The South African Institute for Computer Scientists and Information Technologists

ANNUAL RESEARCH AND DEVELOPMENT SYMPOSIUM

23-24 NOVEMBER 1998
CAPE TOWN
Van Riebeeck hotel in Gordons Bay

Hosted by the University of Cape Town in association with the CSSA, Potchefstroom University for CHE and The University of Natal

PROCEEDINGS

EDITED BY
D. PETKOV AND L. VENTER

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FOREWORD

The South African Institute for Computer Scientists and Information Technologists (SAICSIT) promotes the cooperation of academics and industry in the area of research and development in Computer Science, Information Systems and Technology and Software Engineering. The culmination of its activities throughout the year is the annual research symposium. This book is a collection of papers presented at the 1998 such event taking place on the 23rd and 24th of November in Gordons Bay, Cape Town. The Conference is hosted by the Department of Information Systems, University of Cape Town in cooperation with the Department of Computer Science, Potchefstroom University for CHE and and Department of Computer Science and Information Systems of the University of Natal, Pietermaritzburg.

There are a total of 46 papers. The speakers represent practitioners and academics from all the major Universities and Technikons in the country. The number of industry based authors has increased compared to previous years.

We would like to express our gratitude to the referees and the paper contributors for their hard work on the papers included in this volume. The Organising and Programme Committees would like to thank the keynote speaker, Prof M.C.Jackson, Dean, University of Lincolshire and Humberside, United Kingdom, President of the International Federation for Systems Research as well as the Computer Society of South Africa and The University of Cape Town for the cooperation as well as the management and staff of the Potchefstroom University for CHE and the University of Natal for their support and for making this event a success.

Giel Hattingh, Paul Licker, Lucas Venter and Don Petkov

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ERROR ANALYSIS IN SELECTED MEDICAL DEVICES AND INFORMATION SYSTEMS

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Abstract

The purpose of this paper is to identify and analyse error in selected medical devices: the Datex cardiocap and the capnomac Ultima II. These are both anaesthetic machines used to monitor patients in theatre. A secondary purpose of this paper is to investigate how the present error management technique used in the medical world affects the improvement of the interface in medical equipment.

Introduction

Human factors Engineers are the first to grant that people make mistakes. Research over the years has proved that some of the blame to be found in the design of the equipment people use and that people make more mistakes with some kind of equipment than with others. Research has also shown that many patients suffer from hospital inflicted injuries as a result of human error and that a significant percentage of these errors are machine provocated.

Impetus for this paper arises from these findings. The purpose of this paper is to identify error provocative features in two anaesthetic machines: The Datex Capnomac Ultima and the Datex Cardiocap II and show how these features contribute to human error. Based on the analysis of the error caused by these features, the author suggests changes in the systems that will reduce the error.

Further, the author looks at the error management style and the way error is viewed in the medical world and shows how this culture has failed to reduce the error in the medical field. The author concludes by changing of the error provocating features in the machine is not adequate to curb the error, changes have to be made in the error management style as well.

Background

Error Management

Error management at the organisational level has two components, error reduction and error containment.

Error reduction consists of measures taken to limit the occurrence of errors while error containment consists of the measures taken to limit adverse consequences. Error management can be defined as actions taken either to reduce the probability of errors occurring (error avoidance) or to deal with errors committed either by detecting and correcting them before they have operational impact (error trapping) or to contain and reduce the severity of those that become consequential (error mitigation). [Reason :1997].

How an organisation deals with error and violations is a critical element of its culture. Thus, the success of a program is dependent on whether or not it is congruent with the organisational culture. Therefore it is important to look at how the Medical world views error and how error is dealt with.

How Human Error is viewed in medical World

Efforts at error prevention in medicine have characteristically followed what might be called the perfectibility model: if physicians and nurses could be properly trained and motivated, then they would make no mistakes. The methods used to achieve this goal are training and punishment. Training is directed towards teaching people to do the right thing. In nursing, rigid adherence to protocols is emphasised. In medicine, the emphasis is less on rules and more on Knowledge.

Punishment is through social opprobrium or peer disapproval. The professional cultures of medicine and nursing typically use blame to encourage proper performance. Errors are regarded as someone's fault, caused by a lack of sufficient attention or, worse, lack of caring enough to make sure you are correct.

Punishment for egregious (negligent) errors is primarily (and capriciously) meted out through malpractice tort legislation system.

Students of error and human performance reject this formulation. While the proximal error leading to an accident is in fact, usually a "human error", the causes of that error are often well beyond the individual's control. All humans err frequently. Systems that rely on error free performance are doomed to fail.

The medical approach to error prevention is also reactive. Errors are usually discovered only when there is an incident- an untoward effect on injury to the patient. Corrective measures are then directed toward preventing a recurrence of a similar error, often by attempting to prevent that individual from making a repeat error. Seldom are underlying causes explored.

The Impact Of Human Error In Medical Information Systems

Evidence from a number of sources, reported over several decades indicates that a substantial number of patients suffer treatment-caused injuries while in the hospital.

A research carried out in 1964 reported that of all patients admitted to teaching hospitals, 20% suffer treatment caused injuries, 20% of those injuries are serious or fatal. [Schimmel:1964]

A later research carried out in 1991 reported that 36% of patients admitted to a university medical service in a teaching hospital suffered an iatrogenic event (treatment caused injuries), of which 25% were serious or life threatening. More than half of the injuries are related to use of medication. [Steel et al]. All the major government hospitals in South Africa are teaching hospitals. They found that 64% of cardiac arrests in teaching hospitals are preventable. Again inappropriate use of drugs is the leading cause of cardiac arrests. [Bedell et al:1991]. A population- based study of iatrogenic injury in patients hospitalised in New York State in 1984 revealed the following results: Nearly 4% of patients suffered injury that prolonged their hospital stay or resulted in measurable disability. For New York State this equalled 98609 patients in 1984. Nearly 14% of these injuries were fatal. If these rates are typical of the United States, then 180, 000 people die each year partly as a result of iatrogenic injury, the equivalent of three jumbo-jet crashes every 2 days.[Harvard medical Practice:1991].

When the causes were investigated it was found that most iatrogenic injuries are due to errors and are therefore potentially preventable. For example, in Harvard Medical Practice Study, 69% of injuries were due to errors (the balance was unavoidable).

Injuries are only a tip of the iceberg of the problem of errors since most of the errors do not result in injury. For example medication errors occur in 2% to 14% of patients admitted to hospitals but most do not result in injury. Autopsy studies have shown high rates (35% to 40%) of missed diagnoses causing death. One study of errors in a medical intensive care unit revealed an average of 1.7 errors per patient of which 29% had the potential of serious or fatal injury.

Given the complex nature of medical practice and the multitude of interventions that each patient receives, a high error rate is perhaps not surprising. The patients in the intensive care unit study were recipients of 178 "activities" per day. The 1.7 errors per day indicates that the hospital personnel were functioning at a 99% level of proficiency. However a 1% failure rate is substantially higher than is tolerated in the industry.

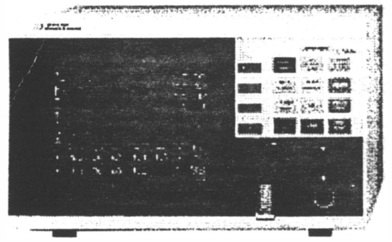
> "If we were to live with 99.9% we would have 2 unsafe plane landings per day at O'Hare, 16 000 pieces of lost mail every hour, 32 000 bank checks deducted from the wrong bank account every hour."
>
> W. E. Demming.

In view of how high the rate of error is in the medical field and the intolerant nature of the error management system in the medical world, Is it not possible that the medics are going about the error management in the wrong way? Is it not probable that the cause of human error may be more than just negligence or lack of Knowledge? This paper sets out to show some of the blame may be found in the design of the equipment used in hospitals and that redesigning of the equipment could reduce human errors.

This paper bases its study of error on two machines used to monitor patients in theatre, the Datex Capnomac Ultima and the Datex Cardiocap II. . These two machines are chosen because of the critical nature of their function and because they are among the best monitoring machines available in the market.

For optimal monitoring, the two machines are normally used together. Together they give the haemodynamic and gas parameters, including agent identification and visual loops describing the patient's ventilatory status. Their interfaces are quite similar therefore their errors will be discussed under the same titles.

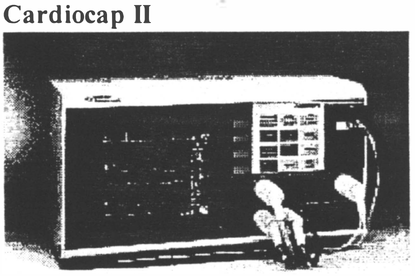
Capnomac Ultima



The Datex Capnomac Ultima is a respiration and ventilation monitor. It combines airway gas monitoring with anaesthetic gas monitoring and identification. Patient Spirometry, obtained by the use of an airway adapter, can be added as an option. This option lets the anaesthetist verify that the proper volume per breath is being delivered at the lowest possible pressure.

The Capnomac is used for the measurement of the essential airway gas parameters: $CO2$, Patient $O2$, $N2O$ and anaesthetic agents for example Halogen, Isoflurane.

Cardiocap II



Cardiocap II is a combined haemodynamic and airway gas monitor. All models provide the basic haemodynamic measurements. Four of the models include built-in gas measurement, breath-by-breath with waveforms.

Analysis Of Errors Observed With The Devices Under Concern

This paper distinguishes error on the part of the system that causes the error: Machine Errors and Human Errors. Machine errors are errors that occur as a result of 'bugs' in the machine's design while Human errors are errors caused as a result of inadequate implementation of human factors. The human errors are further divided according to the phase in which the error takes place.

- Perceptual errors are caused by insufficient perceptual cues, resulting in a failure to detect important information or discriminate correctly between display objects or types of feedback.
- Taxing the memory and problem solving capabilities of the human mind causes cognitive Errors. Taxing the eye-hand co-ordination and level of motor skill of the users causes motor Errors. For instance requiring awkward motor movements.

Machine Errors

Machine errors are manifested in improperly designed equipment, in failure to assign effective roles to equipment, and in failure to meet system requirements. Many machine errors are made while the engineer is considering a number of alternatives. Only those alternatives which are not caught and which, appearing in the final design remain to influence the operational usage of the system are within the definition of the term.[Meister:1971]. Following are the machine errors observed in the two machines:

The accuracy of the readings in a Datex machine are especially important for the Anaesthetist to make correct decisions on the actions that must be taken at any particular time during the cperation. It is therefore imperative that the Datex machines must be accurate at all times and inform the anaesthetist in the event of an error in the system.

However sometimes the machine's readings do not correlate to the patient's actual case even though the anaesthetist has gone through the correct set-up procedure. If this happens the machine has to be manually calibrated. The only problem is that the anaesthetist will only realise that the machine readings are not right after a few readings have been taken from the patient. Unfortunately the machine cannot be calibrated manually whilst it is connected to the patient. This means that throughout the operation anaesthetist will not be able to use the machine. If the anaesthetist does not realise that the machine's readings are wrong the results may be fatal.

The Datex Capnomac makes use of the pulse oximeter. The pulse oximeter gives the levels of oxygen in the blood of the patient without being invasive. The pulse oximeter will only work as long as there is a pulse reading. It works well until when it is most needed, that is, when the patient arrests. When the pulse rate is too low to be read or there is no pulse at all the pulse oximeter does not work. To get a reading on the amount of oxygen present in the patient's blood, the patients blood has to be drawn and tested for oxygen levels on a different machine a process which takes approximately 5 minutes. The pulse-oximeter may not be the correct device to use in a theatre situation where cardiac arrests are common. An invasive device may be more useful so that the oxygen levels may be read at all times regardless of how low the pulse of the patient is.

Every now and then during the operation the machine will auto-calibrate. During which time no readings on the gas levels are given (5 to 10 seconds). The anaesthetist will have to rely on his intuition and judgement during this time. This could mean a lot depending on how ill the patient that is being operated on is or how critical the readings were at the point of calibration. Auto-calibration should not affect the machine's display. If this has to be the case then the process should be short and far spaced. It should only take place if the readings are normal.

The Capnomac Ultima allows the anaesthetist to set two or more waveforms depicting the same thing. This option is of no use to the anaesthetist as the waves are synchronous and thus exactly the same. For example all the waveforms could be set to depict carbondioxide levels. This function adds no advantage to the system.

Although the machine has an error check when first switched on. It does not have other error checks after this. When the machine becomes faulty it gives inaccurate readings and this goes undetected until an anaesthetist realises that the readings are wrong. If this goes undetected for long and an anaesthetist adjusts the agents according to the machines reading the patient may die. Frequent self-checks are required so that so that the anaesthetist does not get wrong readings.

As an anaesthetic technique the anaesthetist may use one anaesthetic agent and then change to another agent in the middle of the operation. The Capnomac Ultima requires the anaesthetist to identify the anaesthetic that he is using at the beginning of the operation. After this all the readings it gives will be directly related to this agent. For example the anaesthetist may enter Halothane as his agent at the beginning of the operation and halfway through he may change the agent to Isoflurane. The Datex Capnomac uses an infrared spirometer to test for the anaesthetic agents that are in use. This machine is not very accurate although it can accurately differentiate between carbondioxide and oxygen it cannot differentiate between the anaesthetic agents, some of which are isomers[1]. The Capnomac will continue to give him readings relating to the halothane. For example after giving 1.6% of isoflurane it may have a reading of 0.23% of halothane. There is no correlation between the actual case and the readings. The readings are important for the anaesthetist as it is important for him to know the amount of each of the anaesthetic agents in the patients system at all times so as not to overdose the patient.

[1] gases with the same molecular mass but a different molecular structure

The Infrared Spirometer is not a good choice for detection of different anaesthetic agents. A new device that can differentiate between the different agents as well as oxygen and carbondioxide is required.

Human Error

These errors occur when the designer of the system fails to ensure that man and machine components interact effectively. Designing systems for people is big business. It is not fair to hold a designer responsible for human performance problems that are beyond his or her control. But it is fair to hold designers responsible for poor design decisions that lead to degraded performance, particularly if these decisions result from ignorance of human performance technology.[Bailey:1996]. If the designer of a system does not design the system to suit human perceptive and cognitive capabilities then he leaves an 'open door' for human errors to occur. Following are some of the human errors that occur in the two systems.

Perceptual Errors

Visual Perception

Adults read approximately 250 words a minute. It is unlikely that words are scanned serially, character by character, since experiments have shown that words can be recognised as quickly as single characters. Instead familiar words are recognised using word shape. This means that removing the word shape clues (for example by capitalising the words) is detrimental to reading speed and accuracy. The two machines mainly use capital letters to write. [Refer to Appendix A5] It is easy for the Anaesthetist using it to mix up words like P1 and P2 especially while working under pressure or while in a hurry.
[Dix et al :1993]

The Anaesthetist is required to read and set up both machines at a relatively high speed especially in a case of an emergency. People read slower from computer screens than from paper. Reading speeds equivalent to those on paper were found for textual interfaces that made use of character fonts that resembled those on paper (rather than dot matrix fonts), that have a polarity of dark character on a light background; that are anti aliased (contain a grey level) and that are shown on displays with relatively high resolution (i. e 1000 x 800). [Gould et al: 1986]. However, both machines have a green monochrome screen and a resolution of 1024 x 256. This slows down the reading process.

Characters and Numbers are visually similar when represented on a Low-resolution screen. The Datex Capnomac Ultima and the Cardiocap II have a great handicap in that the numerical values displayed are small and therefore very difficult to read. Look at appendix A5 the mean values for both the P1 and the NIBP are very difficult to read.

The following visual angles are recommended for reading tasks [Human factors: 1988]
When reading speed is important (As is with the case for anaesthetists especially when the patient is critical)
Minimum 16 minutes of arc.
Preferred 20 to 22 minutes of arc
Maximum 24 minutes of arc.

Taking the worst case the anaesthetist's farthest distance from the Datex Machine during an operation is 3 feet. The Length of each character should be: -

$$= \frac{(20)(3*12)}{3438}$$

$= 0.2$inch   Where 20 is the visual angle
3*12 is the distance of the anaesthetist from the machine in inches.

The errors that are caused by poor visual perception in the two system can be reduced by

- Avoiding the use of capital letters in the interface should be so as to keep the word shape.
- Increasing the screen resolution and changing the background to white and the writing to black so as to increase the speed in which the anaesthetist reads the screen.
- Increasing the character size should be increased so as to increase the accuracy in reading.

Operation Visibility

Errors can be caused by the user's ignorance of the mode that he is working in currently. This happens when the user makes settings suited to one mode while working in another. It is important therefore that the user is made aware of the mode that he or she is working in. There are many different modes in which the machine could be set. The main ones are the paediatric or the adult mode. Both systems do not indicate their current mode in the monitoring screen [Appendix A5]. An anaesthetist has to physically go to through the menu sequence to find out what the current mode is. An assumption by the anaesthetist that he is in a particular mode while he is actually in another may have fatal consequences. The anaesthetist should always be aware of the mode which he is working in. It would be helpful if the mode that he was in was on the screen as he makes settings on the machine.

The Cardiocap II has two transducer readers [refer to Appendix A2]. The transducer readers will measure the pressure in the veins and pressure in the arteries. Both readers are invasive. Before they are inserted into the patients blood vessels they have to be exposed to the air for a while so as to be zeroed to the atmospheric pressure. If the exposure is not sufficient then the pressure readings obtained will be wrong. The anaesthetist would be more accurate on the amount of exposure required if a message would appear on the screen informing him that the exposure was adequate or inadequate.

Touching

The Cardiocap Keyboard [refer to Appendix A3] has keys with dual functions. Pressing such a key for long activates the second function of the key written in Italics in the Key. If a user with a "heavy" hand touches the key too long he may end up with disastrous effects. An example of such a key is the Mark/Reset Key. Pressing the Key lightly will produce an event marker on the trend printout. Pressing it for 5 seconds will reset the monitor, trend data will be cleared and all the alarm limits will return to default. A message appears on the screen informing the user that the reset will take place and the count-down begins. The system however does not inform the user how to undo his action. Therefore an anaesthetist who only wishes to display an event marker on the trend printout may end up losing all the trend data instead. Dual functions of keys on a keyboard must be selected carefully. Erase function must not share a key with any other function.

Cognitive Errors

Memory

The Datex systems both require a number of settings to be made. Settings are in specific screens and apart from an occasional tiny NEXT sign there is no indication to the user what the NEXT page may hold. Discussions with an expert user of the Datex revealed that constant prompting would be distracting and annoying to an expert user. On the other hand for a novice it might be too tasking to remember all the settings that he is required to make. Human beings tend to forget more as the amount of information needed to be remembered increases. It would be helpful for the user if he received prompts as to what the next pages held. Refer to Appendix A4.

Slips are more common in expert users than they are in novices. It is important then for the system to be able to pick up an erroneous setting. For this to happen it would be important for the anaesthetist had to input what his intentions are at the beginning of the settings. This would equip the machine with enough information to correct the anaesthetist if he made wrong settings on the machine.

With the Datex the user moves from screen to screen and he has to remember what his settings were in the previous window. The output window [refer to Appendix A5] does not show which selections have been made. It is easy for the anaesthetist to forget and make settings that do not collaborate. Introduction of a toolbar would reduce the number of things that the anaesthetist has remember. The toolbar would indicate all the settings that he has made. The toolbars may be in different levels and he may choose as many toolbars as he wants depending on how much detail he wants to see.

The transducer lines are simply named as pressure 1 and pressure 2 [refer to Appendix A2]. This would be better named as Venous line and Arterial line so that the anaesthetist would know what reading he was looking at each time without having to recall from memory that he had his arterial line in Pressure 1 and his venous line in Pressure 2 or vice versa.

Learning

If a system is easy to learn then the occurrence of error will be greatly reduced. Humans' learning is facilitated by structure and organisation. This is due to the short-term memory. When information can be viewed as a few associated pieces of information, rather than many unassociated pieces of information it is easier to store that information in short term memory.

Most of the anaesthetists interviewed and who answered the questionnaire learnt how to use the two Datex machines in the following sequence:

- Observing an experienced user during a number of operations.
- Using the machines under supervision
- Trial and error

The first two steps took three weeks at most. Due to lack of anaesthetist the training process cannot be longer than this. Anything that the anaesthetist does no pick up during this time will be learnt as he works by trial and error. Most anaesthetists had never used the manual to learn how to use the two machines.

Problem Solving

Both the trends on the Capnomac Ultima and the Cardiocap II [refer to Appendix A5] are represented by graphs. The graphs are in a 0 to 100 scale and are therefore very difficult to translate. The anaesthetist could convert this graph to numerical values but the reason most of them do not is because they do not know how to or the numerical values are too tiny for them to read and the anaesthetist has to continuously scroll downwards to get the latest readings. [Refer to Appendix A6].

Carbon-dioxide measurements are given in millimetres of mercury (mmHg), KiloPascals (kPa) and percentages. Although the machine indicates what mode it is in it is not clear to the anaesthetist how to change from one mode to another. This means that if the anaesthetist is mot in the mode of measurement that he is conversant with then he has to convert from one unit of measurement to the other. (1 Pascal = 1mmHg X 133.322). It is important for the anaesthetist to be in the mode of measurement that he is most conversant with so as not to make conversion mistakes.

Human beings have a tendency to be heuristic rather than algorithmic problem solvers. An interactive system that forces a user to execute algorithmic procedures over and over again will quickly cause boredom and frustration. [Mayhew: 1992]. The cardiocap uses an algorithmic problem solving method. There are no shortcuts to solving a problem. The user has to go through certain set steps to attain a solution to his problem. For example to set-up the pressure alarm the user has to press the pressure Key on the Keyboard, Press 2 for Pressure Alarm and ref., Press 2 for Pressure 1 alarm and finally press 1,2, 3 or 4 depending on how low or how high he intends to set the alarm. Both Datex machines should be made intelligent enough to be able to differentiate between an expert user and a novice. The expert user should be allowed to take shortcuts in setting up the machine.

Decision Making

The Datex Capnomac has an alarm that goes on each time there is an error with messages that appear on the screen but the messages are cryptic and non-specific. One of the most mind boggling ones is Occlusion. This message could mean any of the following things:

- The suction tube that collects gas samples from the patient is blocked
- The sample filter is blocked and therefore needs to be changed
- The patient's airway is blocked
- The sample box has moisture in it

This error message would be of more help if the message was more specific. For example Occlusion in the Suction tube would be a more informative error message.

When I asked one anaesthetist how often he used the help in the Cardiocap system.
His question was does it have help facilities? The anaesthetist only gets help when he asks for it and he has to know how to find it. The dialogue is fully user pre-emptive.

This is very dangerous in this case, as the anaesthetist is free to input any value for the parameters. E.g. he may input dangerous amounts of the anaesthetic gasses without a 'murmur' from the system. An active help or a suggestion system would be much better in that it would suggest to the anaesthetist acceptable levels depending on whether he is dealing with a paediatric case or an adult case. It would also be able to guide the anaesthetist in setting up the machine so that he would not leave out any critical settings.

Giving anaesthesia may require the anaesthetist to take risks at certain times. The anaesthetists need to be informed of the risk that they are taking each time. For example if the cardiocap critical levels for Oxygen are higher than normal then the anaesthetist needs to be informed of the risk that he is taking and the consequences. If he chooses an anaesthetic agent, which might cause negative side effects in a patient, he needs to be reminded of the side effects that may be suffered by the patient in question. Having all the contraindications of the different agents will help him make a quicker and more informed decision.

Conclusion

Because of the way in which error is viewed in the medical world, as either being a result of negligence or inadequate knowledge, most of the anaesthetist interviewed during this paper's research believe that a doctor should never have to rely on machines his know how should always pull him through. However, it is evident from the previous discussion on the impact of human error in medical information systems that this is not always the case.

I believe that a different approach to error management must be taken to reduce error in medical information systems. Rather than a reactive approach to error prevention, underlying causes of error must be explored. To encourage open discussions on error by the medical practitioners a change of attitude towards error must take place. Error must be regarded as an integral part of the human nature. It is my opinion that until medical practitioners feel 'safe' enough to discuss errors that occur in the medical information systems that they use, effective error management of medical devices will never take place.

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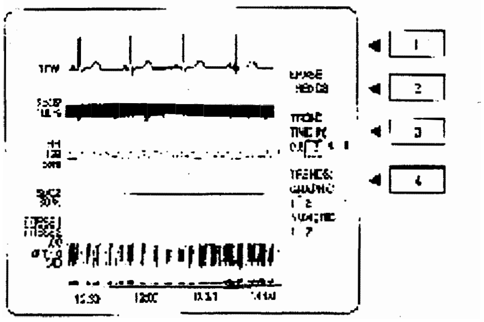
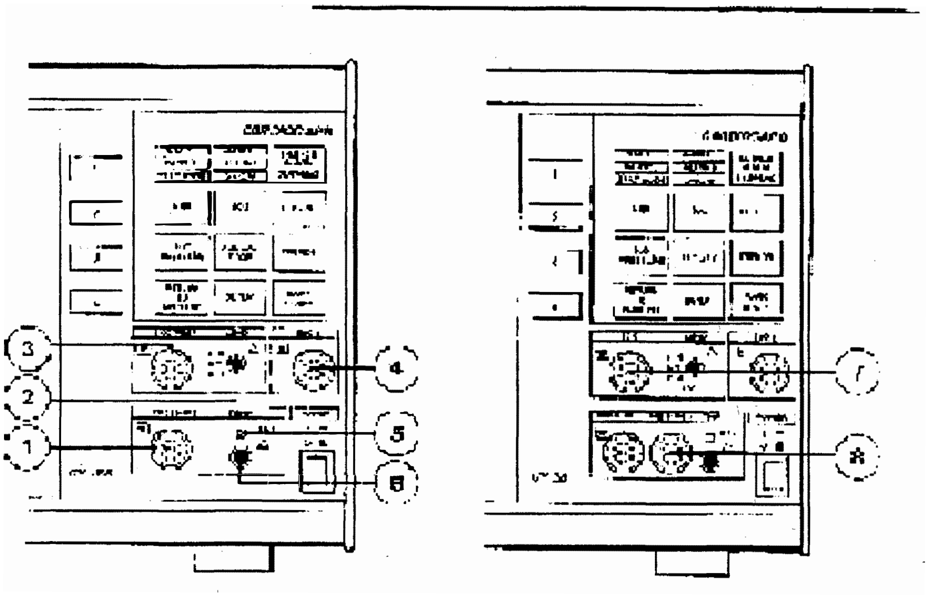
APPENDICES

APPENDIX A1: CARDIOCAP II SCREEN



APPENDIX A2: FRONT PANEL CONNECTORS



1. Invasive blood transducer connector
2. ECG lead selector
3. ECG/Respiration cable connector
4. SpO2 sensor connector
5. Temperature test button to check temperature calibration
6. Temperature probe connector
7. ECG cable connector
8. Invasive blood pressure 2 transducer connector.

APPENDIX A3: KEYBOARD PANEL

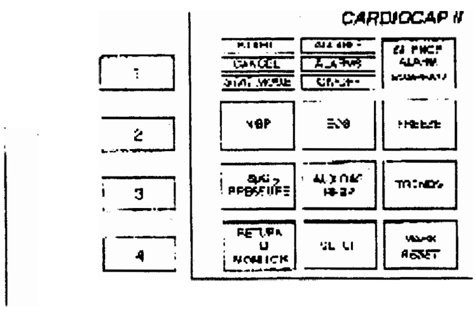


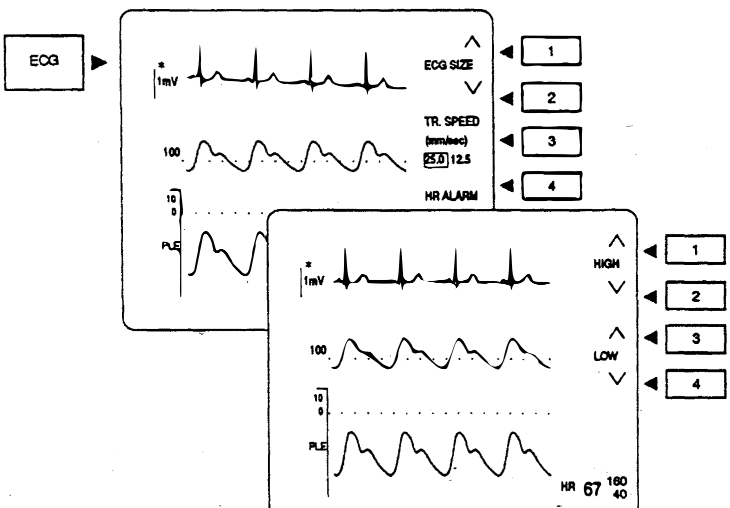
Table 1: Keyboard Panel

KEY	FUNCTION
NIBP, ECG, SPO_2 PRESSURE, AUX GAS RESP	Parameter Keys – Selecting one of the parameter keys will call up a menu on the video screen from which the adjustments can be made.
SETUP	Provides access to basic monitor settings such as sound, volume, alarm limits display and NIBP safety limits.
1, 2, 3, 4	These softkeys are used to perform adjustments or move to other menus
RETURN TO MONITOR	Pressed after completing softkey adjustments and to return to monitoring mode.
AUDIBLE ALARMS ON/OFF	Turns ON/OFF all alarms except for ASYSTOLE and APNEA
SILENCE ALARM/ SUSPEND	Silences a triggered alarm for 2 minutes Press and hold for 2 seconds to silence in advance all audible alarms for 2 minutes.
START/CANCEL/ STAT MODE	Starts a NIBP measurement Press again to cancel NIBP measurement Press and hold for 2 seconds to initiate 5 minutes of continuous fast NIBP measurements
FREEZE	Freezes wave-forms for 10 seconds Press the key again to unfreeze wave-forms Press and hold for 2 seconds to store the ECG reference trace. Erase the reference trace press and hold for another 2 seconds
TRENDS	Provides up to 8-hour graphical and numerical trend information to monitored parameters. Press the RETURN TO MONITOR key to return to monitoring mode
MARK/RESET	Produces a numbered event marker on the trend printout. The marker number appears briefly on the bottom of the screen Press and hold for 5 seconds to produce a monitor rest. Trend data will be cleared and all alarm limits will return to default. A self-check is also performed after reset.

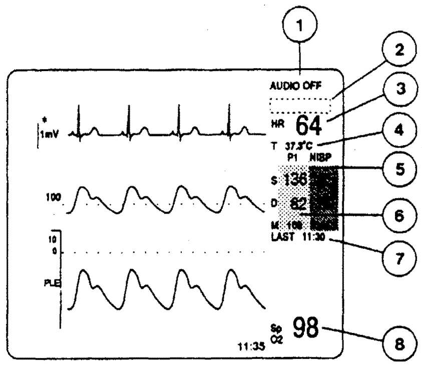
APPENDIX A4: MENU DISPLAY

This is an example of how the menu display works

- Press the ECG Key
  The menu is shown on the right hand side of the video screen
- Use softkey 1, 2, 3 or 4 to perform the adjustment or move to the next menu.
  - softkey 1 and 2 (arrow-keys) adjust the wave-form size.
  - Softkey 3 scrolls through selections. The activated selection is highlighted with a box.
  - Softkey 4 enters the following adjustment menu.

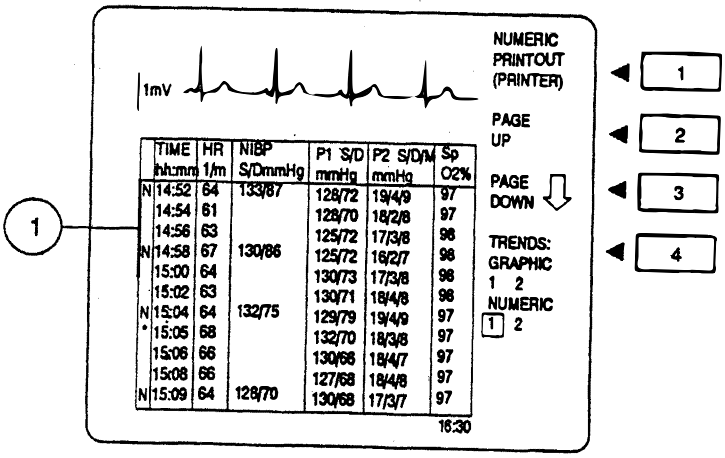


APPENDIX A5



1. AUDIO OFF message indicates that audible alarms are turned off.
2. Message field related to ECG monitoring
3. Heart Rate Value
4. Temperature Value
5. Systolic, Diastolic and mean pressure values of non-invasive blood pressure (NIBP)
6. Systolic, diastolic and mean pressure values of invasive blood pressure(P1)
7. Time indicator of LAST NIBP measurement

Oxygen saturation (SpO_2) value



	TIME hh:mm	HR 1/m	NIBP S/DmmHg	P1 S/D mmHg	P2 S/D/M mmHg	Sp O2%
N	14:52	64	133/87	128/72	19/4/9	97
	14:54	61		128/70	18/2/8	97
	14:56	63		125/72	17/3/8	98
N	14:58	67	130/86	125/72	16/2/7	98
	15:00	64		130/73	17/3/8	98
	15:02	63		130/71	18/4/8	98
N	15:04	64	132/75	129/79	19/4/9	97
•	15:05	68		132/70	18/3/8	97
	15:06	66		130/66	18/4/7	97
	15:08	66		127/68	18/4/8	97
N	15:09	64	128/70	130/68	17/3/7	97

APPENDIX A6: NUMERICAL REPRESENTATION OF TREND

The up and down arrows indicate whether there is more information stored in the trend memory.

1. The haemodynamic trend page
   - HR Heart Rate
   - NIBP Non Invasive Blood Pressure
     - S/D Systolic Reading/ Diastolic Reading
   - P1 Pressure 1 reading
     - S/D Systolic Reading/Diastolic Reading
   - P2 Pressure 2 reading
     - S/D/M Systolic reading/Diastolic reading/Mean
   - SpO_2 Oxygen saturation value