LECTURES ON ELECTRICAL SAFETY

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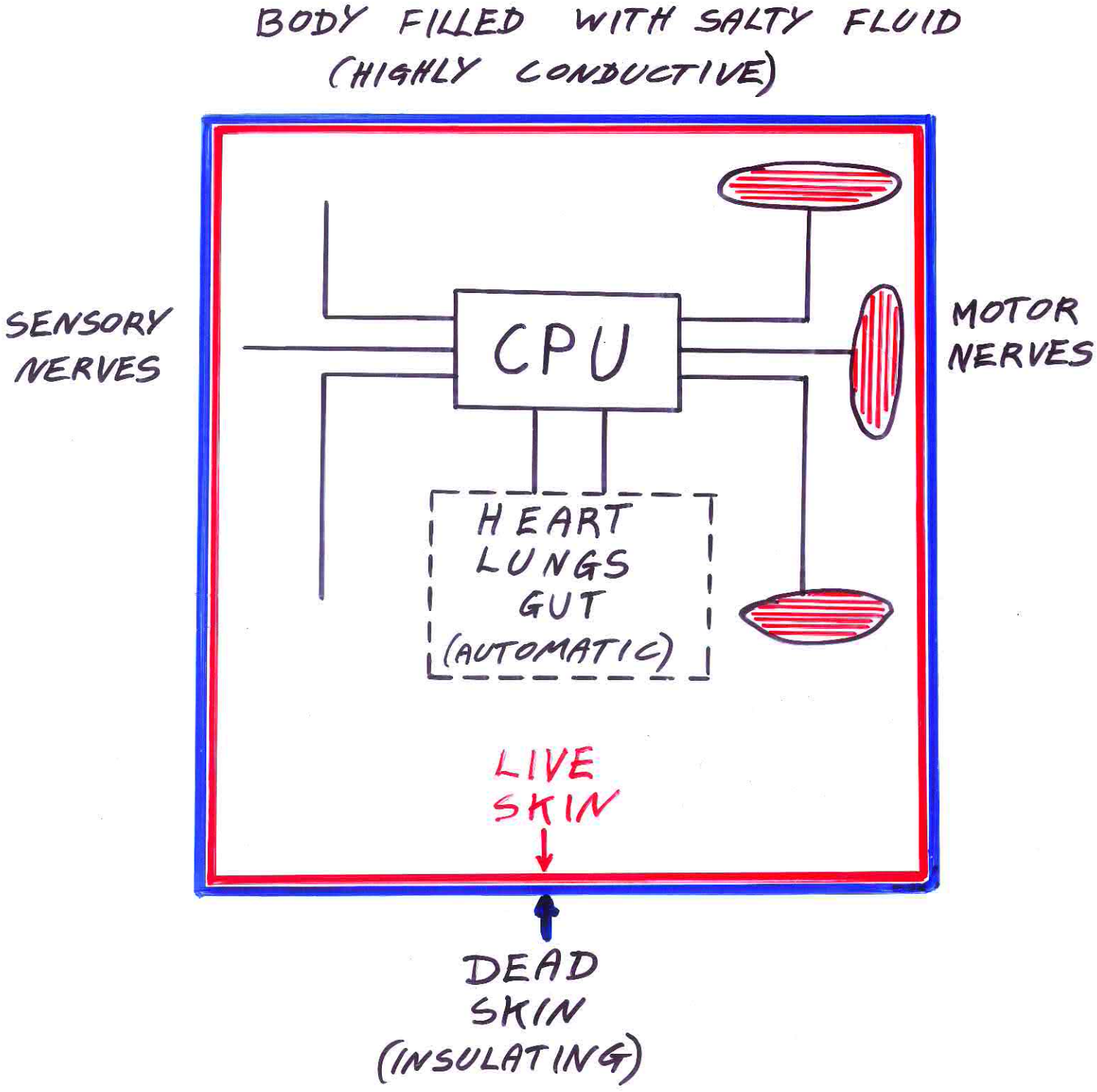
AN ELECTRONIC ENGINEER'S VIEW OF THE BODY



EFFECTS OF ELECTRICITY ON THE BODY

1. NEURO-MUSCULAR EFFECTS

A. Sensory nerves – pain, smell, taste, etc
B. Motor nerves – muscle contraction
C. Muscles - contraction

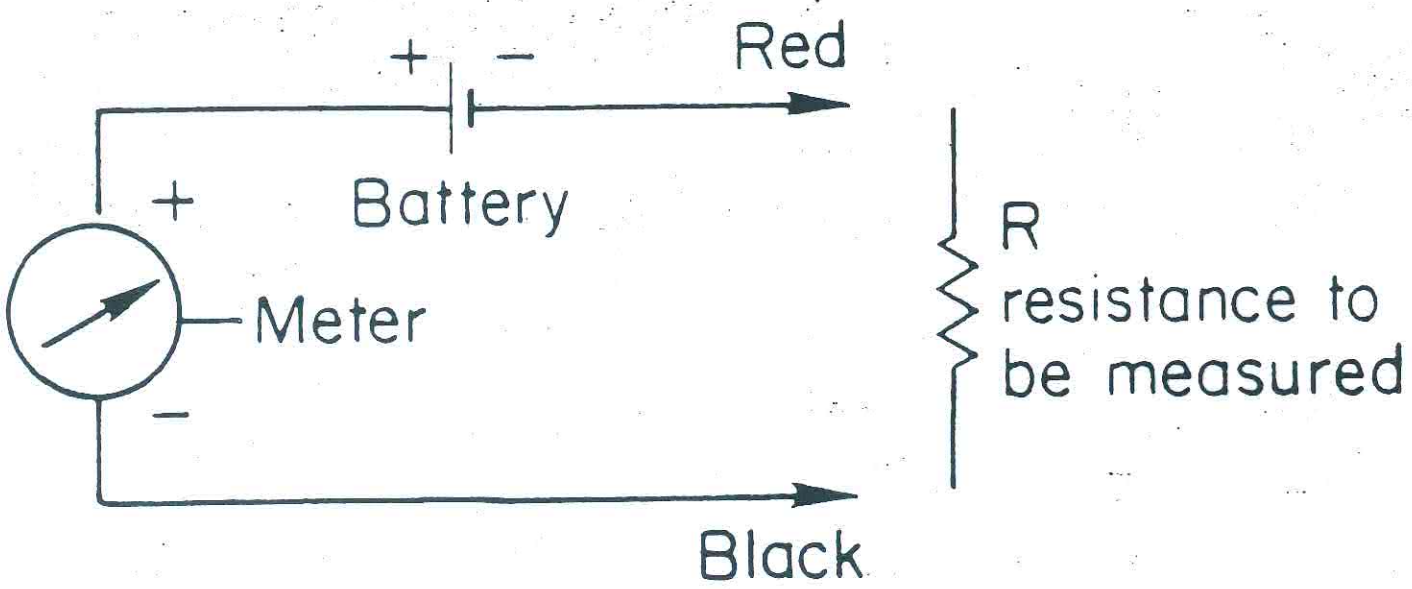
2. HEATING

3. ELECTROLYSIS

1. NEURO-MUSCULAR EFFECTS

100μA	Ventricular fibrillation (myocardial connection)
1mA	Perception
10mA	Can't let go
100mA	Severe pain and interference to heart and chest function (applied across chest)
1A	Sustained heart contraction

HOW DOES AN OHMMETER WORK ?



- Meter gives deflection ∝ current
- Calibrated from Ohm's law

- Zero resistance gives full scale reading
- Infinite resistance gives no deflection

- Switchable series resistors - select ranges
- Values between 1R and 10M measurable

CURRENT THROUGH SKIN @ 230 V

	R	I
SWEAT ↓	100 000	2.3 mA
	10 000	23 mA
	5 000	46 mA
	1 000	230 mA

Engineer's talent is a real shocker

AN ENGINEER immune to electric shocks can touch wires charged with 380 volts and feel only a slight itch. Constantin Craiu discovered his gift in 1972 while working on a circuit board. Since then he has never switched off the power while fixing anything. The Romanian's resistance was found to be 2,000 times stronger than that of an average person.

SKIN AND BODY RESISTANCE

Skin resistance:

1. Limits current that can flow through the body
2. Varies widely depending on:
    - Part of body
    - Water (liquid, moisture or sweat)
    - Natural oil present
    - Intact or broken
3. Inversely proportional to the area of contact

Resistances of body & connections at 50Hz:

Skin: 15kΩ.cm^2 to 1MΩ.cm^2
Limb: 200Ω
Trunk: 100Ω
Liquid-filled catheters: 50kΩ to 1MΩ
Electrodes: (Ag/AgCl): 500Ω

Copper handles example:

Diameter:	22mm
Length of skin in contact:	7cm
Area of skin in contact:	$\pi.D.L = \pi \times 0.22 \times 7cm$ $= 4.8cm^2$
Skin Resistance:	$\frac{15k\Omega.cm^2}{4.8cm^2}$ to $\frac{1M\Omega.cm^2}{4.8cm^2}$
	$= 3k\Omega$ to $200k\Omega$

John Webster (1998), "Medical Instrumentation: Application and Design (3rd edition)", p.634

It consists of a large chair, in which the patient sits, provided with four troughs or buckets in which carbon electrodes are secured, and a switchbound board of

Fig. 69. Dr. Schneè's Bath.

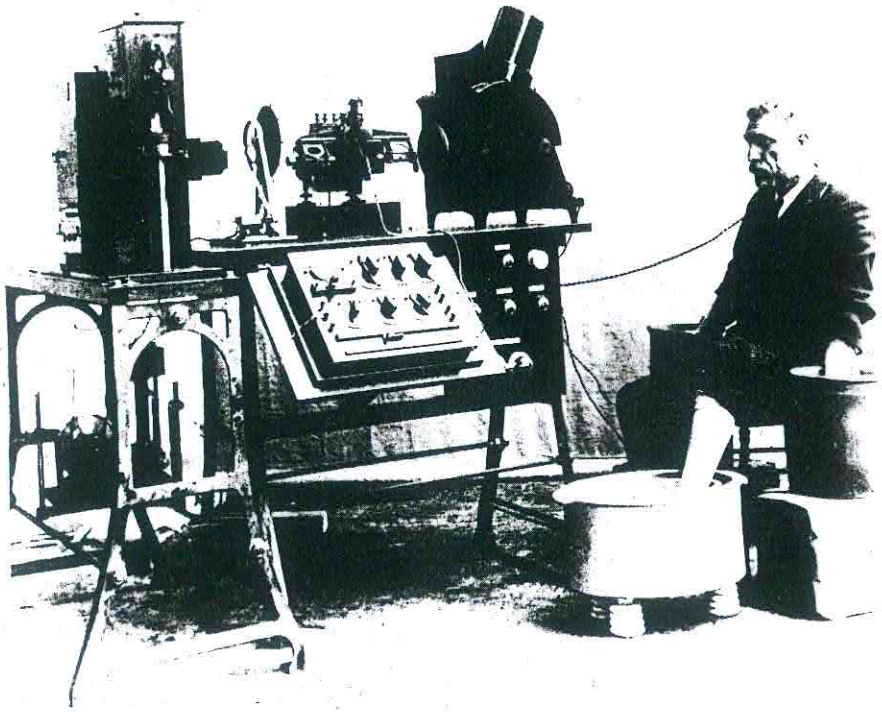
special design. The regulation is by means of a shunt resistance. In the lower part is a small motor, on the shaft on which are mounted a series of commutators and

switch close by makes the current supplied to the board constant or sinusoidal as required. Instead of two arms, an arm and a leg may be immersed or both arms and both legs.

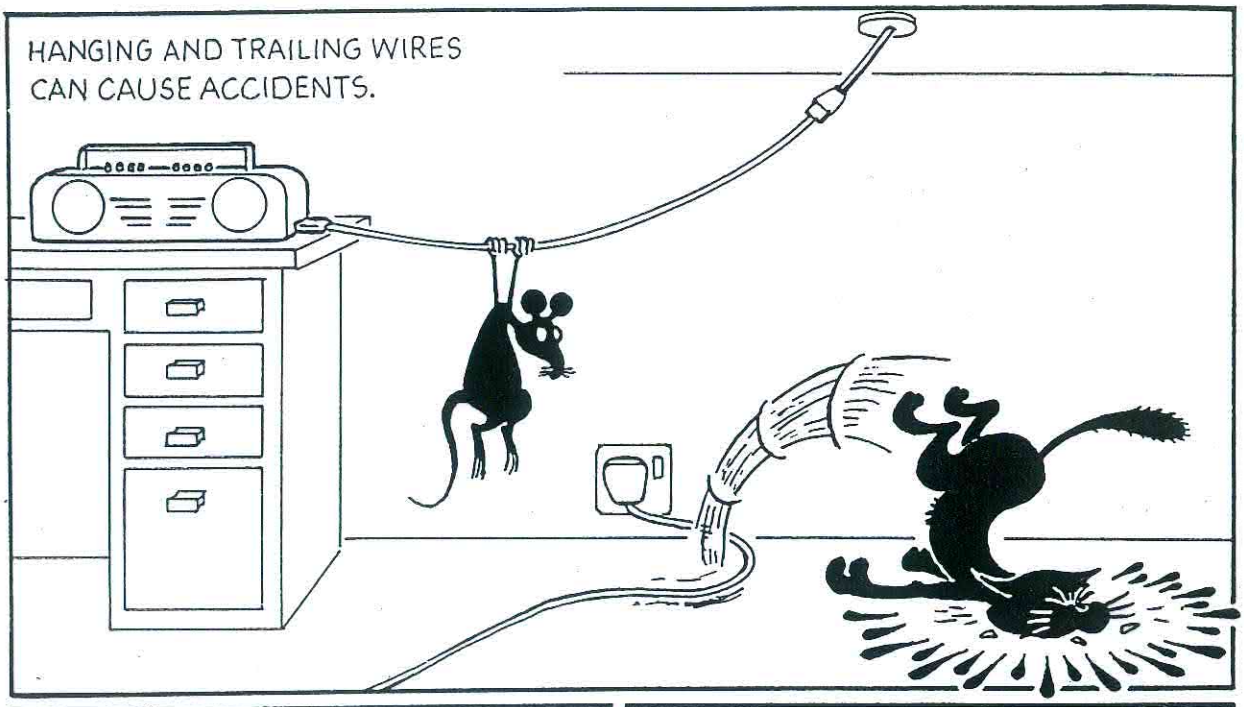
Fig. 68. Arm Bath.

The most highly developed form of the monopolar bath is that designed by Dr. Schneè, which is shown in figure 69.

The First Electrocardiograph Machine



HANGING AND TRAILING WIRES
CAN CAUSE ACCIDENTS.



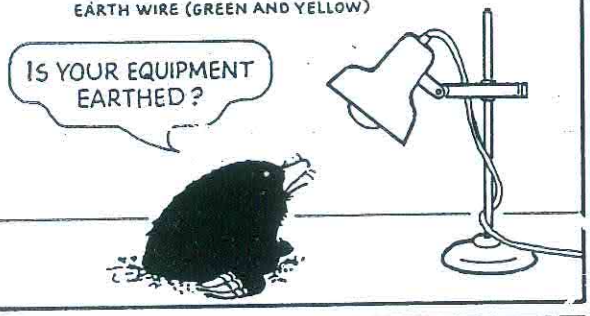
ELECTRICAL EQUIPMENT
MUST BE EARTHED
UNLESS IT IS DOUBLE INSULATED

TWO-CORE FLEX
FOR DOUBLE-INSULATED
EQUIPMENT ONLY.

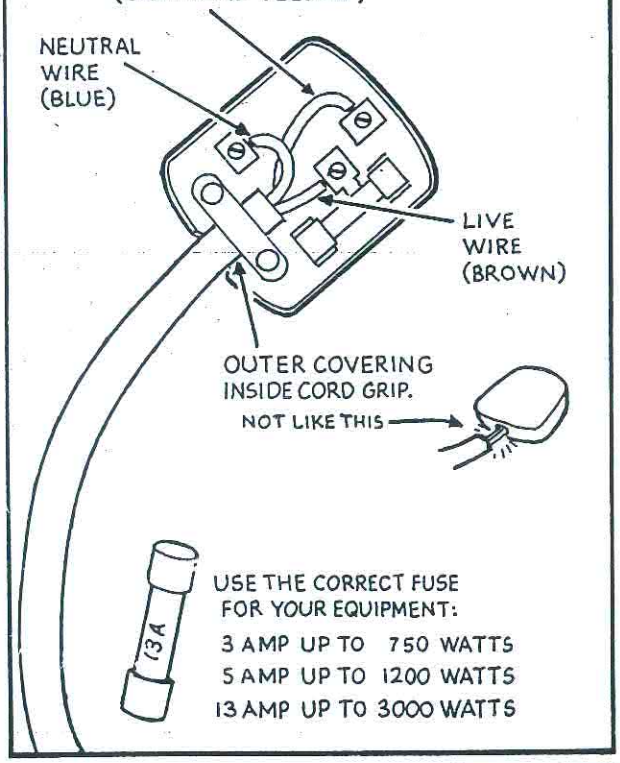
SIGN FOR
DOUBLE
INSULATION.

ALL OTHER EQUIPMENT
NEEDS THREE-CORE FLEX.

EARTH WIRE (GREEN AND YELLOW)



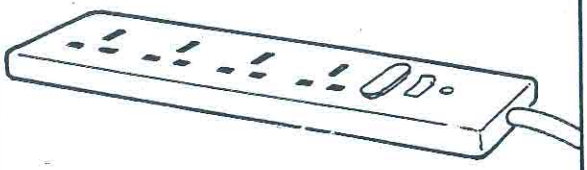
FIT PLUGS CORRECTLY
FOR SAFETY.



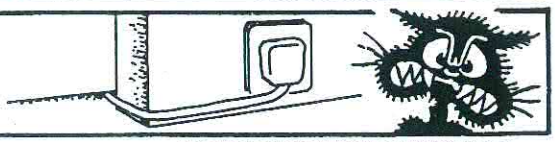
USE THE CORRECT FUSE
FOR YOUR EQUIPMENT:

3 AMP UP TO 750 WATTS
5 AMP UP TO 1200 WATTS
13 AMP UP TO 3000 WATTS

TO POWER FOUR 3-AMP LAMPS, COMPUTERS, ETC.
FROM ONE 13-AMP SOCKET, USE A
FUSED DISTRIBUTION BOARD.



TAKING POWER FROM OUTSIDE THE ROOM
CAN CAUSE TROUBLE (IT INTERFERES WITH THE WORK OF CLEANING AND MAINTENANCE).



DOCTOR FRY'S
DOCTORED AND FRIED LEAD
VISUAL INSPECTION LAB

"My worst work ever !"

Most faults:
Mains lead and plug

Aim of practical:
Visual inspection of mains leads to identify:

- Faults
- Possible hazards which would arise if the leads were used
- Non-compliance with BS EN 60601-1
- Recommendations to rectify faults, hazards and non-compliance

THE NUMBER ONE RULE OF MEDICAL PHYSICS:

"YOU MUST NOT KILL THE PATIENT (OR YOURSELF OR ANYONE ELSE)"

All have ≥ 5 faults; some are:

- Blatantly obvious and really dumb
- Potentially lethal
- Subtle, but nevertheless fail to comply with BS EN 60601-1

Faults may have arisen by:

- Misuse, abuse or damage
- Improvised "Ingenious repairs" by unqualified staff
- Sabotage

Your task is to spot all the faults you can simply by **VISUAL INSPECTION**.

Do **NOT** under any circumstances attempt to test these cables by plugging them into a mains socket or any test device.

You may **ONLY** use:

- Your Hands
- Your Eyes
- Your Brain
- A screwdriver

This practical session introduces you to:

THE NUMBER TWO RULE OF MEDICAL PHYSICS:

"THERE ARE LOTS OF WAYS
TO GET THINGS WRONG
– BUT USUALLY ONLY ONE WAY
TO GET IT RIGHT !"

SAFETY ASPECTS OF THE LEAD LAB

ASSEMBLY

- At work - people "borrow" things without asking
  - Tell colleagues what's being done
  - Don't leave leads lying around
  - Label each lead: DANGER: DO NOT USE
  - Legal disclaimer on each lead

- At home - small children
  - Can't read
  - Like "plugging in plugs"

LAB

- Verbal instructions
- Written instructions
- Ensure all cables are returned

STORAGE

- Store in locked metal case
- Warning notice on case
- Store case in locked office
- Don't lend out to anyone

BE PROACTIVE: SAVE LIVES !

- Give me your dodgy cables
- Be vigilent at home, at work and when visiting family, friends and relatives

YOUR NAME

LEAD VISUAL INSPECTION REPORT

LEAD NO.	FAULT NO.	DESCRIPTION OF FAULTS, HAZARDS, NON-COMPLIANCE AND RECOMMENDATIONS
1	1	
	2	
	3	
	4	
	5	
	6	
2	1	
	2	
	3	
	4	
	5	
	6	
3	1	
	2	
	3	
	4	
	5	
	6	
4	1	
	2	
	3	
	4	
	5	
	6	
5	1	
	2	
	3	
	4	
	5	
	6	
6	1	
	2	
	3	
	4	
	5	
	6	
7	1	
	2	
	3	
	4	
	5	
	6	