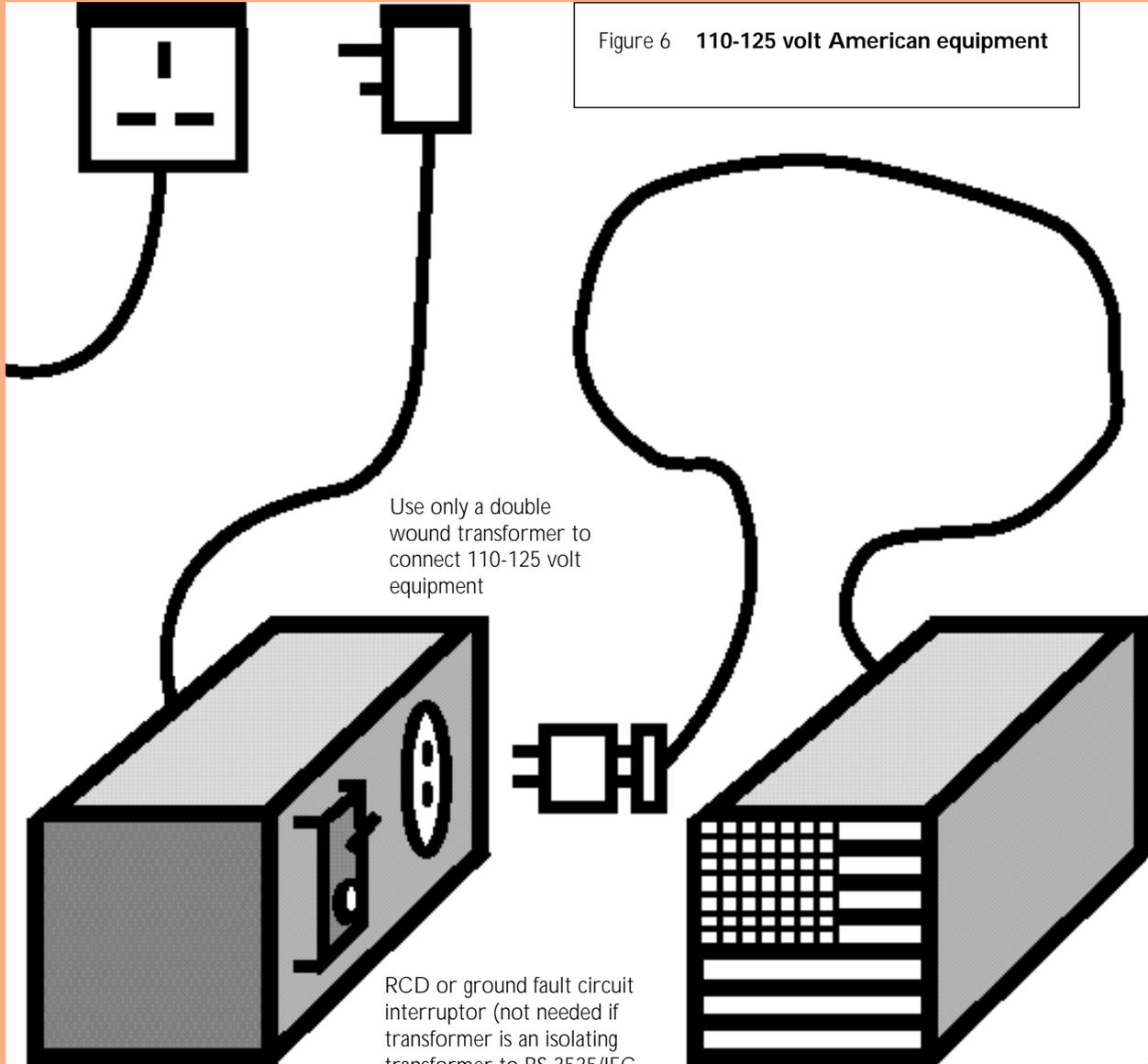
If only one item of American equipment is being supplied by a transformer, **and** the cable to the equipment is kept short, **and** the equipment is double-insulated (Class II), it is recommended that you use a safety isolating transformer to British Standard 3535 or IEC 742, without a protective earth connection to the transformer secondary. If the equipment is not double-insulated the equipment protective conductor, or earth wire, should be connected to the system protective earth.

If a number of items of equipment are powered from the same transformer, **or** if the output of the transformer is connected to long cables (eg across the stage), then it is recommended that you use a double wound isolating transformer, with one side of the secondary earthed and an RCD (known in America as a ground fault circuit interruptor) connected into the transformer secondary circuit.

Transformer output(s) should have suitable excess current protection (fuses or preferably circuit breakers) and, where a protective conductor is needed, it should be efficiently connected to an effective earth. The earthing conductor should be at least as large as the phase and neutral conductors of the primary circuit, and may be connected to the earthing conductor of the 230 volt mains supply. If a 'clean' earth for sound equipment has been provided, have it tested by a specialist electrician before use.

Do not use two 120 volt lamps in series on a 230 volt supply unless both of the light fittings are designed for 230 volt operation. It is important that you do not use standard 230 volt plugs on lower voltage equipment. Accidentally connecting such equipment to 230 volt mains could be dangerous. If in doubt, ask your electrician which plug you should use.

Figure 6 110-125 volt American equipment



Transformer

LIGHTING

Supports

Unless specifically designed for use at a low level, put lighting rigs out of reach of performers and the audience. If cables to lights are run overhead, support them along their length (preferably by an earthed strain wire) unless the cable is of the special type which incorporates its own strain wire. Take the strain off the flexible cable of suspended light fittings by supporting them with chains or other suitable devices (Figure 7).

Circuit separation

If possible you should take the electrical supply for lighting from sockets which are separate from those used for audio equipment. This avoids problems that may occur with RCDs on lighting circuits. The audio equipment needs reliable RCD protection.

Residual current devices

RCDs may not always be appropriate for lighting circuits. Some types of dimmer control have a relatively high electrical leakage which may cause nuisance tripping when a number of units are fed from one RCD. Other dimmers produce a direct current which can prevent some types of RCD operating correctly.

It might be tempting to put an RCD on the secondary (output) side of a dimmer to give additional protection to a lighting rig, particularly where it is positioned at low level. However, some RCDs which contain electronic components do not operate satisfactorily at voltages much lower than 230 so the additional protection may not work. Check with the manufacturer of the RCD.

Remember:

- RCDs are recommended for circuits supplying outdoor lighting.

Three-phase supplies

If lighting is connected to two or three phases of the electrical supply, use separate dimmer cubicles on different phases to avoid confusion. Only supply a single phase to any one boom.

Connections

If you have lighting on a bar or boom connect the individual lights to the boom by plug and socket. For indoor lighting these can be the 'old type' 15 amp or 5 amp three (round) pin types which are often used and quite satisfactory for lighting. High power lights, eg 5 kW 'follow' spots, need correspondingly high power sockets, usually a 32 amp industrial type or the sort used for theatre or location lighting.

The metalwork of individual lights and the bar or boom should be adequately connected to the protective earth conductor.

Always disconnect the supply **locally** before changing any lamps. The use of plugs and sockets makes this easier as well as providing flexibility for different lighting arrangements.

Plugs and sockets to BS EN 60309 (previously BS 4343) provide better protection against damp and rain, and are ideal for use at outdoor locations. Since they are a tougher design, and are usually cheaper than the specialist 15 amp designs, they are also recommended for all new installations.

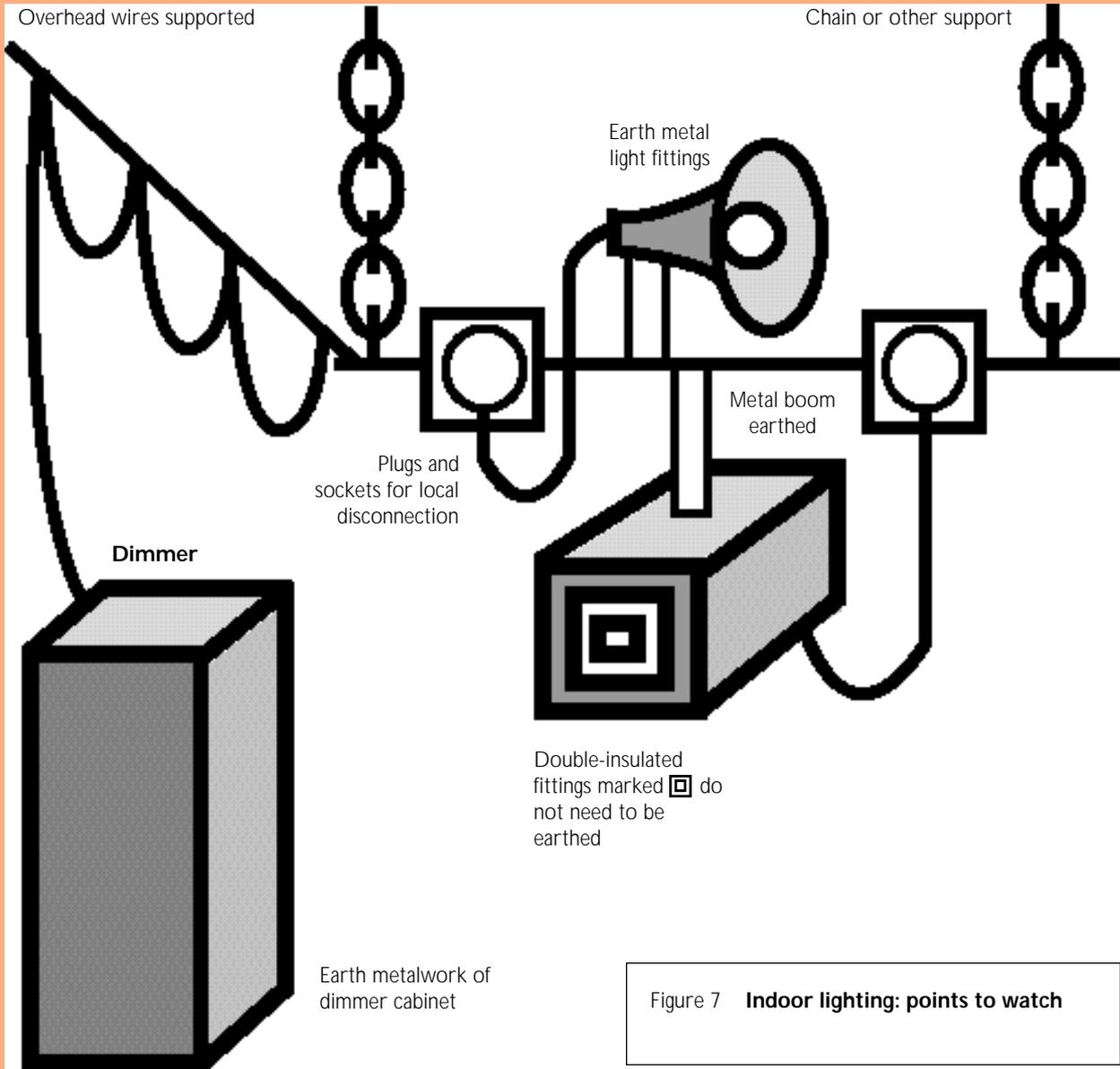


Figure 7 **Indoor lighting: points to watch**

Cables

Power cables from the lighting booms to the dimmer cabinet or control cubicle are often multi-core. You should ensure that such cables are suitable as regards flexibility and protection against abrasion or other mechanical damage. If there is any risk of the cables getting hot from the lights, they should be of a type which is sheathed in, or protected by, heat-resisting material.

- Make sure flexible cables are properly secured in a cable grip at the plug or other termination.
- Multi-core power cables should not be used to feed more than one phase to a boom.
- All plugs and sockets should be adequate in terms of voltage and current ratings and they should be in good condition; the protective earth connection is particularly important.
- Every circuit should have its own line and neutral conductors. If earth connections are looped, you must take care that the wire size is adequate along its whole length.

Earthing

Dimmer control cubicles also provide the marshalling points for cables to the lighting booms. All the exterior metalwork of the cubicles should be adequately earthed. There is sometimes separate provision for the connection of outgoing earth wires for lights. Alternatively, you can rely on the earth connection of the outgoing plugs and sockets. There should be no provision in control cubicles for 'lifting' (ie disconnecting) earths.

Special effects

Lasers, strobes and other high-intensity lighting may require special arrangements or approval from the local authority etc before use. Some of these items use high voltages internally so it is particularly important to ensure they are in good condition and properly earthed if necessary. There may be non-electrical risks such as radiation or epilepsy-induction from such equipment as well. HSE publication HS(G)95 *The radiation safety of lasers used for display purposes*³ contains useful advice.

THE LAW

Health and Safety at Work etc Act 1974 (HSW Act)

If you are paid for entertaining, what you are doing probably comes within the scope of the HSW Act⁴. If you are self-employed (even if entertaining is not your main job), you have to look after your own safety and the safety of anyone else who might be affected by what you are doing (section 3 of the Act).

If you are employing other people, you must ensure their safety so far as is reasonably practicable. This includes making sure that the equipment they use is safe and that they are properly informed about possible dangers. You should make sure that they are properly trained and adequately supervised (section 2 of the Act).

If you are an employee (even if this is not your main job), you must make sure that what you do does not injure yourself or anyone else. You must also co-operate with your employer on health and safety matters and must not interfere with, or misuse, anything provided for safety purposes (sections 7 and 8 of the Act).

Management of Health and Safety at Work Regulations 1992

Whether you are an employer or self-employed, you will need to undertake a risk assessment (think about what might go wrong and what you can do to prevent it) of your work activity to identify what control measures you need to take to comply with health and safety law.

In addition, these Regulations require that you co-operate with and co-ordinate your activities with other employers at the venue, so that reasonable steps are taken to ensure health and safety.

Electricity at Work Regulations 1989

Everybody working with or on electrical equipment (even if they are self-employed) comes within the scope of these Regulations⁵. Further guidance is given in the *Memorandum of guidance on the Electricity at Work Regulations 1989*⁶ and the leaflet *Electrical safety and you*⁷.

Enforcement

The HSW Act is enforced either by the Health and Safety Executive (HSE) or by local authority environmental health officers, depending on what usually goes on at the premises. If you have any doubt about safety matters relating to a place of entertainment, please contact your local HSE office or the environmental health department of your local authority.

Almost all places of entertainment also need a licence from the local authority. The law does not say what must be contained in the licence. There will usually be requirements for fire precautions (the fire brigade will be involved) and the licence

can include conditions relating to electrical safety. If in doubt, please contact the local authority licensing inspector about the need for a licence and any conditions which may apply. If you have a problem with any of the conditions, do not just ignore them but seek help, either from the authority or through your trade association.

REFERENCES

- 1 HS(G)107 *Maintaining portable and transportable electrical equipment* HSE Books ISBN 0 7176 0715 1
- 2 *IEE Code of practice for in-service inspection and testing of electrical equipment* The Institution of Electrical Engineers ISBN 0 85296 844 2
- 3 HS(G)95 *The radiation safety of lasers used for display purposes* HSE Books ISBN 0 7176 0691 0
- 4 *Health and Safety at Work etc Act 1974* HMSO ISBN 0 10 543774 3
- 5 *Electricity at Work Regulations 1989* SI 1989 No 635 HMSO ISBN 0 11 096635 X
- 6 HS(R)25 *Memorandum of guidance on the Electricity at Work Regulations 1989* HSE Books ISBN 0 11 883963 2
- 7 IND(G)231 *Electrical safety and you* HSE Books
Single copies are free, multiple copies are in priced packs
ISBN 0 7176 1207 4
- 8 GS50 *Electrical safety at places of entertainment*
Second edition 1997 HSE Books ISBN 0 7176 1387 9

CHECKLIST

Listed below are typical routine electrical checks for portable apparatus. This checklist is only intended as a guide; certain apparatus may need different or additional inspections and tests. The checks should be carried out by a suitably competent person. *Note: Non-electrical checks are outside the scope of this leaflet.*

Equipment:		
Make	Model	Serial number
User inspection: With equipment disconnected		
<i>Item</i>	<i>Test</i>	<i>Pass condition</i>
1 Mains lead	Check for cuts, splits and crush damage	No inner (coloured, brown blue or green/yellow) insulation visible; no bulges in cable.
2 Mains plug	Check for broken casing, and cable properly clamped	No cracks in plug casing. No damage allowing contact with plug internal connections. Cable clamped securely by outer sheath, no inner insulation visible.
3(a) Equipment connector (or)	Check for broken casing on equipment and cable connectors. Check cable clamp	No cracks in plug or socket casing. No damage allowing contact with plug or socket internal connections. Cable clamped securely by outer sheath, no inner insulation visible.
3(b) Equipment cable entry	Check grommet or clamp still there. Check cable clamp	No sharp edges on contact with cable. Cable clamped securely. No inner insulation visible.
4 Mains on/off switch, voltage selector switch, fuse holders etc	Check for broken insulation	No cracked insulation, no loose parts, no parts missing.
5 Equipment housing	Check for general condition. Check for loose parts inside	No holes (large enough to put a finger in) close to mains cable or switches. No rattles when you tilt it a quarter of a turn.

FURTHER INFORMATION

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 6FS. Tel: 01787 881165 Fax: 01787 313995.

HSE priced publications are also available from good booksellers.

For other enquiries ring HSE's InfoLine Tel: 0541 545500, or write to HSE's Information Centre, Broad Lane, Sheffield S3 7HQ.

HSE home page on the World Wide Web:
<http://www.open.gov.uk/hse/hsehome.htm>

This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

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