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(Under section 3 of UGC Act 1956)

Infusion Pumps

Introduction

- Infusion pump delivers measured amounts of fluids or medications into the bloodstream over a period of time.
- They supply a controlled amount of drugs very slowly into the bloodstream over a period of time.

Infusion Pumps

Techniques for the pumping action.

- One method is *peristaltic* action where fingers or rollers on a drum squeeze the fluid tubing in a controlled manner to force the fluid down the tubing.
- A second method is obtained by using a cassette (or chamber) that fills with fluid & is then emptied out by the pumping mechanism in a controlled manner

WORKING

- The Infusion Pump uses a combination of these two techniques described as *quasi-peristaltic*.
- A three-chambered cassette is employed with the pumping mechanism operating on these three chambers in turn.
- The user can set the rate of fluid delivery in milliliters per hour (ml/hr) together with the volume of fluid that should be delivered in milliliters (ml).

WORKING

- The pump will not deliver fluid beyond a certain delivery pressure to prevent harm to the patient.
- This is achieved by monitoring the pressure in the giving set & ensuring that it does not exceed a certain level.
- If the pressure is exceeded, pumping is stopped & an alarm sounded to alert the user.

WORKING

- This alarm is called an *occlusion alarm* (restriction of flow).
- Monitoring of the function of the pump occurs continuously & alarm sound will prevent any possible danger to the patient such as failure of delivering fluid in the manner expected .
- The Infusion Pump has battery back up so that it can continue operating even when mains failure occurs

COMPONENTS OF INFUSION PUMP:

- The drug infusion systems basically consist of two components:
- OPEN LOOP SYSTEM:
- The art of delivery is set by the nurse on the basis of past experience, mathematical computation, or by trial & error.
- The fluid is delivered at the set rate untill the setting is changed.

COMPONENTS OF INFUSION PUMP:

- CLOSED LOOP SYSTEM:
- The effect of drugs are monitored by apropriate transducers.
- The desired delivery rate is computed & set automatically.

TYPES OF INFUSION

- The user interface of pumps usually requests details on the type of infusion from the technician or nurse that sets them up:
- CONTINUOUS INFUSION.
- INTERMITTENT INFUSION.
- PATIENT CONTROLLED INFUSION.
- TOTAL PARENTERAL NUTRITION.

CONTINUOUS INFUSION

- Consists of small pulses of infusion, usually between 20 nanoliters and 100 microliters depending on the pump's design.
- The rate of pulses depending on the programmed infusion speed.

INTERMITTENT INFUSION

- Has a "high" infusion rate.
- Alternating with a low programmable infusion rate to keep the cannula open.
- The timings are programmable.

PATIENT CONTROLLED

- Is infusion on-demand, usually with a preprogrammed ceiling to avoid intoxication.
- The rate is controlled by a pressure pad or button that can be activated by the patient.
- It is the method of choice for patient-controlled analgesia .
- *Total parenteral nutrition* usually requires an infusion curve similar to normal mealtimes.

TYPES OF PUMP

- There are two basic classes of pumps.
- Large volume pumps can pump nutrient solutions large enough to feed a patient.
- Small-volume pumps infuse hormones, such as insulin, or other medicines, such as opiates .

Large-volume pumps

- Uses peristaltic pump.
- They use computer-controlled rollers compressing a silicone-rubber tube through which the medicine flows.
- Another common form is a set of fingers that press on the tube in sequence .

Small-volume pumps

- *Small-volume pumps* use a computer-controlled motor turning a screw that pushes the plunger on a syringe.
- Some of the smallest infusion pumps use osmotic power.
- Basically, a bag of salt solution absorbs water through a membrane, swelling its volume.
- The bag presses medicine out.
- The rate is precisely controlled by the salt concentrations and pump volume.
- Osmotic pumps are usually recharged with a syringe .

Procedure:

- Perform patient assessment and record vital signs
- Assess patient meets criteria for the protocol.
- Ensure there are no contraindications to use any protocol.
- Hospital staff will draw up the medication or IV fluid to be infused and ensure the infusion pump is functioning properly .

Procedure:

- Prior to transport, the EMS personnel will confirm:
- The physician's written and signed order for the infusion
- The infusion pump has enough medication for the expected transport time

Procedure:

- The infusion tubing is properly connected to a three-way stop clock on the patient's intravenous line
- At some facilities, heparin can be infused via a syringe pump without being piggybacked into a running intravenous line
- The rate of infusion pump delivery has to be checked
- The volume of infusion already administered has to be checked

Procedure:

- If an alarm is displayed during transport, the attendant should attempt to correct the problem.
- If the problem is corrected, the alarm display message will disappear.
- If the problem cannot be remedied, the attendant should press the start / stop button to turn the infusion off.

Error Messages

- Error conditions indicate the pump has detected a possible internal malfunction.
- If an error message appears, the attendant should turn the pump off and then on again.

Error Messages

- If the error display message disappears when the pump is turned on again, ensure the medication is infusing at the prescribed rate.
- If the error message persists, the pump should be turned off.

Error Messages

- The possible internal error malfunction should be reported to the sending and receiving facilities.
- These volumes should be charted on the patient care report.
- Inform the receiving hospital of any problems encountered with the infusion, and how they were resolved

MAINTENANCE OF INFUSION PUMP:

- Always place pump and supplies on a clean surface.
- Keep food and drinks away from the area around the pump.
- Monitor children when in the pump area.

Before touching the pump

- wash hands thoroughly for 15 seconds
- use liquid soap (not bar soap) and rinse
- dry with a clean paper towel .
- Change tubing according to pump's Instructions for Use.
- Change batteries or recharge the pump as directed by healthcare provider.

Surroundings

- Radio transmitters (such as cell phones, wireless hand-held computers, two-way radios) and other sources of strong electric and magnetic interference (EMI), such as large electric motors, could affect pump.
  - Pump users, care givers, and others should use caution and keep electromagnetic sources away from the pump.

Errors in infusion pump:

Over- or under-infusion :

- Infusion pump does not deliver the correct dose at the proper rate
  - Check tubing for leaks, links twists and disconnects.
  - Check for visible particles in the solution, tubing and filter area that might block the flow.
- Monitor pump to assure it is pumping .

Errors in infusion pump:

- Check clamps to make sure they are open.

- Note infusion begins and end time to help monitor the pump's accuracy.

- Change tubing according to instructions

Wrong programming

- Check pump screen to be sure programmed rates and dosages matches medicine's label.

Batteries

- Batteries should be used for back-up only.
  - alarm will occur when the batteries are low .
  - keep an extra supply of new batteries at all times .
  - the life of the batteries should be known from the suppliers.

CLEANING OF UNIT:

- Don’t use organic solvents such as alcohol & thinner in cleaning.
- Before starting any cleaning, be sure to turn OFF the power & pull out the AC power cable.
- Power cord failure & cleaning.
- Check for any damage , deformation & chemical solution stuck in the connector unit.
- If any chemical solution has adhered onto the occlusion detector unit or air line detector or if either of them wipes it thoroughly with cotton swab softly.

Pump Basics

- To power On – Insert battery. Pump will boot up and begin an automatic review.
- To silence alarms push View/Silence.
- To review program, push View/Silence.

Pump Basics

- When screen is blank (screen saver), push View/Silence and main screen will reappear.
- To program the pump, push View/Silence to go to first screen. Use arrows to scroll to desired amount, and push Enter to save into the memory.
- To Start/Stop the pump, push Stop/Start and then push yes.

- To turn power off, remove battery and unplug AC adapter.

To attach the tubing

- Attach the short end of the tubing to the bag.
- Attach plastic cassette to the bottom of the pump, by placing the hooks on the metal bars.
- The plastic block fits inside the pump.

To attach the tubing

- Press against a hard surface and use the SIDE of the key depress and turn the large button on the side of the pump to latch the cassette on.

1) Be sure to latch it straight up.
2) Next, insert the key into the hole on the side of the pump and lock it.
3) Place the bag inside the security shell and mount the pump onto the clear divider, by sliding it down.
4) Use the key to lock the security shell.

Change syringe or bag:

- If pump is still running, Press Stop/Start and Yes, to stop the infusion .
- Unlock the security shell front and flip the pump forward. Do NOT turn key in pump .
- Simply, remove the bag and replace with new bag.
- Flip the security pump back in place, and close the door to the security shell.
- Relock the front of the security shell.

To reset the volume:

- ***To reset the SAME volume*** :
- (Pump screen must say “Stopped”), press ENTER on the main screen.
- The pump will ask “Reset volume to xxx ml?” Press Yes.
- Pump will ask “Start Pump?”.
- Press Yes.

To reset a DIFFERENT volume

- Pump screen must say “Stopped”.
- Take the key and insert into the hole on the side of the security shell.
- Unlock the side of the pump (do not detach the cassette).
- From the main screen (pump screen says “Stopped”), press BACK.
- You will see Reservoir Volume

To reset a DIFFERENT volume

- Use arrow to scroll to desired reservoir volume.
- Press Enter.
- Press Start and Yes to restart infusion

APPLICATION:

- The most common application is to maintain appropropriate fluid levels in the patient.
- Fluid therapy is used in the management of patients during & after surgery, for treatment of burns, & in treating dehydration in pediatric patients.

APPLICATION:

- Infusion systems are also most commonly used to intravenously supply nutrients to support life & to maintain growth & development in pediatric patients.
- Continuous drug infusion is also used in application such as to deliver anesthetics during surgery, chemotherapy for cancer, oxytoxic agents for inducing labor & anti-arrythmatic drugs for patients in the coronary unit.

TROUBLESHOOTING

- 9-volt battery low – Battery is low, but pump is operable.
- Push View/Silence and change battery soon.
- 9-volt battery depleted, Install good battery – Install a fresh battery, pump cannot run on a depleted battery.

- High Pressure, Pump Stopped – Check tubing for a link, closed clamp, patient site.
- Push Start/Stop to restart the pump

Upstream Occlusion

- Fluid is not flowing from the bag to the pump.
- Push Stop/Start to silence the alarm.
- Unlock security shell and reposition tubing.

Reservoir Volume

LOW:

Press View/Silence to silence the alarm.

- (There is 5 ml left).

- ZERO:
- Push View/Silence to silence alarm.
- Install a new cassette.
- Error Detected :
- There is a problem with the pump, remove from service.

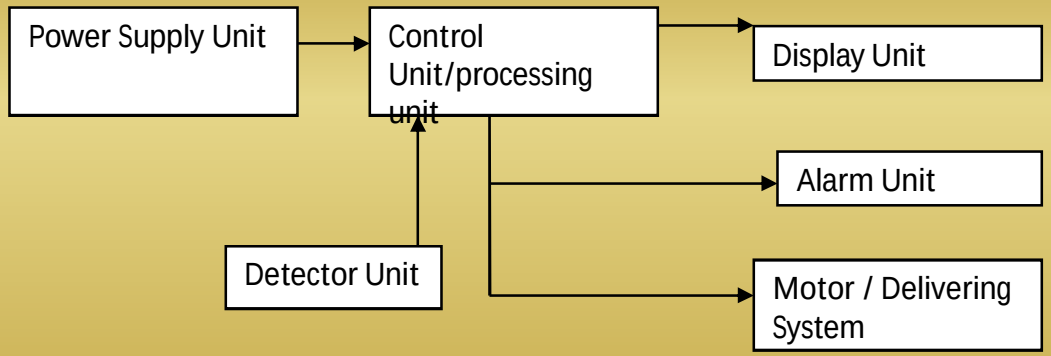
To Prevent the malfunction :

- Do not spray cleaning fluid onto the body of the pump or submerge the pump for cleaning.
- Under normal use and following the recommended cleaning instructions (attached), cleaning fluid will not enter the pump.
- Pressing the black Panel Lockout button on the back of the pump will enable this feature.

To Prevent the malfunction :

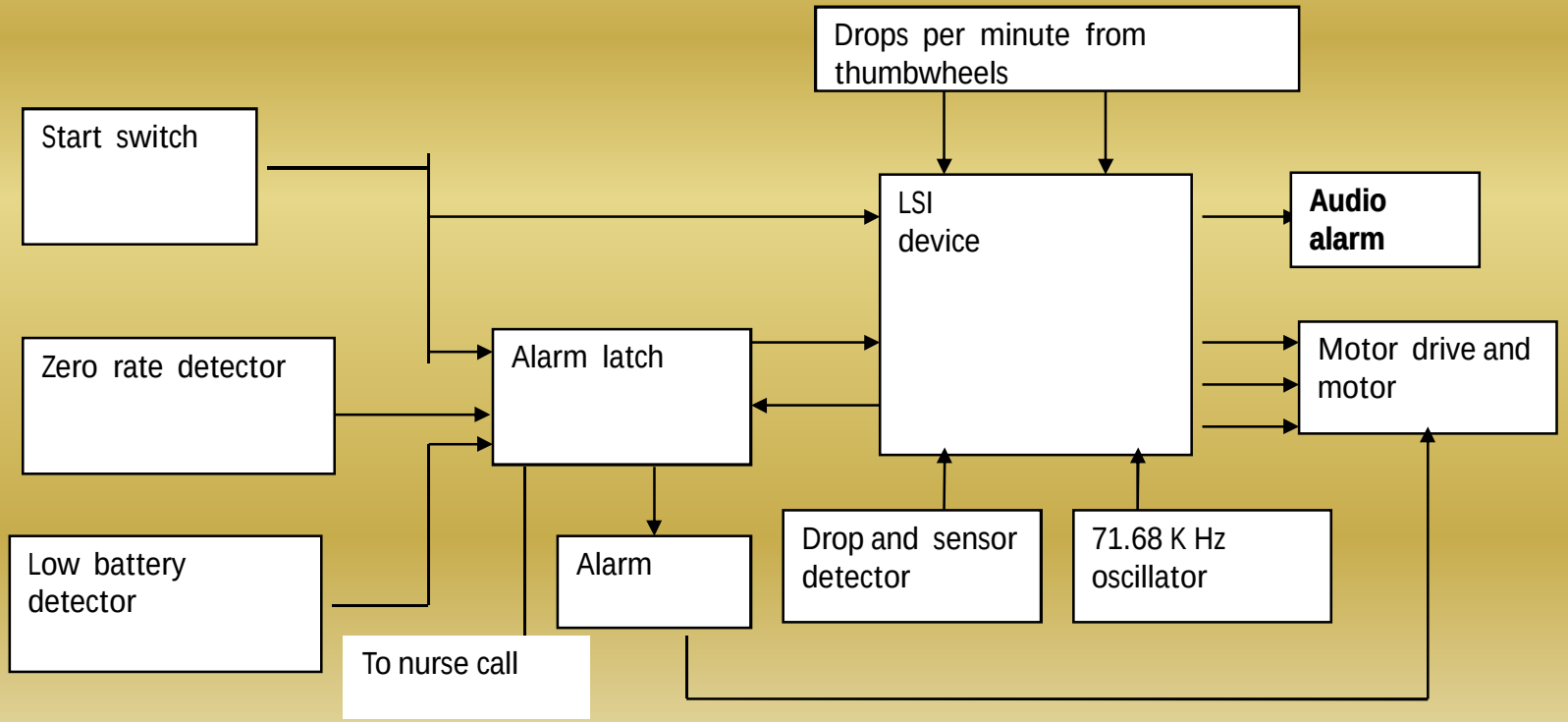
- When the Panel Lockout is enabled, all inputs from the on/off key are ignored and the behavior described above should not occur or should it occur, a failure alarm will sound.
- Alternatively, the Auto lock feature can be enabled in the configuration for each personality.
- This results in the automatic setting of the Panel Lockout 2 minutes after the start of an infusion.
- If any of the pumps become exposed to excessive fluid from spills or inadvertent immersion, remove the pump from use .

Block Diagram of Infusion Pump



- Display Unit
- Alarm Unit
- Motor / Delivering System
- Detector Unit
- Power Supply Unit
- Control Unit/processing unit

Drop rate counter type infusion pump



- Start switch
- Zero rate detector
- Low battery detector
- Alarm latch
- Alarm
- LSI device
- Drops per minute from thumbwheels
- Motor drive and motor
- 71.68 K Hz oscillator
- Drop and sensor detector

Programmable Volumetric Infusion Pump

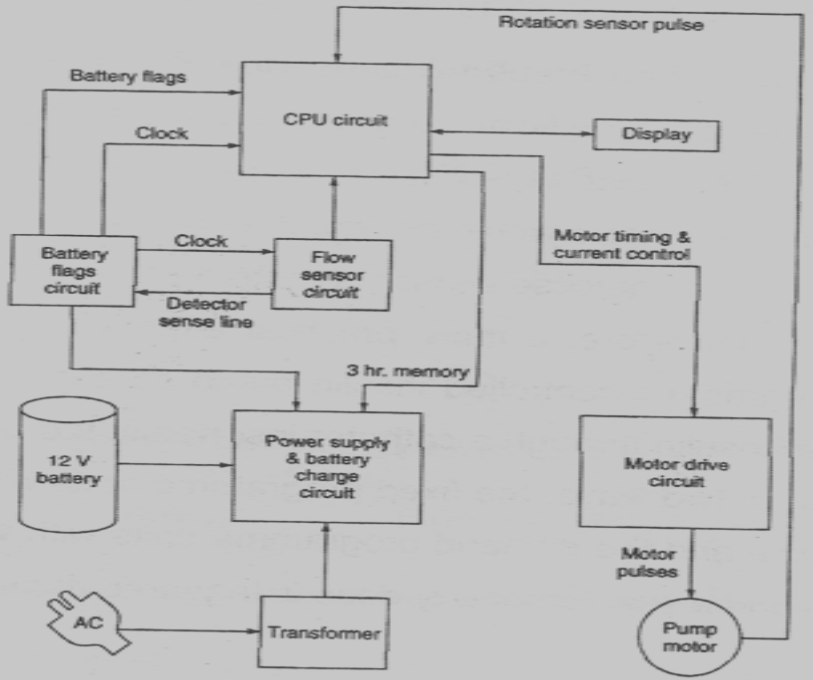


Fig. 7.6: Block diagram of the programmable volumetric infusion pump.

Implantable Infusion Pump

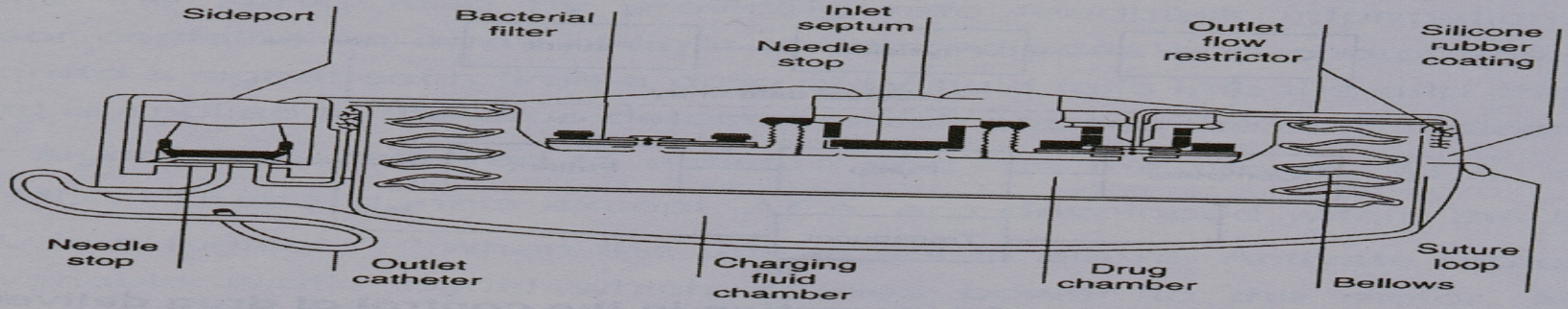
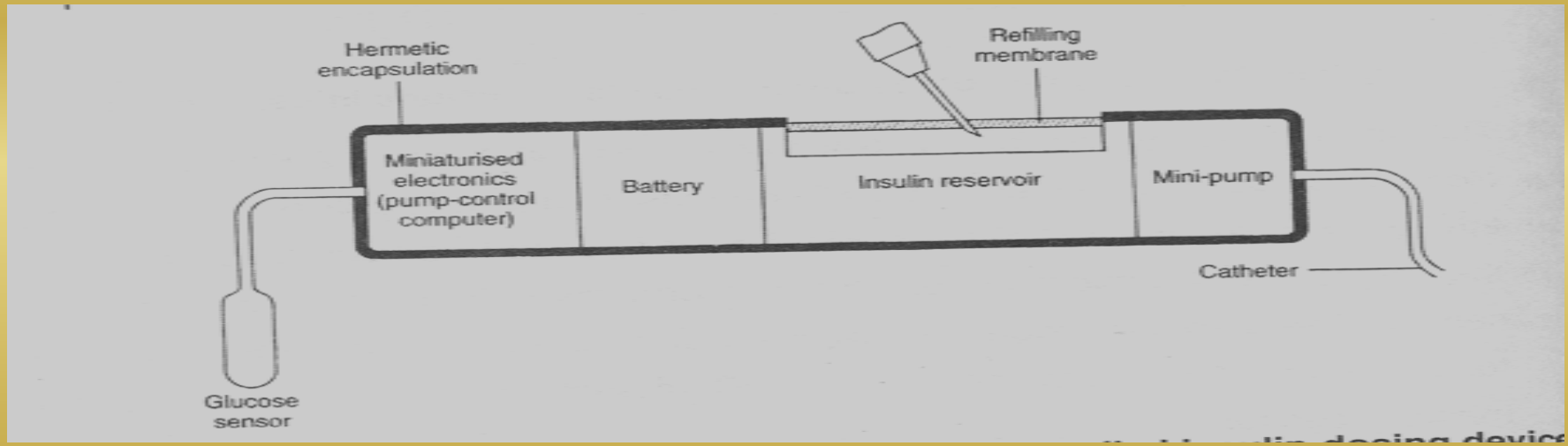
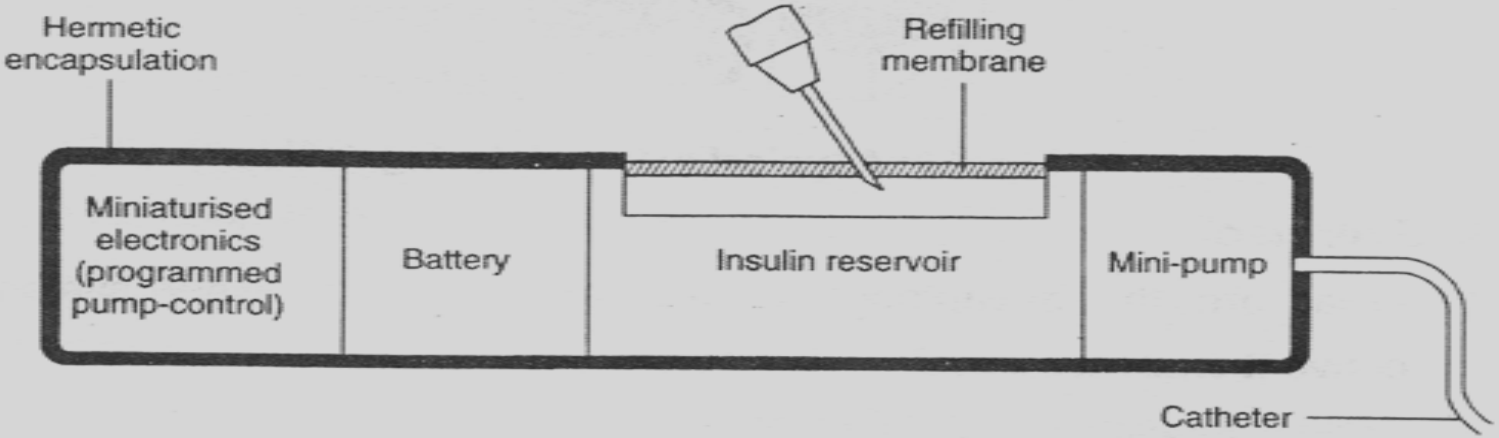


Fig. 7.3: Cross-section of an implantable pump.

Glucose sensor controlled insulin Infusion Pump




Hermetic encapsulation
Refilling membrane
Miniaturised electronics (programmed pump-control)
Battery
Insulin reservoir
Mini-pump
Catheter

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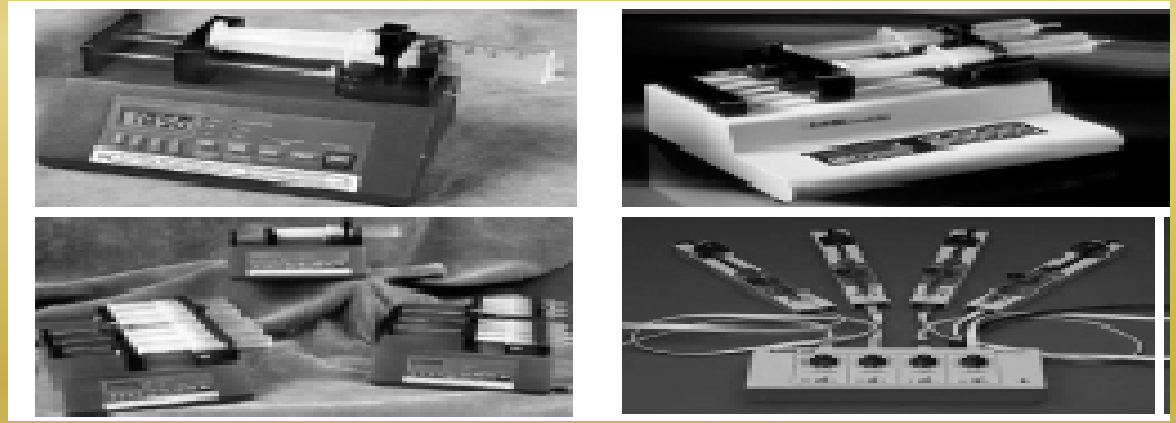
SYRINGE PUMP

INTRODUCTION

- *The syringe pumps are designed for the infusion of vasopressor drugs, depressor*



FEATURES

- Fully programmable; automation capable
- Operates stand-alone or from a computer
- Infusion and withdrawal
- Set a single pumping rate and/or dispensing volume
- Program up to 41 pumping phases that change pumping rates, set dispensing volumes, insert pauses, control and respond to external signals, sound the buzzer .

FEATURES

- Network, control, and monitor up to 100 pumps with one computer .
- Create expandable and reconfigurable automated fluid dispensing systems by attaching pumps to each other.
- Worldwide power supplies available.
- Dispensing accuracy of ± 1% .
- Unlimited lifetime technical support

CONIFUGRATION

- **All Modes:**
- When **ALL** is selected as the volume to be infused the entire contents of the syringe will be delivered.
- **Auto Pressure:**
- When enabled and a pressure sensing disc is in use, the Auto Pressure option is displayed in the Pressure Limit screen.
- Auto Pressure automatically sets the alarm limit for a shorter time to alarm, as follows:

CONIFUGRATION

- **Auto Pressure Limit Adjustment:** When a bolus is delivered, the pressure alarm limits are temporarily raised to the maximum limit .
- **Auto Syringe Size Identification:** The system automatically detects the syringe size and narrows down the syringe selection list .
- **Back Off** This feature is only available when the administration set in use has a pressure sensing disc. When enabled, the motor reverses plunger movement during an occlusion until the pressure returns to preocclusion levels, automatically reducing bolus flow

CONIFUGRATION

- **Bolus Dose** The Bolus Dose mode allows a bolus infusion to be programmed & the bolus infusion can be programmed with or without a continuous infusion following the bolus .
- **Channel Labels**
- The Channel Labels feature is available when the profiles feature is enabled.
- It provides a hospital-defined list of labels, displayed in the Message Display, and identifying the module with the solution being infused, the catheter location, or other helpful information.

CONIFUGRATION

- **Concentration Limits** Specified for the range of concentrations allowed for a particular drug in a profile .
- **Delay Options** The Delay Options feature allows the system to be programmed to delay the start of an infusion .
- a) For up to 120 minutes or
- b) For a specific time up to 23 hours 59 minutes .

Drug Calculation

- The Drug Calculation mode allows:
- Entry of drug dose .
- It calculates correct flow rate to achieve desired dose.
- Entry of flow rate.
- It calculates corresponding drug dose.

Dynamic Pressure Display

- The Dynamic Pressure Display appears on the Main Display.
- If enabled, it graphically displays the current patient-side occlusion pressure set point and the current patient-side operating pressure for that module.
- **Event Logging:**
- Event Logging records instrument operations

Fast Start

- When Fast Start is enabled and an administration set having a pressure sensing disc is used,
- The instrument runs at an increased rate when an infusion is first started, taking-up any slack in the drive mechanism.

Multi dose Mode

- The Multidose Mode option allows 2 - 24 doses to be programmed at equally spaced intervals on the same Syringe Module over a 24-hour period.
- This mode is designed to allow delivery of multiple, equal doses from the same syringe at regularly scheduled intervals.

Near End of Infusion (NEOI)

- The NEOI option allows an alert to be configured to sound anywhere from 1 to 60 minutes before the infusion is complete.

Occlusion Pressure

- A complete range of downstream occlusion detection options is provided.
- *With pressure sensing disc:* Downstream occlusion alarm threshold is selectable between 25 and 1000 mmHg, in 1 mmHg increments.
- *Without pressure sensing disc:* Downstream occlusion alarm threshold can be set to low, medium, or high.

Pressure Sensing Disc

- When installed, the pressure sensing disc significantly improves the instrument's pressure sensing capabilities for a faster occlusion detection time .

Pressure Sensing Disc

- FEATURES:
  - Auto Pressure
  - Back-Off
  - Customizable Pressure Alarm Settings (see “Occlusion Pressure”)
  - Fast Start
  - Pressure Tracking

Pressure Tracking

- The dynamic current pressure display is only available when the pressure sensing disc is inserted .
- The pump accepts the syringe size of 5ml, 10ml, 20ml, 30ml, and 50/60ml.

Changing syringe in the pump

- Turn power on.
- Hold down the third arrow key from the left and push the bolus key .
- Press the change key repeatedly until the brand of syringe needed is obtained.
- Press stop.
- Turn the power off to the pump .

Changing syringe in the pump

- Turn the power back on and the first screen displayed will show you the brand of syringe programmed in the pump .

CLEANING THE PUMP:

- The pump may be decontaminated by wiping it with a mild disinfectant solution.
- Care must be taken not to wipe the display screen with any harsh chemicals as it may permanently deface the screen.

Warning:

- It is neither designed nor intended to detect infiltrations and will not alarm under infiltration conditions .
- Syringe Module is designed to stop fluid flow under alarm conditions .

Positive displacement infusion

- The use of positive displacement infusion devices ported together with **gravity flow infusion** systems into a common IV site may impede the flow of common “gravity only” systems, affecting their performance.
- Hospital/facility personnel must ensure the performance of the common IV site is satisfactory under these circumstances.

When the system is turned on

- Verify and/or set the monitoring mode, resistance alert, and/or pressure alarm limit.
- If the monitoring mode, resistance alert, and/or pressure alarm limit are not verified, the instrument may not operate within the desired occlusion detection parameter(s).

SAFETY SOFTWARE

- The Safety Software incorporates dosing limits and instrument configuration parameters based on hospital/facility protocol.
- The software adds a test of reasonableness to drug programming based on the limits defined by the hospital/facility.
- Qualified personnel must ensure the appropriateness of drug dosing limits, drug compatibility, and instrument performance, as part of the overall infusion.
- Potential hazards include drug interactions, inaccurate delivery rates and pressure alarms, and nuisance alarms.

Epidural administration

- Epidural administration of drugs other than those indicated for epidural use could result in serious injury to the patient.
- It is strongly recommended that the syringe, administration set, and Syringe Module used for epidural drug delivery be clearly differentiated from those used for other types of administration.

Epidural administration

- The System can be used for epidural administration of anesthetic and analgesic drugs.
- This application is only appropriate when using anesthetics and analgesics labeled for continuous epidural administration and catheters intended specifically for epidural use.
- Without a ‘Y’ connector or injection port, for epidural infusions.

Epidural administration

- *Epidural administration of anesthetic drugs:* Use indwelling catheters specifically indicated for short-term (96 hours or less) anesthetic epidural drug delivery .
- *Epidural administration of analgesic drugs*: Use indwelling catheters specifically indicated for either short-term or long-term analgesic epidural drug delivery .

Before loading or unloading the syringe

- Always turn off fluid flow to the patient, using the tubing clamp or stop clock.
- Uncontrolled fluid flow can occur when the administration set is not clamped or turned off, and may cause serious injury or death.

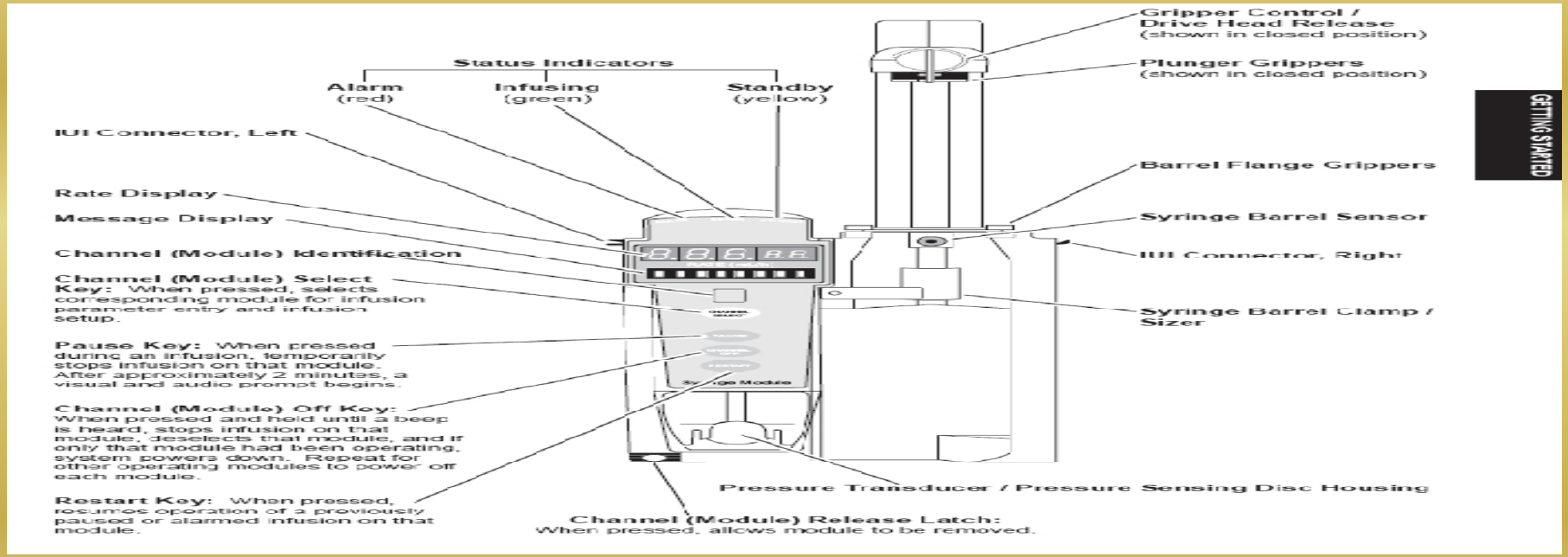
When priming:

- Ensure patient is not connected .
- Ensure air is expelled from line prior to beginning infusion (unexpelled air in line could have serious consequences).
- Ensure the syringe manufacturer and syringe size displayed matches syringe manufacturer and syringe size installed in the Syringe Module.
- Mismatches may cause an under-infusion or over-infusion to the patient that could result in serious injury and/or death.

When priming:

- Installing a pressure sensing disc after an infusion has started can result in a bolus to the patient .
- Discard if packaging is not intact or protector caps are unattached.

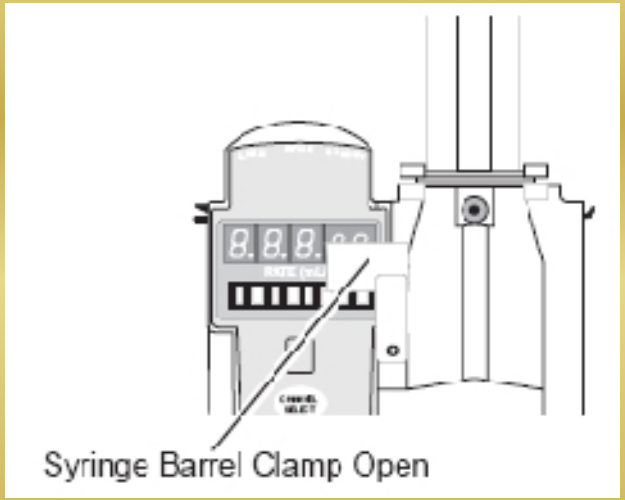
Operating Features:



Loading the syringe

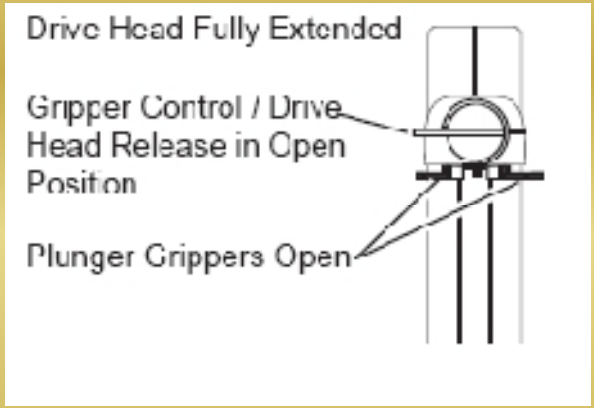
- Open syringe barrel clamp.
- Pull syringe barrel clamp out and hold.
- Rotate clamp to left (clockwise or counter clockwise) until it clears syringe chamber.
- Gently release clamp.

Loading the syringe:

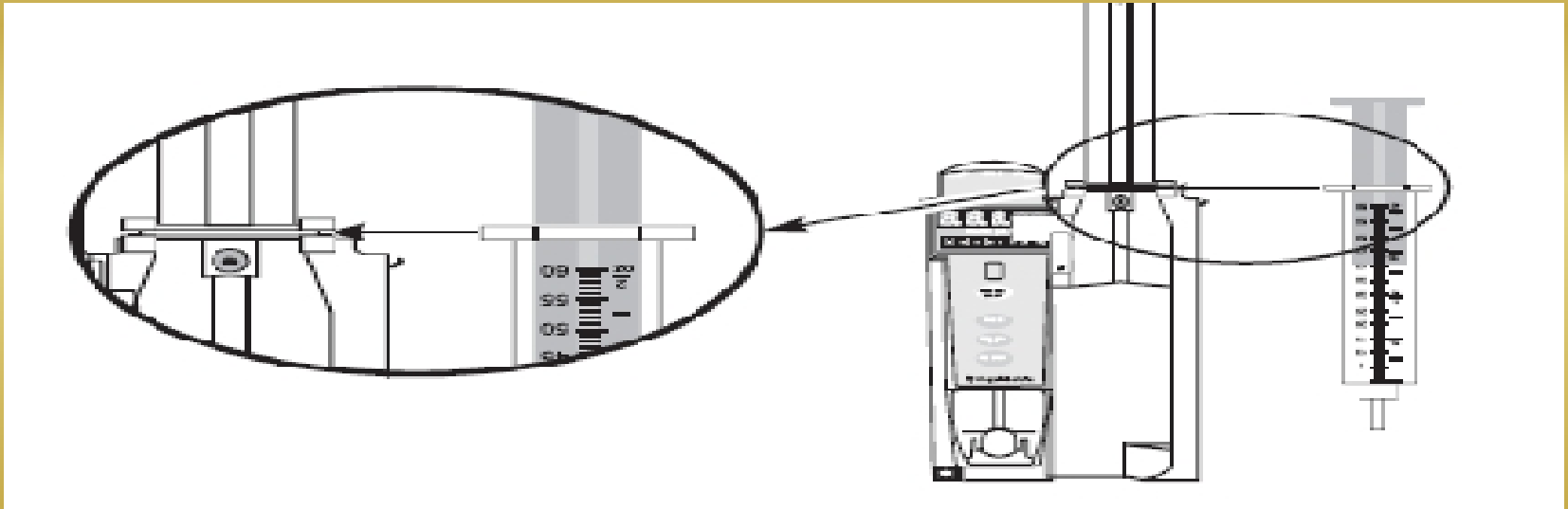


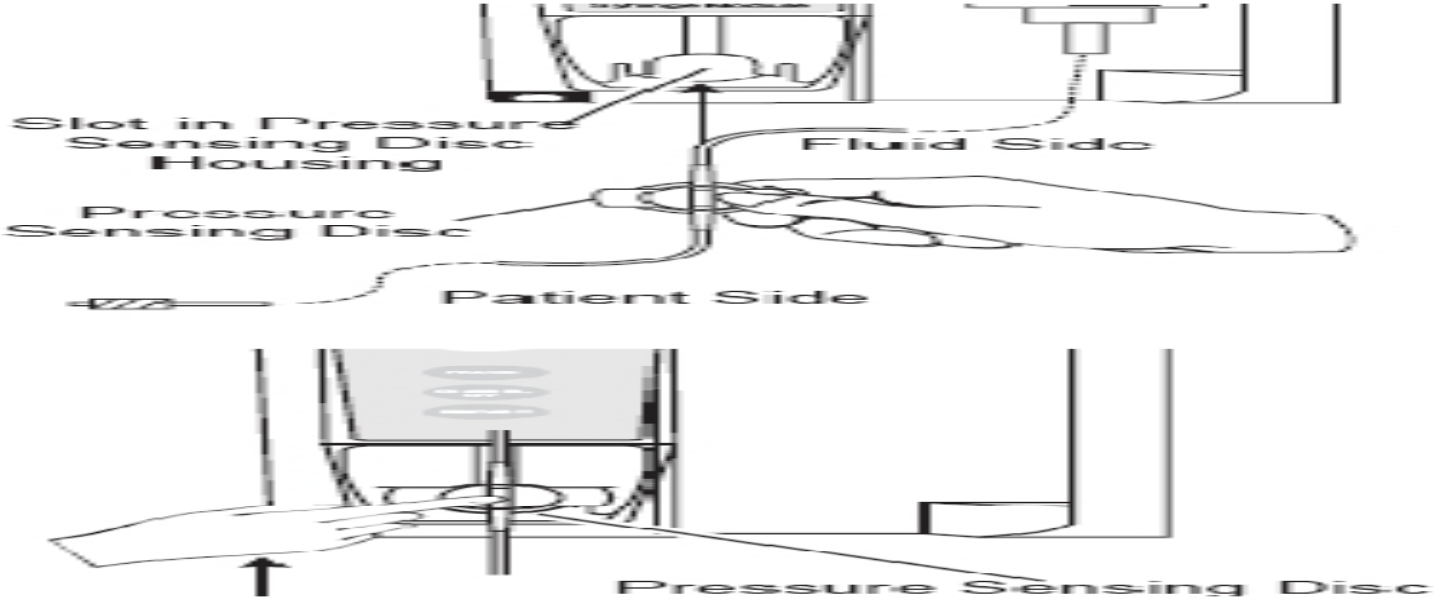
- Raise drive head to its fully extended position.
- Twist gripper control clockwise and hold in position .
- While holding gripper control in open position, raise drive head to full extension.
- c. Gently release gripper control

Loading the syringe:



- The gripper control is spring loaded.
- When twisted to the open position and then released, it (and the plunger grippers) will return to the closed position


60
55
50


Slot in Pressure
Sensing Disc
Housing
Fluid Side
Pressure
Sensing Disc
Patient Side
Pressure Sensing Disc

At the start of an infusion program

- The system prompts to select and confirm the syringe type and size.

1)Press **CHANNEL SELECT** key.

2.)Press soft key next to installed syringe type and size.

3) Selection is highlighted. 4)To accept, press **CONFIRM** soft key

Start up section

a. Power on system.

b. Choose **Yes** or **No** to **New Patient**.

c. Confirm current profile or select a new profile

.

d. Enter patient identifier, if required.

Preparing infusion

- Prepare syringe and administration set.

  Load syringe and administration set.

  Select syringe type and size, and **Basic Infusion** as infusion type.
- Prime.
- Start an infusion, as described in following “Starting Rate / Volume Infusion” or “Starting Volume / Duration Infusion” section.

Starting rate or infusion:

- To enter flow rate, press **RATE** soft key and use numeric data entry keys.
- To enter a numeric **VTBI** value (instead of infusing **ALL**), press **VTBI** soft key and use numeric data entry keys. **OR** To deliver entire contents of syringe, leave **VTBI** as **ALL**.
- 3. Attach administration set to patient's vascular access device.
- 4. Verify correct infusion parameter entry and press **START** soft key

Starting volume:

- Press **VOLUME DURATION** soft key.
- To enter a numeric **VTBI** value (instead of infusing **ALL**)
- Press **VTBI** soft key and use numeric data entry keys.
- **OR** To deliver entire contents of syringe, leave **VTBI** as **ALL** .
- To enter volume duration, press **DURATION** soft key and

Starting volume:

- Attach administration set to patient's vascular access device. Verify correct infusion parameter entry and press **START** soft key.

Pausing infusion:

- Press **PAUSE** key (on Syringe Module).**OR** Press **CHANNEL SELECT** key and then press **PAUSE** soft Key (on Point-of-Care Unit).
- **PAUSE** scrolls in Message Display.

Pausing infusion:

- **PAUSED** appears on Main Display.
- Yellow Standby Status Indicator illuminates.
- After 2 minutes, “PAUSE-RESTART CHANNEL” visual and audio prompts begin, and yellow Standby Status Indicator flashes.

ALARMS & ERROR MESSAGES

- Channel error:
- Error detected.
- Operation stops on affected module .

- Response :
- To silence alarm & continue operation of unaffected modules, press CONFIRM key.
- Replace module with an operational instrument as required.

Syringe calibration required

- Error on infusing module indicating calibration is required.
- Infusion stops an affected module.
- CALIBRATE scrolls in message display .
- Response:
- To silence alarm & continue operation of unaffected modules press CONFIRM key.
- Replace module with an operational instrument as required.

Syringe Driver Head Error

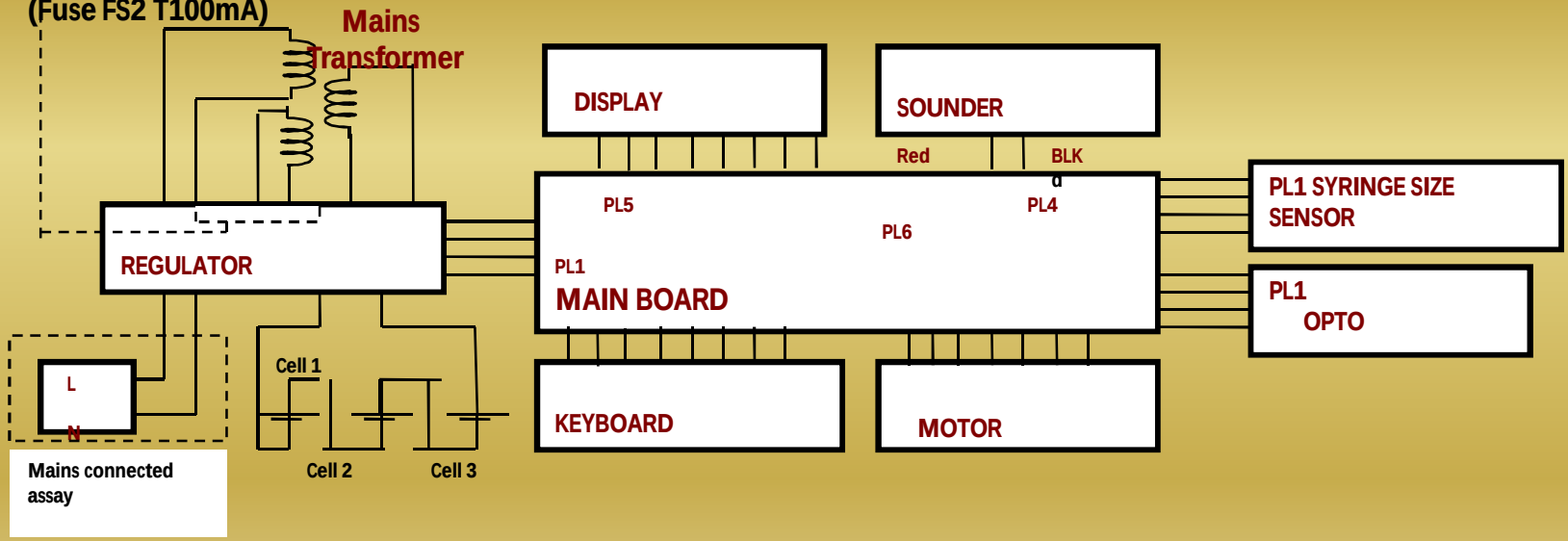
- Non infusing module, with plunger grippers open, senses excessive pressure being applied downward on Drive head.
- OCCLUSION scrolls in message Display.
- Response:
- To silence alarm & continue normal operation, press CONFIRM key .

Dose mode with drug menu:

- Drug name and dose are prominently displayed on screen.
- Unique Drug Menu provides a **custom list of drugs** and their concentrations for each patient care area.
- Miscalculation is avoided because all field entries are confirmed for appropriate data.
- **Medication error opportunity is reduced.**
- Epidural infusions are preset with occlusion and rate limitations

Circuit Diagram

Shown connected for 220/240V
(Fuse FS2 T50mA)
For 110/120V move BLK from PL8 to PL3 & move GRY from PL4 to PL7
(Fuse FS2 T100mA)



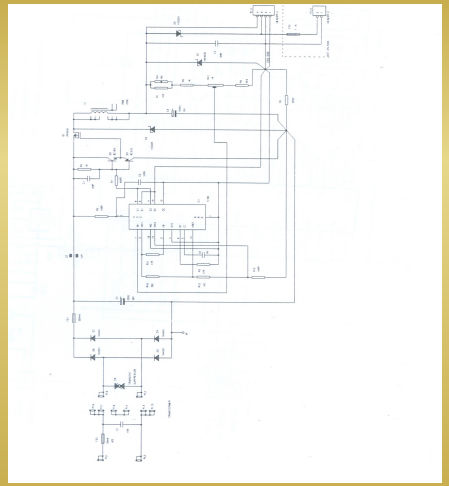
Syringe circuit board

- The syringe circuit board consists of four separate circuit boards:
- The main PCB.
- The regulator PCB.
- The opto-sensors PCB.
- The syringe sensor PCB.

Mounting

- The opto-sensors & syringe size sensor boards provide a mounting for the sensors & junction points for their output to be carried to other circuits.

The Regulator PCB:



Working:

- It is based around a regulator chip TL 594.
- The regulator circuit is protected by a mains fuse FS2 .
- PL8 & PL4 are used to set the supply to 220/240 V, PL7 & PL3 are used to set the supply to 100/120 V.
- L2 & D8 are for the suppression of transients.
- the output is smoothed by the small reservoir capacitor C4 which should have 25-35 V across it.

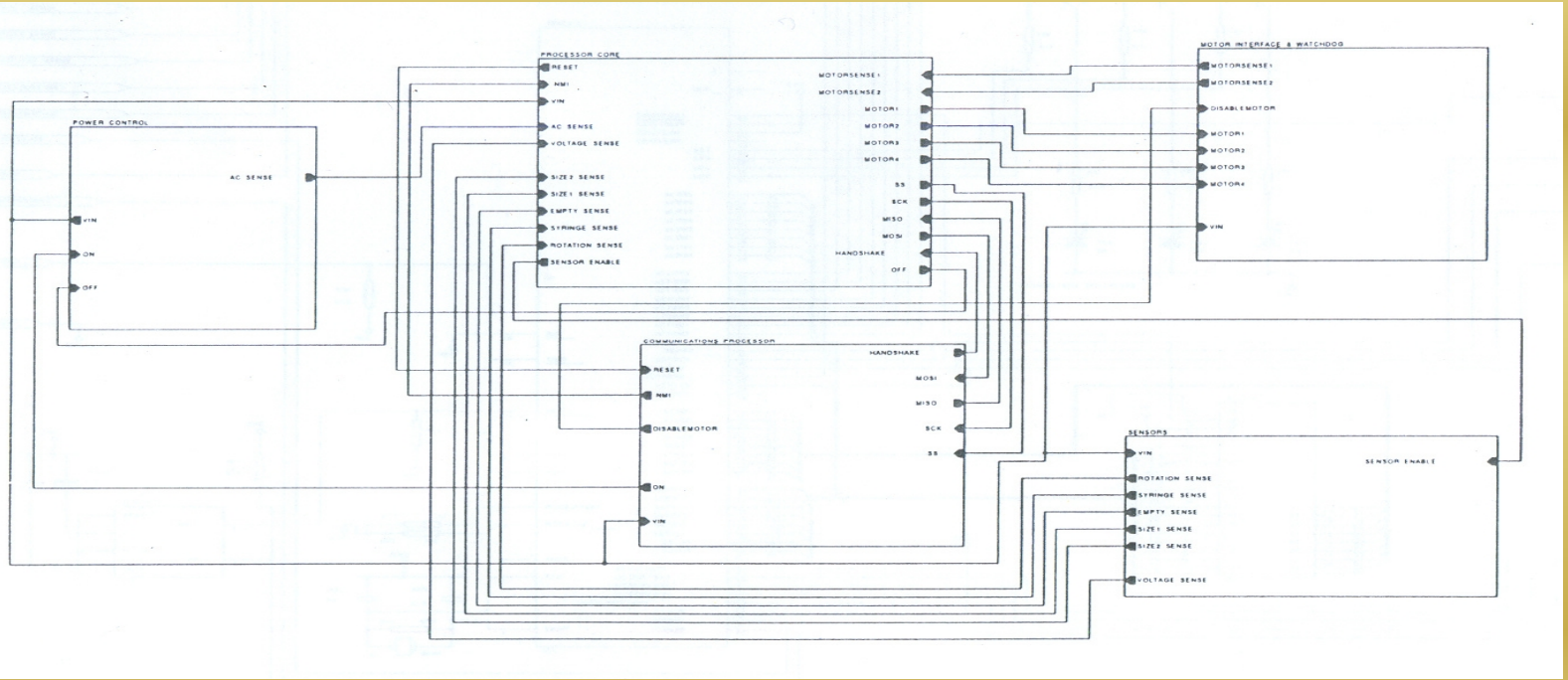
Working:

- Power is supplied to pin 12 of the regulator chip via a 500 mA fuse (FS1).
- The output of pins 8 &11 controls the operation of Q1, causing it to cycle on & off such that the mean voltage produced is 7 V.
- AS Q1 turns off, the voltage across switching inductor L1 charges C3 via fly back diode D2.
- A feedback voltage is supplied to pin 1 of the regulator by means of a potential divider comprised of R1, TH1, R9, RV1 & R8. TH1 varies the output voltage according to temperature to compensate for the battery charging characteristics.

Working:

- C2 acts as a decoupling capacitor.
- The zener diode D1 protects circuits if the regulator fails completely

The main Board



Circuit configuration

- It contains the processor core, the motor interface & watch dog circuits, the keyboard & sensor interface circuit, the power control & the slave processor .
- The main processor has an EEPROM, which stores information such as the syringe type for which unit is set .

Circuit configuration

Reset circuit:The chip IC3 & associated components C7, C8 & R10 form a reset circuit. Its output if fed to pin 17 of the main processor.

On power up, this circuit holds pin 17 low to reset the chip. On power down, it holds pin 17 low.

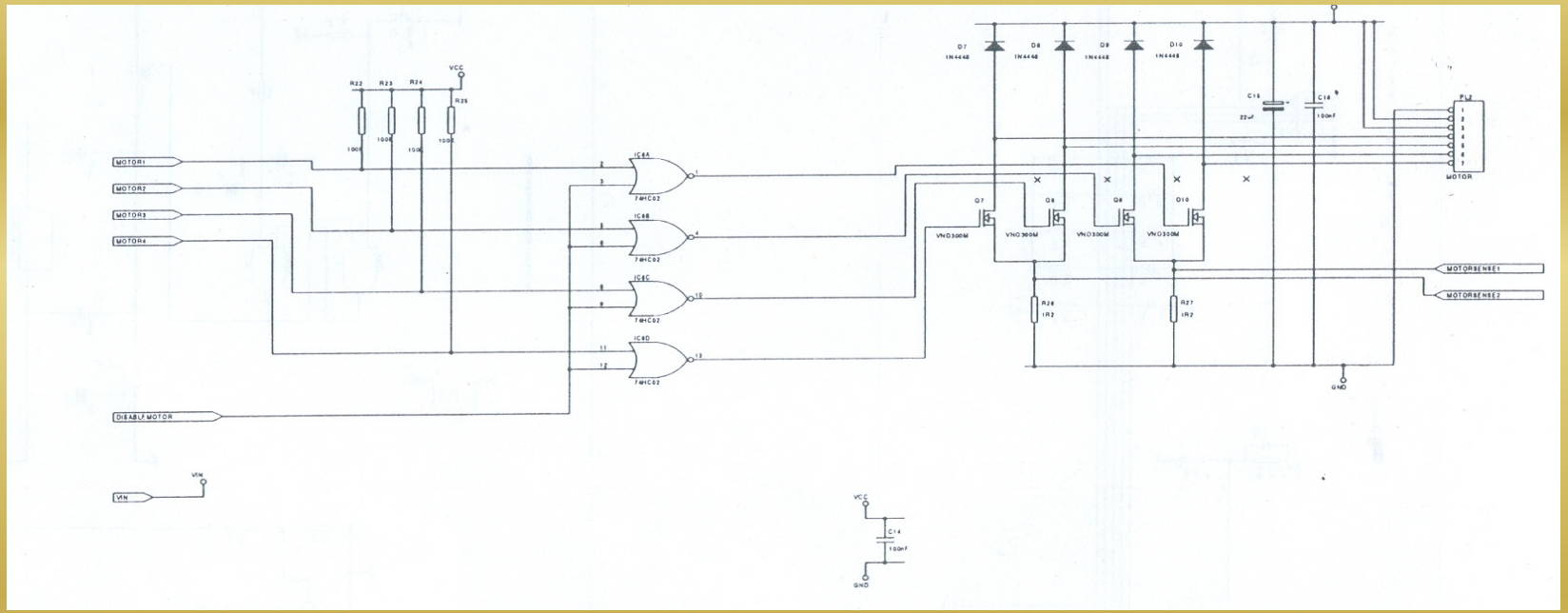
Circuit configuration

- X_1 & associated components R_{11}, C_9 & C_{10} form an 8 MHz oscillator, providing clock pulses for the main processor on pins 6 & 7.
- The EEPROM chip IC5 stores the systems software .
- Pins 2 &3 on the main processor control its mode of operation. They both are held high to set the processor to address the external EPROM (IC5).
- Pins 68 & 67 are held at Vcc & ground respectively as the reference inputs to the processors built in AD converter .

Circuit configuration

- The main processor directly controls the outputs to the stepper motor via pins 36 to 39.
- D4, D5 & D6 are three LEDs that indicate the syringe size as detected from the input on pins 60 & 65.
- They are controlled by the output of pins 25, 26 & 27 .

Motor interface:



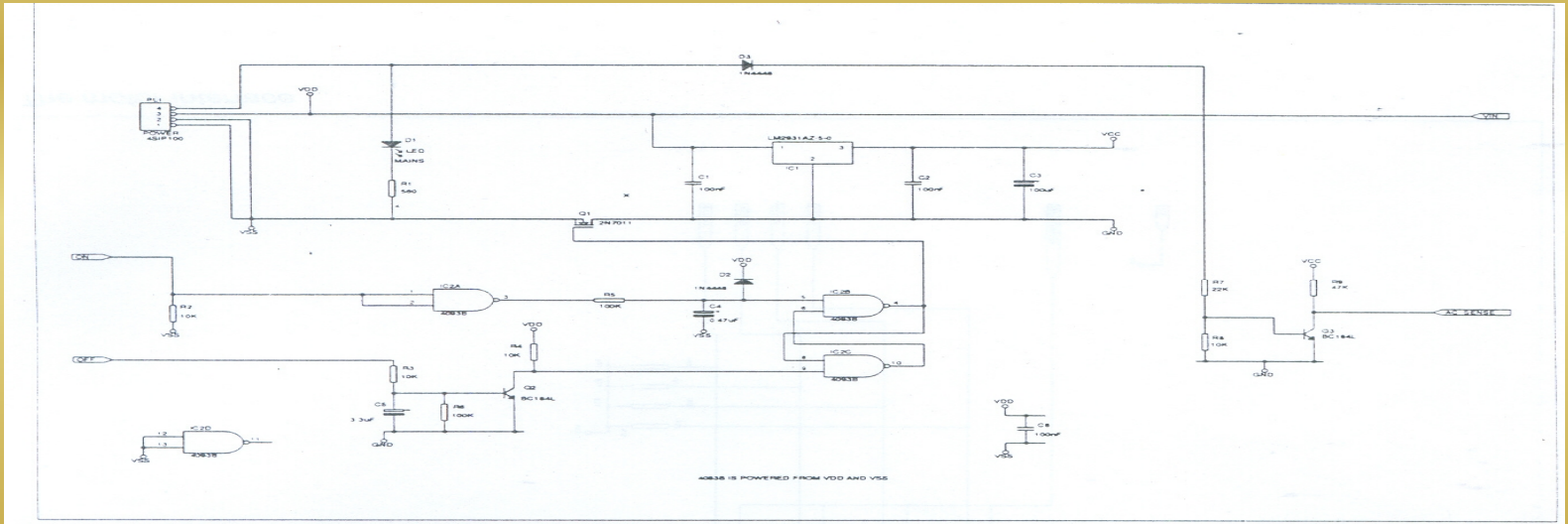
Working

- The stepper motor is controlled by pulses supplied directly from the main processor in appropriate sequences.
- Each of the motor control lines is fed to a NOR gate.
- Each NOR gate generates a high pulse in turn.
- Each pulse switches one of four power MOSFETS which in turn drive the stepper motor.
- The diodes provide a path for current stored in the motor coils when the transistors are turned off.

Working

- R26 & R27 enable the main processor to detect current flow through Q7 & Q8 & Q9 & Q10.

Power control circuit



The power control circuit

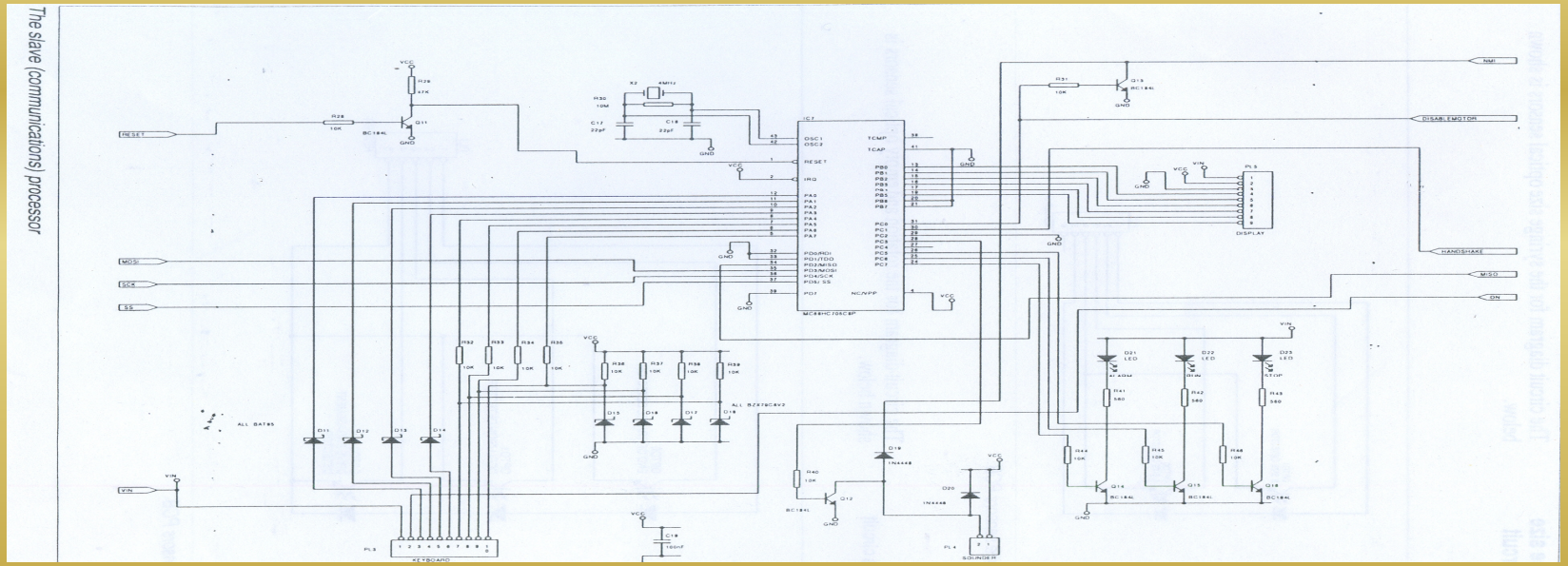
Working

- The inputs on PL_1 correspond to the output on PL_{11} on the regulator board.
- D_1 is a mains on LED, it lights whenever the mains supply is in operation.
- IC_1 is a linear regulator which provides a 5 V DC supply (Vcc) for the logic circuits.
- C_1, C_2 & C_3 are decoupling capacitors.

Working

- R_7, R_8, R_9 & Q_3 enable the main processor to detect the presence or absence of mains power.
- R_{55} & R_{56} act as a potential divider, enabling the voltage between them to be fed to the A: D converter of the main processor.

The Slave Processor



WORKING

- The slave processor handles communication with the display, the alarm, run & stop LEDs, the sounder & the keyboard.
- R28, R29 & Q11 provide a buffer such that pin 1 of the slave processor can receive reset pulse from the reset controller.
- X2, R30, C17 & C18 form a 4 MHz oscillator, providing clock pulses for the slave processor.

WORKING

- Outputs on pin 9, 10, 11 & 12 are used to strobe the keyboard which has 4x 4 matrix structure.
- D19 allows the NMI active low signal to turn on the sounder directly during a fault condition. D 20 protects against reverse voltage from the sounder
- Pins 13 to 19 provide an interface to the display circuit via PL5

Testing

- Mechanical Inspection:
- Before applying power to the unit, check that the case & exposed mechanical parts are free from any damage.
- Result:
- NO damage .

Electrical safety test

- Method:
- Using a test voltage of 500 V DC, measure the insulation resistance between the mains inlet & the exposed metal parts .
- Result:
- The insulation resistance must exceed 200 ohms .

Syringe test

- Method:
- Connect the AC supply . Press ON .
- Result:
- The AC lamp lights
- All LEDs are illuminated.
- The syringe type currently selected is displayed.
- The unit shows a rate & the STOP & AC MAINS lights will remain ON

Keyboard tests

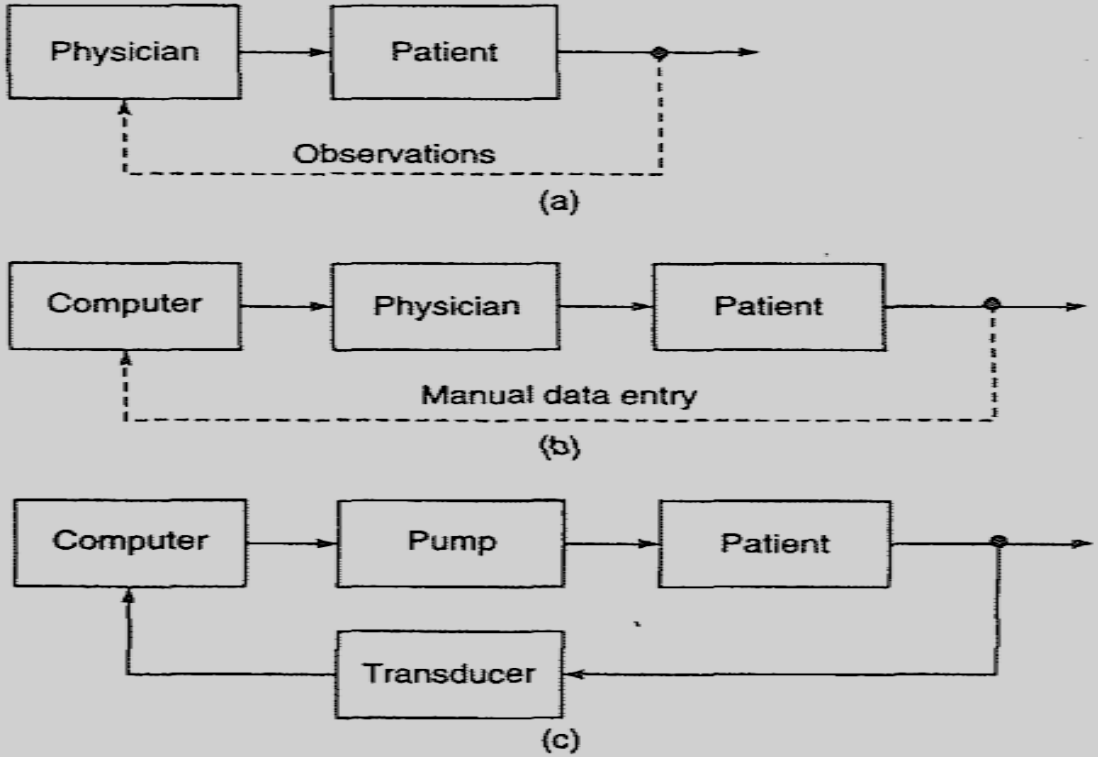
- Method:
- Press OFF: The display goes blank, but the AC lamp remains lit.
- Press ON: As initial power ON. The pump reverts to the set-up mode .
- Press alarm :The alarm is silenced & the pump goes to set-up mode .

AC failure

- Method:
- Press START to start the unit pumping. & switch on the AC supply.
- The alarm sounds intermittently & the display shows “AC MAINS FAIL “.
- Switch on the AC supply.
- Result:
- AC lamp lights .

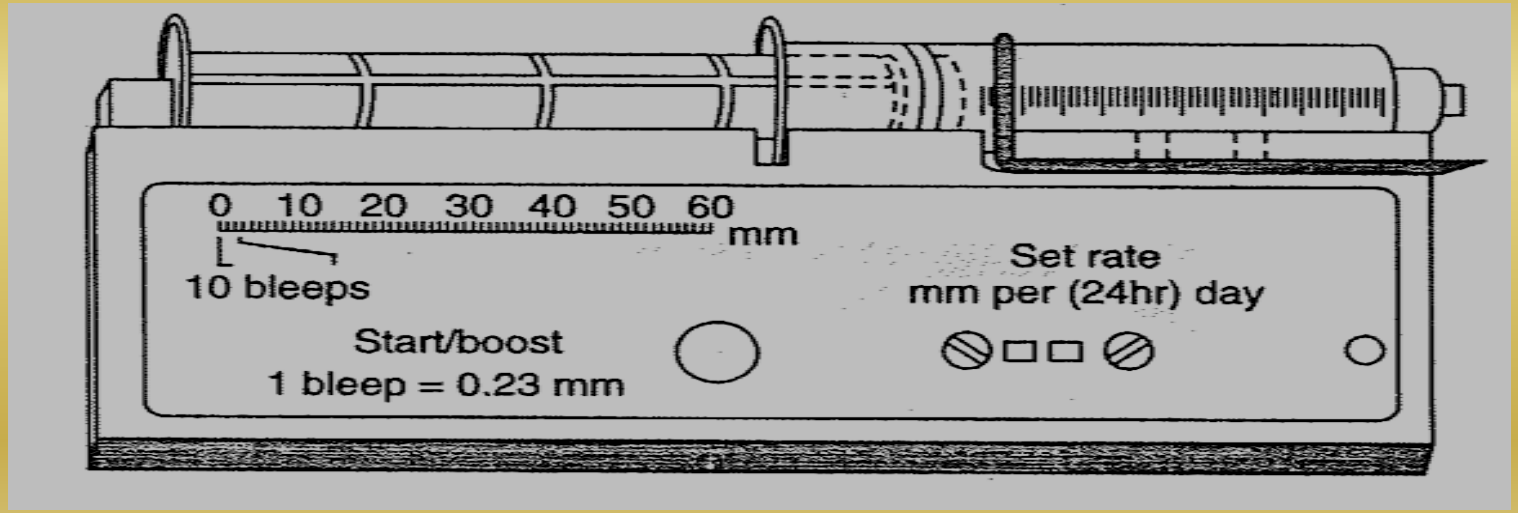
Accuracy

- Method: This test is performed only with the new syringe.
- The used syringe gives the wrong results.



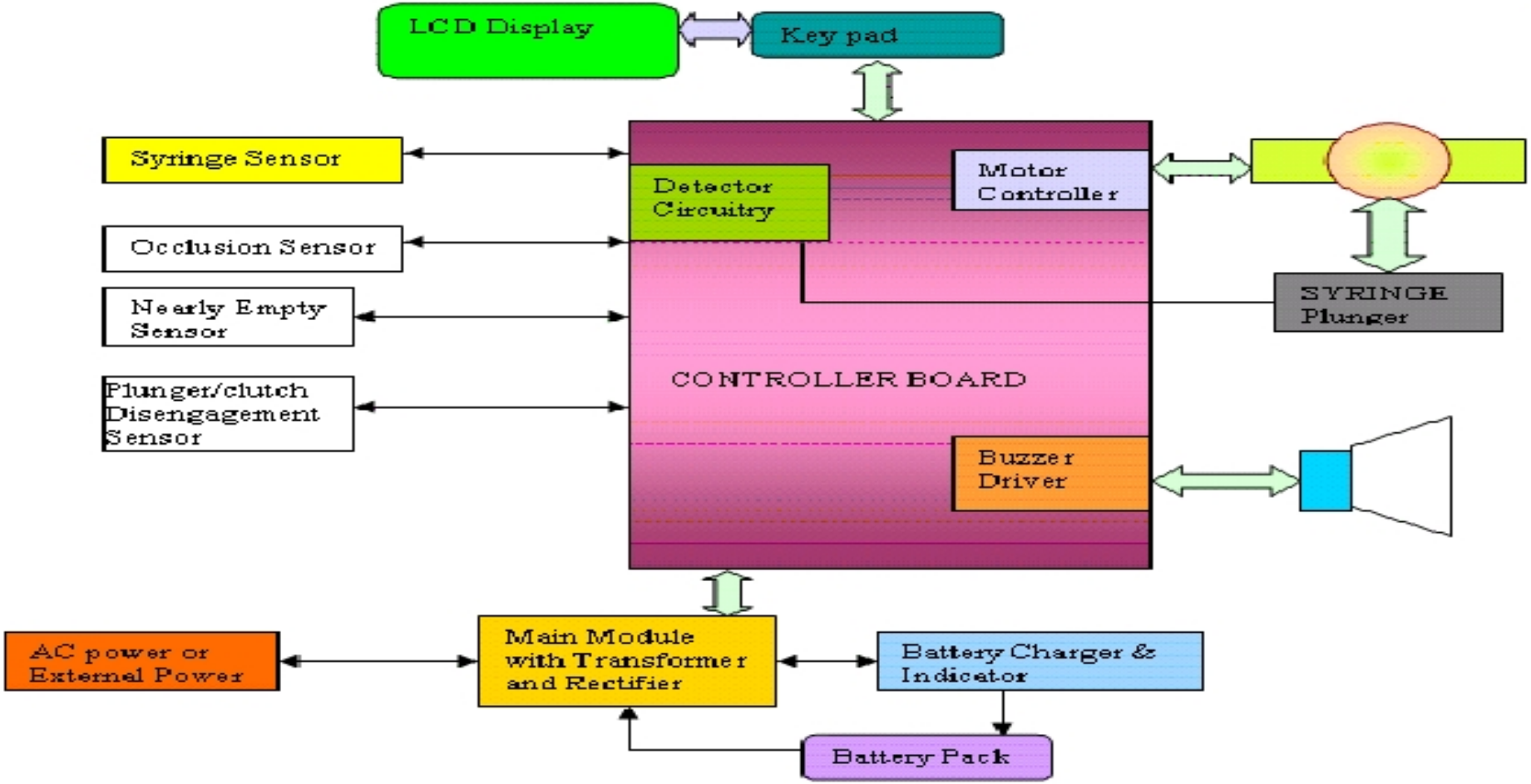
Various levels of automation in the control of drug delivery.

Syringe Pump



- **Mechanism of Delivery:**
- Delivery Mechanisms
  - Stepper Motor with drive screw
- Delivery Characteristics
  - Highly Accurate
  - (+/-) 2-3%
  - Delivery rates as low as 0.01ml/hr
  - Syringe pump incorporates with syringe, controls and actuation mechanism (usually a lead screw

- The linear displacement of plunger results in delivering the fluid to patient.
- Compatible Syringes: 10, 20, 30, 50 mL Syringes
- Flow Rate Setting:
- 0.1– 300.0 mL/hr for 10,20,30 mL Syringe i.e. (0.1 mL/h Steps)
- 0.1 – 1200 mL/h for 50 mL syringe i.e. (1 mL/h Steps)


LCD Display
Key pad
Syringe Sensor
Occlusion Sensor
Nearly Empty Sensor
Plunger/clutch Disengagement Sensor
Detector Circuitry
Motor Controller
CONTROLLER BOARD
Buzzer Driver
SYRINGE Plunger
AC power or External Power
Main Module with Transformer and Rectifier
Battery Charger & Indicator
Battery Pack

- ***Detector Circuit*** **-** It has a sensor circuitry of syringe size, Occlusion detector, syringe plunger Detector and low power detector.
- Once the syringe barrel clamp is lift, the sensor (potentiometer) incorporated with the shaft of syringe barrel will rotate. The resistor value changes according to rotation angle.
- The syringe plunger clamp moves along with nut drive shaft of motor. When the occlusion occurs, there is a reverse load and obstructs plunger to move ahead. The occlusion sensor equipped with strain

- The syringe plunger clamp operates the syringe plunger sensor (micro switch). If the syringe is clamped and sensor is ON, the respective information is sent to CPU.
- If the instrument is using the external power or internal power, the controller recognizes immediately and checks the required voltage and current. It monitors and sends the information to CPU

- ***Controller Board*** **–** This is main board of syringe infusion pump, which has a motor controller, Detector circuitry, power supply and battery charging monitoring, Key pad and Display controller circuitry. It has a micro-controller CPU with ROM, RAM and data converter. It is inter-connected to all PCB's to control and monitor the proper functioning of

- ***Motor Controller*** **-** It monitors and detects the rotation of motor by encoder and controls the actual speed with the calculated speed according to program set up. The motor rotation pulses are given by main CPU to drive the motor and simultaneously encoded input pulse from motor is sent to CPU to calculate and control the drive. It also generates a error

- ***Motor*** **-** In earlier infusion system, a DC motor was utilized to drive the piston pump at rate set by the unit. But now a days, a stepper motor is being used and angular velocity is controlled by digital electronics.
- The internal diameter of syringe is stored in ROM. Also the applicable internal diameter of syringe can be loaded as per the setting of syringe size and brand selected. With reference to this information CPU reads the

- ***Power Supply module*** **–** The power supply has AC line input and transformer. It generates the DC voltage of +/- 5VDC,+/- 12 VDC,+/- 15VDC,7.5VDC after step down transformer and bridge rectifier. The power is given to each PCB and battery charging circuitry.
- ***Battery Operation*** **–** The fully charged battery gives constant supply to the unit and simultaneously monitored by CPU. It monitors the charging current, discharge current and time. If the minimum requirement of voltage is not reached, a battery alarm is activated.

- ***Pump Unit*** **–** The pump is driven by stepper motor. Motor controller board drives the motor by applying number of pulses. Infusion pump motor has two slots, which is detected by sensor. This monitors the direction of rotation and speed of pump.

- ***Front Panel*** **–** The Front panel of pump consists of LCD display and keypad control. The LCD display shows in a plain text, green background and shows the status of Unit. It displays whether the unit is connected on AC mains or Battery operation, Alarm status, History of Drug infused, time interval, bolus doses and quantity delivered to patient. While keypad controls the data feeding for the patient's drug delivery and patient set up.

- **General Features:**
- Highly accurate in volume delivery and constant flow for small volumes
- Appropriate for neonatal, infants and critical care application
- It is useful where the small amount of drug to be delivered over an extended period.
- Drug dose calculation function
- Memory log (Operating events with date and time for drug deliver)
- Alarm facility - Occlusion, End of infusion, Low battery or pump malfunction.
- **Occlusion :** Most of syringe pumps detects the excessive back pressure when the motor drive stalls and some syringe pump

- **General Applications:**
- For delivering anesthetic during surgery , chemotherapy for cancer , oxytoxic agents for inducing labour and anti-arrhythmic drugs for patients in the coronary care units.
- The largest group of potential users of infusion pumps are ambulatory diabetics. Conventional therapy , consisting of one or two daily injections of insulin , allows

- Microfluidics/Nanofluidics
- Neuroscience
- Micro Dialysis
- Drug/Nutrition Infusion
- Cell Injection
- Chemical Reactor Injection
- Low flow dispensing
- Aerosol Spray
- Perfusion Chamber
- Compound Storage

- Secondary Screening
- Primary Screening
- Assay Development.
- Used to administer IV fluids
- Regional anesthetics
- Anti-arrhythmic medication
- Chemotherapeutic agents
- Diabetic management (Insulin)
- Anticoagulant (Heparin)

Advantages for syringe pumps

- Easy to use and virtually maintenance free
- Ideal for low flow at high pressure
- Excellent pulse-less flow
- Available with accuracy of 0.5%
- Repeatability of 0.2%
- Wide dynamic range, typically 100,000:1