ECG

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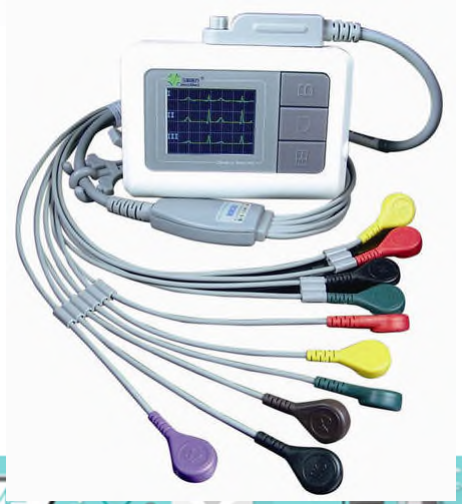
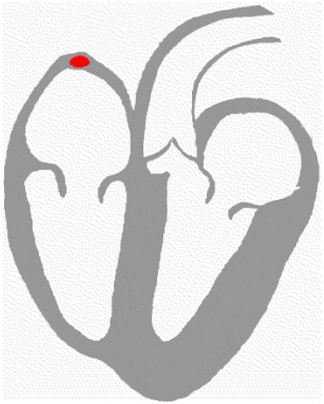
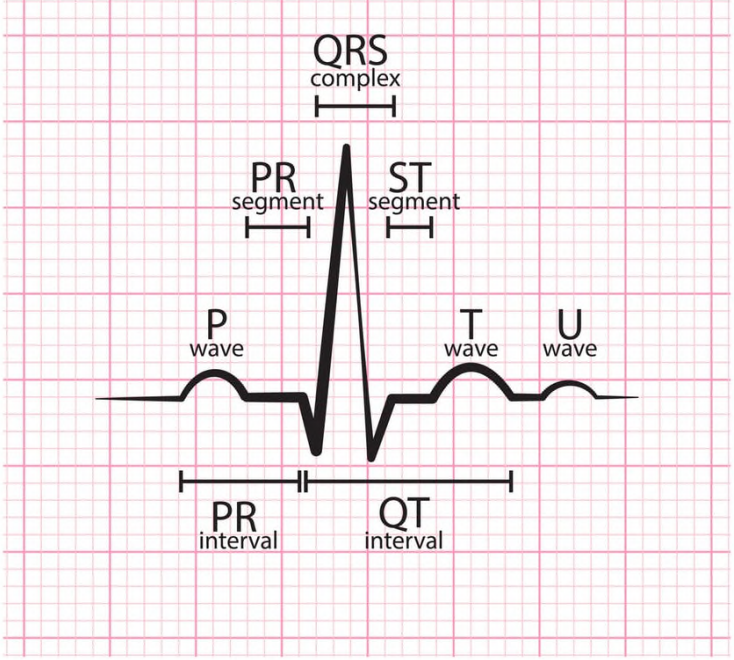
Secretary General, *IUPESM* (2018-2022)
Treasurer, *IFMBE CED* (2018-21)



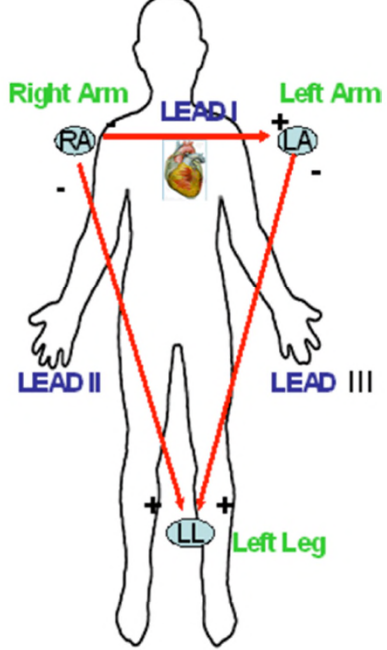
The electrocardiograph is a device that is able to graph
represent the time evolution of the cardiac potentials,
use of a writing system dependent on the cardiac signa
through electrodes placed according to certain derivat
consequently amplified and conditioned.

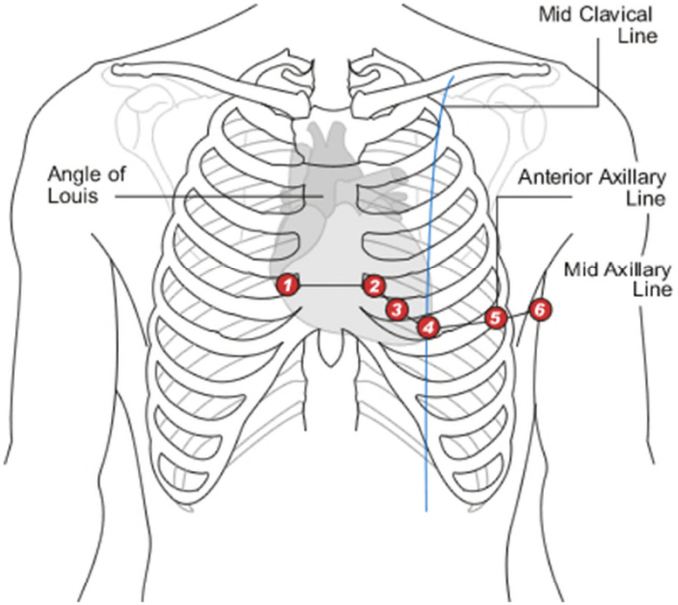


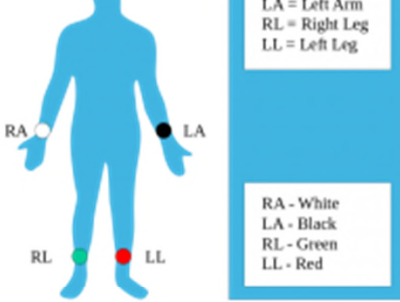


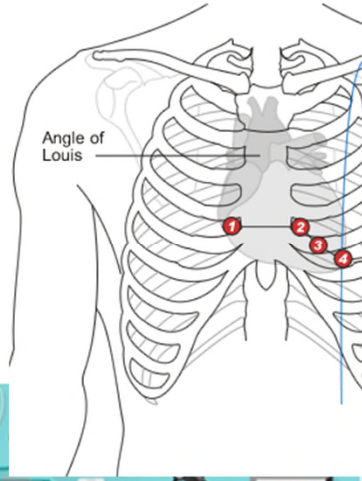
•RR interval: 0.6-1.2 seco
•P wave: 80 milliseconds
•PR interval: 120-200 mill
•PR segment: 50-120 mill
•QRS complex: 80-100 mi
•ST segment: 80-120 milli
•T wave: 160 milliseconds
•ST interval: 320 millisecc
•QT interval: 420 millisec
if heart rate is 60 beats p
(bpm)

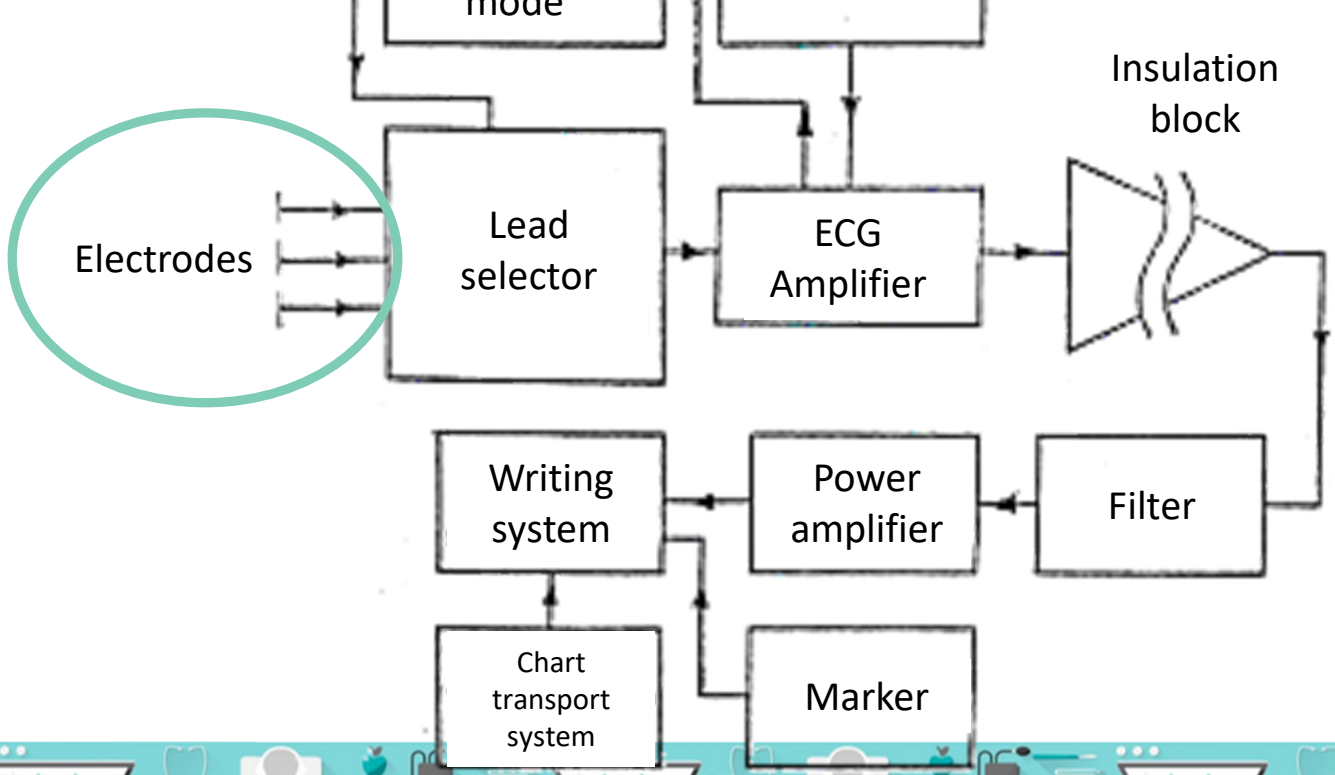
A small box is **1 mm × 1 mm** and represents **0.1 mV × 0.04 seconds**.
A large box is **5 mm × 5 mm** and represents **0.5 mV × 0.20 seconds**.


Right Arm
LEAD I
Left Arm
RA
LA
-
+
-
LEAD II
LEAD III
+
+
LL
Left Leg


Mid Clavical Line
Angle of Louis
Anterior Axillary Line
Mid Axillary Line
1
2
3
4
5
6

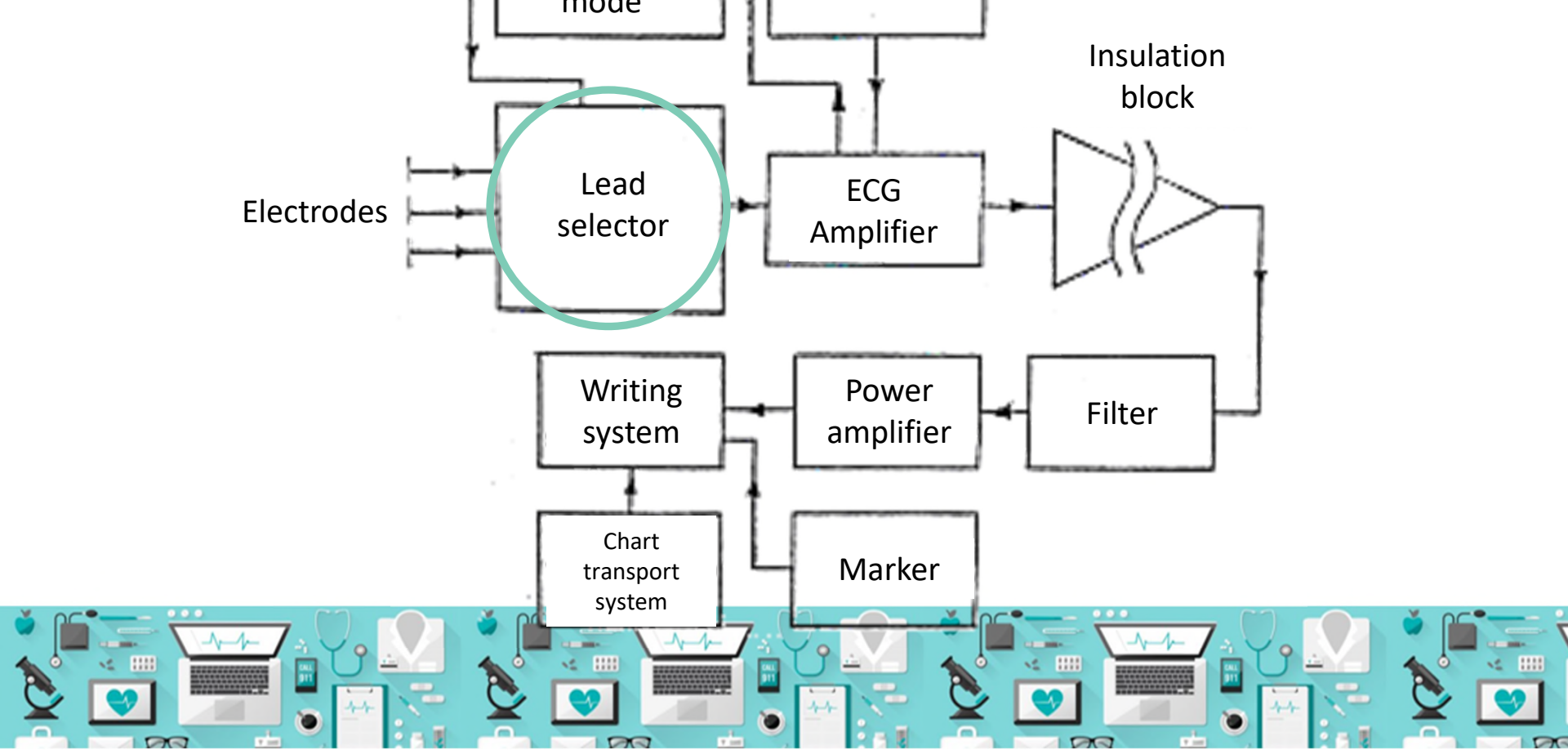

LA = Left Arm
RL = Right Leg
LL = Left Leg
RA
LA
RL
LL
RA - White
LA - Black
RL - Green
LL - Red


Angle of Louis
1
2
3
4

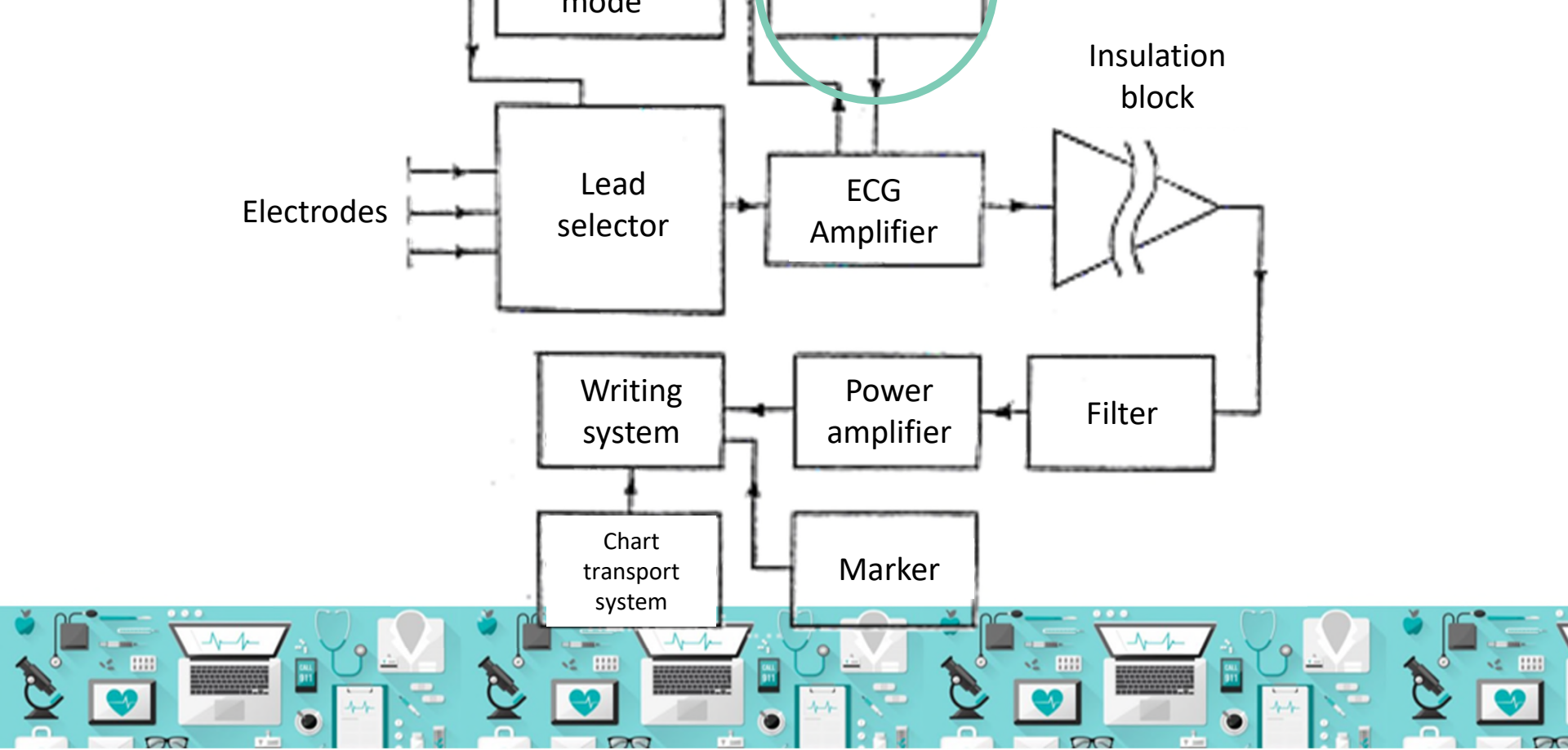

mode
Insulation
block
Electrodes
Lead
selector
ECG
Amplifier
Writing
system
Power
amplifier
Filter
Chart
transport
system
Marker

support, which is used to stick the electrode to the
once it's shaved and degreased. They do not require
electrode gel.

- **Reusable electrodes:** they are made of stainless ste
silver/silver chloride. They require conductive gel, m
cleaned with water or ethyl alcohol after each use t
gel. If the electrodes are made of silver/silver chlori
abrasive substances should be avoided to avoid dam
AgCl layer.


mode
Insulation block
Electrodes
Lead selector
ECG Amplifier
Writing system
Power amplifier
Filter
Chart transport system
Marker

This circuit combines the signals coming from the set of electrodes linked to the patient so that the operator can select the different derivations without changing the position of the electrodes on the patient.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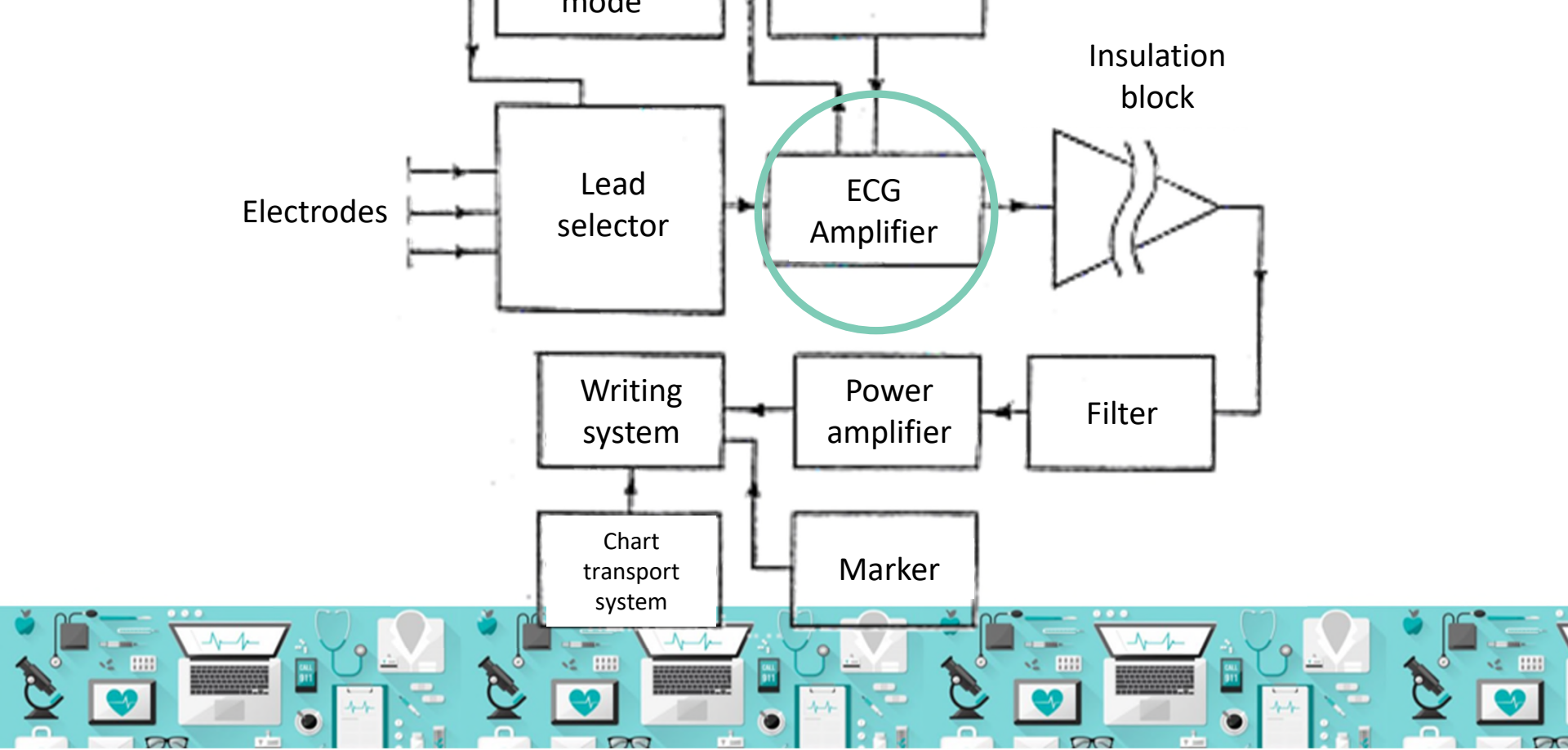
It allows the operator to manually input a signal with a certain amplitude
(ideally constant in time) as an input to the amplifier, in order to calibrate
the device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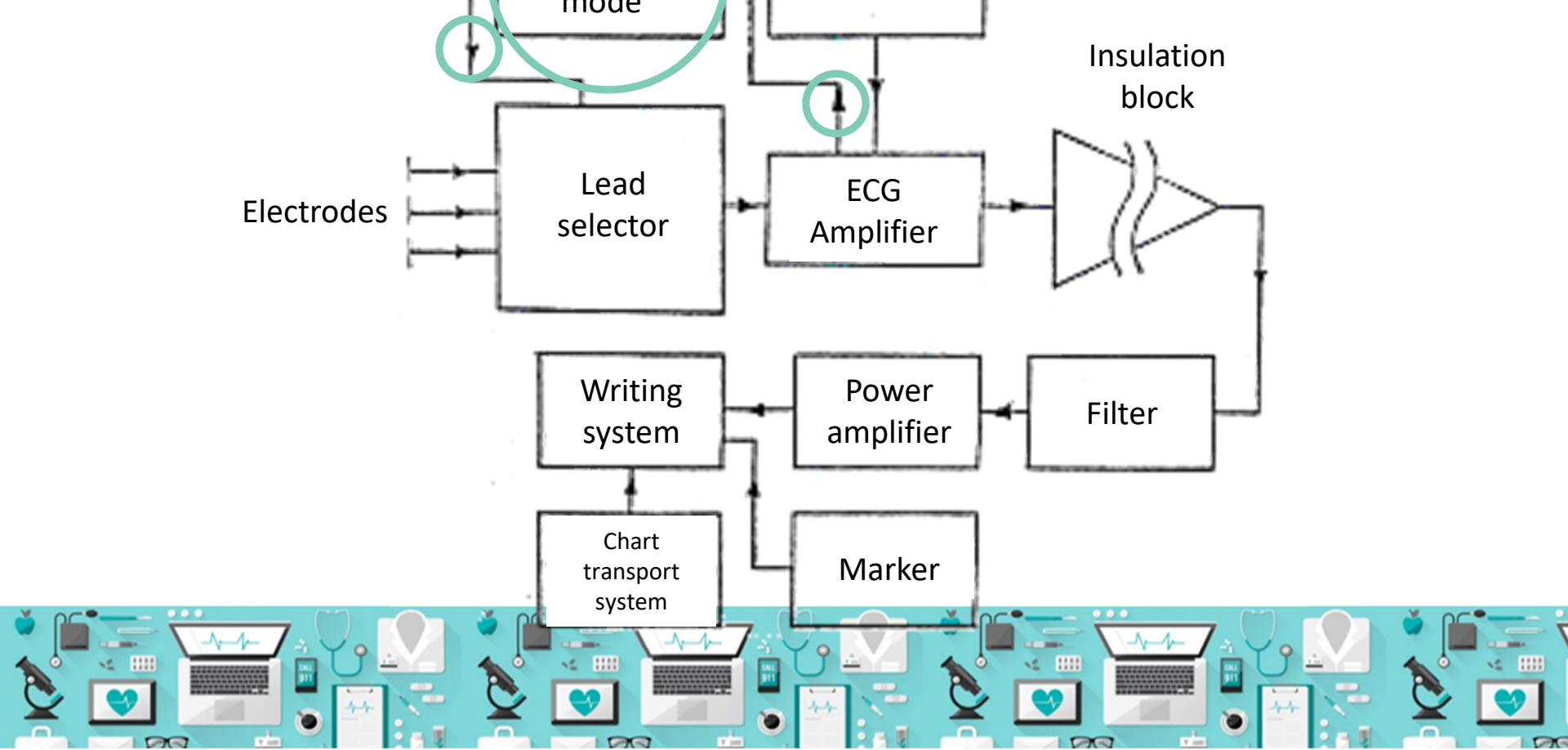
1) Differential input;
2) High input impedance (1-10 Mohm) to optimise the signal transfer to th following stages;
3) High CMMRR (common mode rejection ratio), about 60-80 dB to minim effect of the noise due to the common mode signals that are fed as an i

In some models the preamplifier has the common mode signals as one of t outputs, which can be conditioned and fed back to the patient to diminish on the ECG.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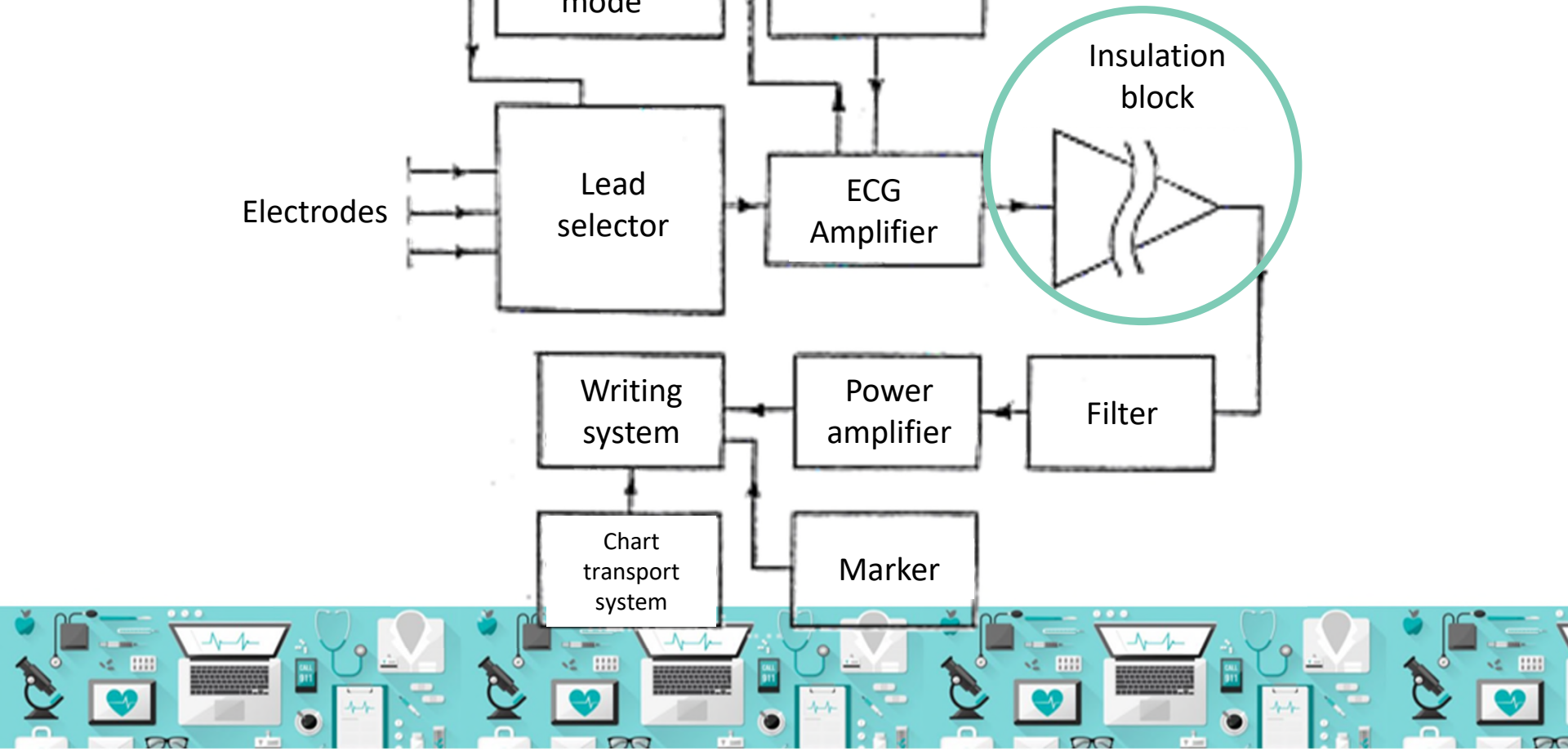
This block allows to feed the common mode signal (one of the outputs of preamplifier) back to the patient. This signal will need to be in phase oppo with the original common mode signal, to diminish its effects.
A high resistor (5-10 Mohm) is placed in series with this output of the prea to avoid that a high current flows in the patient.
Not all the ECGs have this block.


mode
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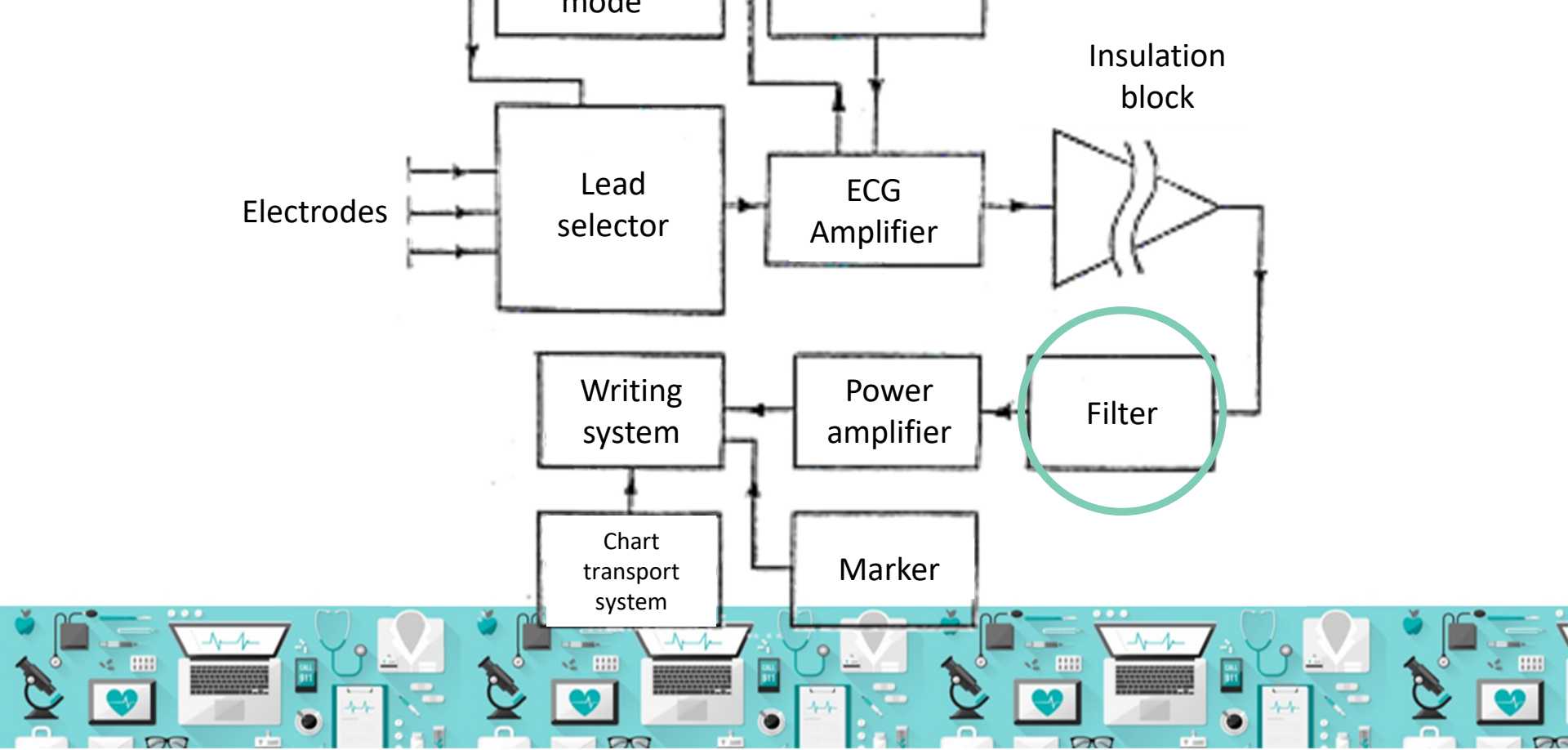
The ones that have it belong to class CF and got this symbol

This block:

1) Electrically insulates the patient from the electrical grid, to avo
   patient is exposed to high currents in case of malfunctioning;
2) Avoid that some leakage currents coming from other devices li
   patients flow to the ground through the ECG.

The insulation can be optic or electromagnetic (usually used toget
A malfunctioning of this block compromises the measures and exp
operators and the patients to the risk of accidental electrocution.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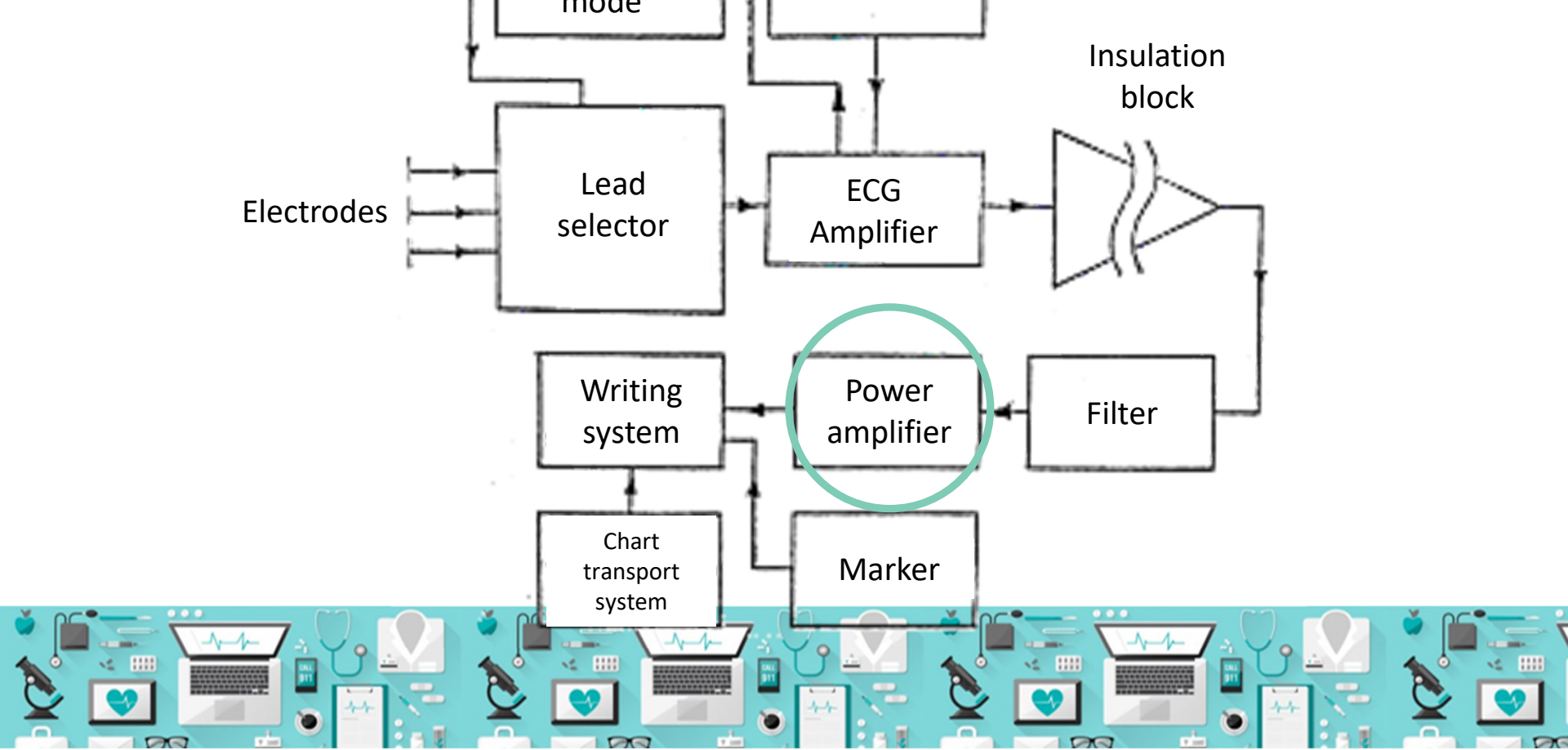
Marker

They let to attenuate some frequency bands in order to improve the reada
the signal. All the available ECGs today allow to apply a band-stop filter to
attenuate the noises that have the same frequency as of the electrical gri
It is possible to add other filters in more advanced devices. The most frequ
is the one used to reduce the artefacts due to breathing and muscle treme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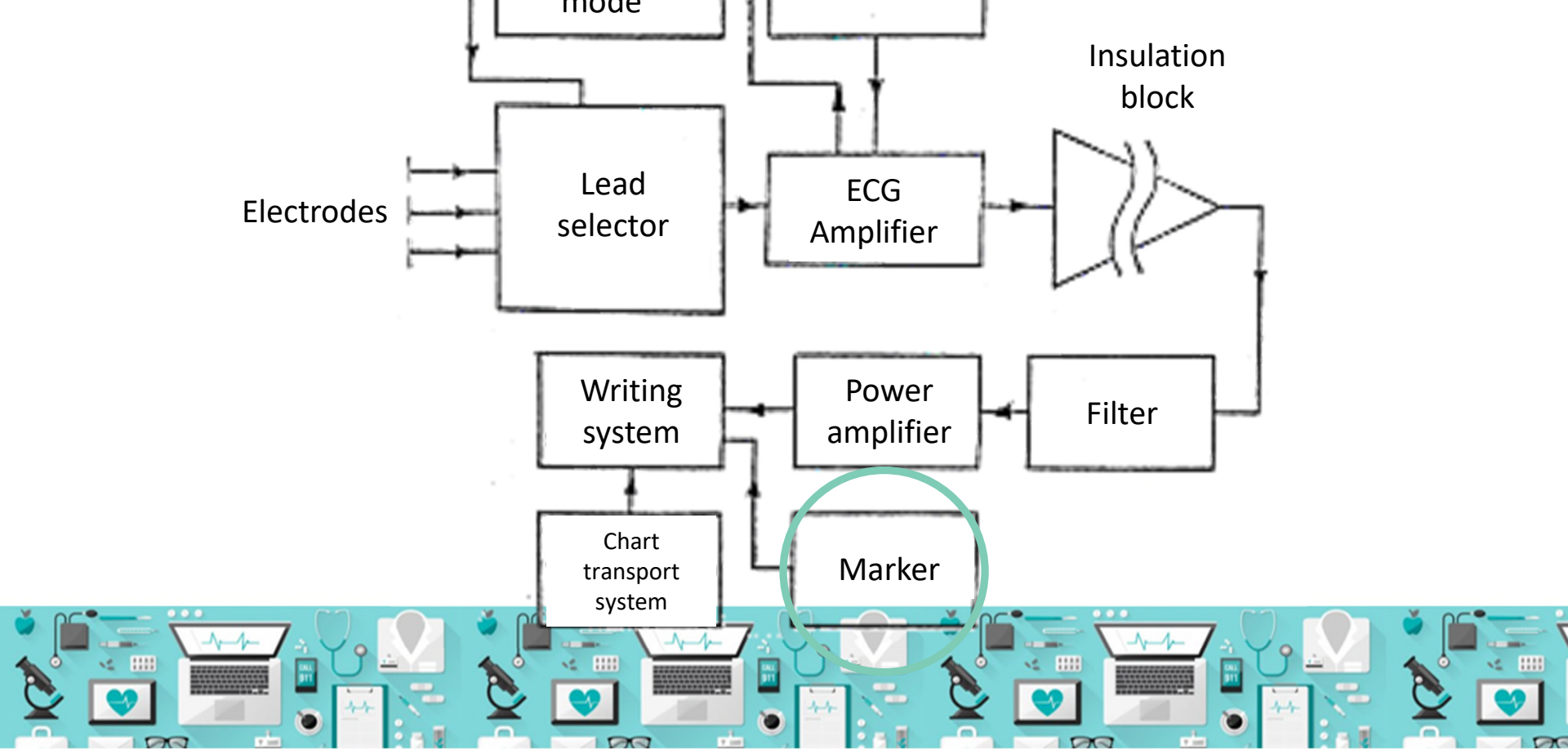
This block amplifies the ECG signal that has been conditioned by the previ
stages. This block allows to superimpose a continuous component, variabl
to a potentiometer, to let the operator to position the pen on the desired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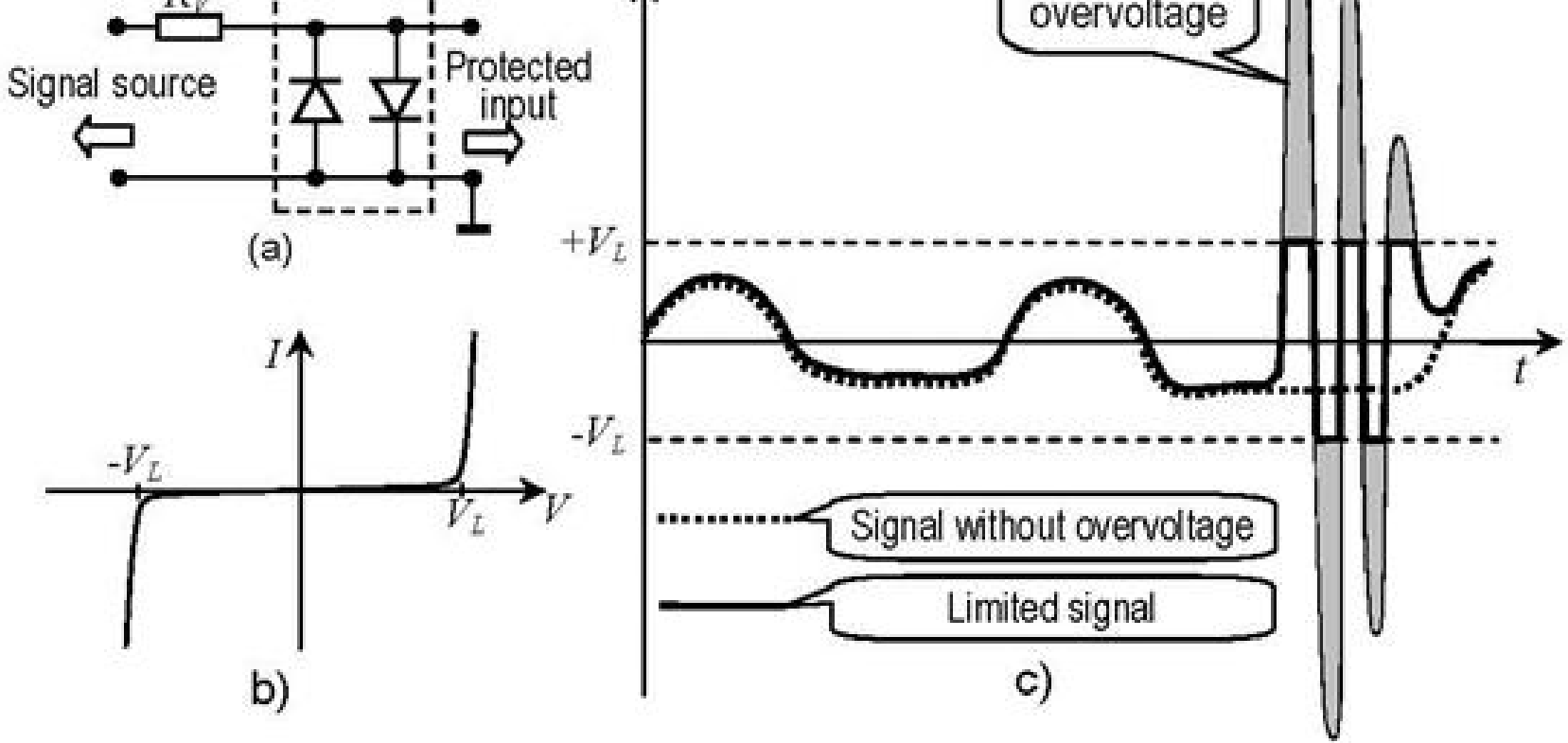
Marker

It allows the operator to mark particularly interesting sections of the signa
order to make them easy to find while reading the ECG.


Signal source
Protected input
(a)
I
$-V_L$
V_L
V
b)
overvoltage
$+V_L$
$-V_L$
t
Signal without overvoltage
Limited signal
c)

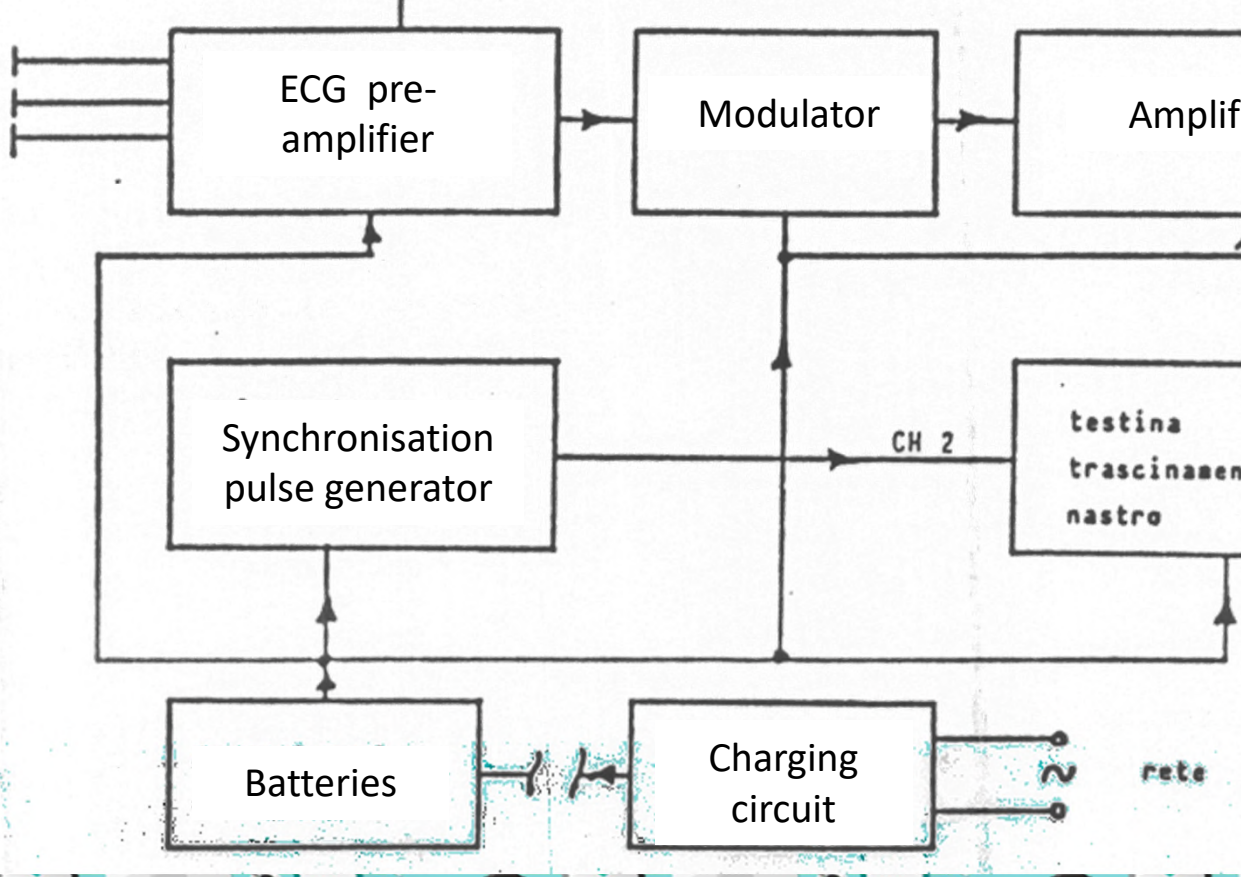
The patient linked to a ECG can be exposed to the risk of electrocution in 2
1) When leakage currents, coming from the electrodes on the patient or f
chassis of the device towards the ground, flow through him;
2) When the patient is linked to other devices or when the patient comes
contact with a metallic mass with a potential different from the ground po

link patient-device is done through electrodes directly positioned on the h
the leakage current should be less than 10 microampere.

In order to avoid accidental electrocution with other devices, the patient s
be isolated from the ground:

- Use beds made of insulating materials;
- Avoid linking the patient to other devices that can be a low-impedance
  towards the ground;
- Avoid that the patient comes into contact with metallic masses such as
  radiators, metallic bedside tables etc.


Recording device
Electrode


ECG pre-amplifier
Modulator
Amplif
Synchronisation pulse generator
CH 2
testina
trascinamen
nastro
Batteries
Charging circuit
rete

1.4 AC Plug - verify integrity
1.5 Line Cord - verify proper insulation and integrity
1.6 Strain Reliefs - verify physical integrity at both ends of line cord
1.9 Inspect patient cable and leads
1.10 Fittings/Connectors examine all cable connectors
1.13 Controls/Switches - verify proper operation
1.18 Indicators/Displays - verify proper illumination and operation
- verify trace quality and linearity
- verify QRS waveform on display
1.19 1mV Step Response - verify proper operation of TEST/CAL button
1.22 Labeling - verify presence and placement of all labels, placards, instruction cards, etc.

2. Quantitative Tests
2.1 Grounding Resistance [< 0.5 ohm]
2.2 Chassis Leakage [< 300 microamps]
Lead Leakage [< 10 microamps (G), <50 microa
Inter-lead Leakage [< 10 microamps (G), <50
Input Isolation [< 50 microamps]
2.10 Rate Calibration
- verify rate accuracy at 60 BPM and 120 BPM
[+/- 5% or 5 BPM, whichever is greater]
2.11 Rate Alarm
- verify visual and audible alarms at 60 BPM
[+/- 5% or 5 BPM, whichever is greater]
2.12 Alarm Delay
- verify high and low alarm delay
[< 10 sec]
2.13 Asystole Alarm Delay
- verify asystole alarm delay
[< 5 sec]

The following table summarises certain problems that may occur and the relative causes.

Problem	***Cause***
Isoelectric line drift	- Use of electrodes other than originals Use of electrodes in saturation - Insufficient electrode/skin contact - Electrode surface dirty - Patient moving
Interference from a.c. mains supply	- Voltage generator too close; presence of other clinical instruments (e.g. X-rays, etc.) - Patient in contact with metallic parts or with other persons
Muscle tremors	- Patient not relaxed - Peripheral electrodes adhering too tightly
Irregular paper transport	- End of paper roll - Paper roll incorrectly positioned - Use of non-original paper
Analysis impossible	Signal too unstable or noisy
No copy of trace	Recording interrupted before 10 seconds have elapsed
Abnormal signal	- Defective patient cable - Defective electrodes

protection	
Applied part	CF type
Defibrillation protection	Internal
Input dynamic	± 300 mV @ 0 Hz.± 10 mV in pass band
Input impedance	> 100 MΩ on each electrode
Common mode rejection	> 100 dB balanced electrode impedence
Frequency response	0.05 - 150 Hz (-3dB)
Time constant	3.3 s
Acquisition	12 bit 1000 samples/s/channel printing and filters 500 samples/s/channel in calculation and filters Resolution 5 μV/bit
Leads	12 leads in Standard, Cabrera
Signal memory	10 seconds for each lead in auto isochronous
Recording sensitivity	*Manual*: 5 – 10 – 20 mm/mV *Automatic*: dependent on number of channels printed
Writing system	Thermal printer, 8 dot/mm Usable print height 210 mm
Print channels	12
Print format	Automatic mode: 3, 6×1, 6×2, "Full Page"(3×4+R)×1 e (3×4+3R)×1, 12×1 Manual mode: 3, 6, 12
Paper transport speed	5 mm/s ± 10% 25 – 50 mm/s ± 5%
Screen scrolling speed	12.5 – 25 – 50 mm/s
Thermal paper	*in rolls*: height 210x280 mm, length 17 m, gridded. *Z-fold pack:* length 30 m, page 210x150 mm, gridded. *Z-fold pack*: length 60 m, page 210x300 mm, gridded
Pacemaker recognition	Recognises pulse in accordance with current IEC standards
Filters	*Mains interference:* Modified digital notch filter 50 - 60 Hz linear phase - may be switched on/off. *Anti-drift:* Digital high-pass 0.5 Hz, linear phase, always enabled
Serial interface	Infrared
Keyboard	Membrane, with functional and alphanumeric keyboard extended
Display	Black and white type graphic LCD, 320x240 pixels (5.7 inch). Actual display area120x89 mm.

	Timed: acquisition at user-defined intervals *Arrhythmia:* arrhythmic event recognition (optional) *PC-ECG:* real time acquisition with display at PC *HRV*: heart rate variability analysis *Emergency:* acquisition in emergency *Paper saving:* acquisition without printing
Options	- Memories option - ECG measurements option - ECG interpretation option - Arrhythmia option - HRV option - PC archive option - PC ECG option
Battery capacity	*Internal battery:* 1 hour in continuous recording and printing
Recharging time	*Internal battery:* 24 hours 100%
Housing protection category	IP 20
Ambient conditions: - operation	*Ambient temperature:* from +10°C to +40°C *Relative humidity:* from 25% to 95% (without condensation) *Atmospheric pressure:* from 700hPa to 1060 hPa
- transport and storage	*Ambient temperature:* from -10°C to +40°C *Relative humidity:* from 10% to 95% (without condensation) *Atmospheric pressure:* from 500 to 1060 hPa
Dimensions	325 x 80 x 345 mm (length x height x depth)
Weight	5000 grams without paper
Conformity to standards	EN 60601-1: 1990 EN 60601-1/A1: 1992 EN 60601-1/A2: 1995 EN 60601-1/A13: 1995 *General standards for safety of electromedical equipment* EN 60601-1-2: 1993 *Standards on electromagnetic compatibility of electromedical equipment* EN 60601-2-25: 1995 EN 60601-2-25/A1: 1999 *Particular safety standards for electrocardiographs* IEC/60601-2-51/Ed.1: 2001 *Particular standards on essential recording and analysis performance safety of single and multichannel electrocardiographs.*