CHAPTER II

LITERATURE REVIEW

1. The principle of milking machine

The milking machine plays an important role on the dairy farm as an efficient means of milking cows. It is used more often and more hours per year. However, it must be remembered that this machine is one of the few devices which has direct contact with the teat tissue (www.milkingmanagement.co.uk). The teatcup liner is the only equipment that comes into contact with the cows teats. The continuous vacuum within the liner causes the teat canal to open and the milk to flow because of the pressure difference between the milk in the teat and vacuum (FAO).

A milking operation which results in discomfort to the cow and is caused by improper milking equipment or techniques may lead to injury or mastitis. Consequently, before a person attempts to milk cows they should thoroughly understand the basic operation of the milking equipment and the significance of maintaining the equipment in good condition at all times and of employing good milking techniques. (www.omafra.gov.on.ca).

The basic construction

The principle of machine milking is to extract milk from the udder by vacuum. The machines are designed to apply a constant vacuum to the end of the teat to suck the milk out and convey it to a suitable container, and to give a periodic squeeze applied externally to the whole of the teat to maintain blood circulation (FAO).

The vacuum

The amount of air removed from the system will determine the vacuum level. The vacuum level indicated on a vacuum gauge is measured in Kilopascals (metric) or in inches of mercury vacuum (imperial). International standard of milking machines for vacuum measurement is kilopascals (kPa) with zero kPa being equal to atmospheric pressure and 100 Kpa absolute vacuum (www.omafra.gov.on.ca).

Most milking machines operate with 40 to 50 kPa of vacuum. Many knowledgeable workers in the field recommend a vacuum level between 37 and 45 kilopascals (FAO).

The milking process then consists of opening (milk phase) and closing (massage phase) the teat cup liner over and over again. By the pulsator operates, it causes the chamber between the shell and the liner to alternate regularly from vacuum to air source. The inside of the teat cup liner is under a milking vacuum at all times. Thus when air is admitted between the shell and liner, the line collapses around the cow's teat. The pressure of the collapse liner is applied to the teat giving a massaging action. This is called the rest or massage phase. Milk does not flow from the teat during this phase.

During the milk phase, the space between the liner and the shell is exposed to the vacuum by the pulsator. There is now equal pressure on both sides of the liner causes it to open. The end of the cow's teat exposed to the vacuum and the influence of internal milk pressure within the cow's udder causes the milk to be drawn out through the teat opening (www.omafra.gov.on.ca).

The milking machine components

All milking machine systems operate basically in the same way (figure 1) and consist of the three main components:

1. vacuum production
   - electric motor
   - vacuum pump
2. vacuum pipeline
   - interceptor
   - regulator
   - vacuum pipeline
   - vacuum gauge
3. milking unit
   - pulsator
   - cluster (teatcup, liner and claw)
   - milk receptacle (bucket or milk pipe line)

The basic layout of milking machines are the same. Each has a pump to remove air from the vacuum pipeline, a vacuum regulator to control the vacuum level and a container to collect the milk that comes into the teatcup assembly during milking (FAO). Although milking machines have now developed into systems that show considerable diversity, they have the same basic components. For example, milk pipe line type and recorder jar type.

Vacuum pump

The function of the vacuum pump is to remove air from a close system, thereby creating a partial vacuum. The difference of the pressure around half of atmospheric pressure creates the negative pressure and is expressed in kPa. The size of the vacuum pump is usually expressed in terms of cubic feet per minute (CFM).

The CFM required to operate a milking installation depends upon the amount of air introduced into the vacuum system, which in turn depends on the number of milker units used, the size of the milk and vacuum lines, the number and sizes of auxiliary milking equipment (www.milkingmanagement.co.uk).

The vacuum pump in Thailand can be divided into 2 types as rotary oil pump and dry pump with carbon vanes. Air is drawn in through the inlet port by the rotation of the rotor, compressed and ejected to atmosphere.

The function of the vacuum pump is to extract air from the pipeline system and in the majority of milking machines it is a rotary exhauster driven from either an electric motor using pulleys and V-belts. This gives flexibility with speeds ranging from about 800–1,500 rounds per minute and a corresponding of pump capacities to suit several sizes of milking machines (FAO).

Interceptor

A trap fitted in the main vacuum line to prevent liquid and dust material being sucked in to vacuum pump from milking installation. An interceptor with a capacity of not less than 15 litres is fitted in the main vacuum line adjacent to the pump, with provision for draining and cleaning. It should also have a float valve to automatically shut off the vacuum in the event of its filling with liquid (FAO). The tank must be constructed by durable material to enduring high concentration of chemical cleaners or sanitizers and must be self-draining (www.omafra.gov.on.ca).

Regulator

The vacuum controller admits air into the milking system to maintain a set vacuum level on the pulsator and milk lines. The CFM rating of the controller must be equal to or greater than the vacuum pump capacity. A regulator must be able to handle the full-rated capacity of the vacuum pump (www.omafra.gov.on.ca).

Controllers should be installed in a clean area where moisture and dirt will not affect their proper operation. In the pipeline system the controllers should be placed between the vacuum pump and the trap. Controllers are often located near or on the vacuum reserve tank (www.milkingmanagement.co.uk).

An automatic valve to maintain a steady vacuum inspite of varying air usage. A preset force (weight or spring) holds the valve closed until vacuum lifts it and allows air to enter. Valve should maintain vacuum to within the limits of 50 kPa of the designed working vacuum (FAO).

Vacuum gauge

Indicates abnormal levels and fluctuations in vacuum, eg. serious air leaks, dirty regulator and slipping vacuum pump drive belts (FAO).

Vacuum pipeline

The pipeline should be close looped around the milking system with each end of the pipeline connecting into the vacuum reserve tank by its own inlet or looped into an adequate size. Use risers only if absolutely necessary; automatic drain valves should be fitted on all low points on this pipeline. If plastic pipe is used, more hangers may be needed for support than if galvanized pipe is used (www.omafra.gov.on.ca).

Pulsator

The function of pulsators is to alternate the space between the teat cup shell and teat cup liner between a partial vacuum (milking phase) and atmospheric air pressure (rest phase).

During the milking phase, the space between the inflation and shell and the space inside the inflation have the same partial vacuum. This causes the inflation open and milk flow from the teat. Milk flows from the teat because the pressure inside the udder is greater than that outside the teat end.

During the rest phase, air at normal atmospheric pressure enters between the shell and inflation. Due to the partial vacuum inside the inflation, the inflation collapses around the teat. The pressure of the collapsed inflation helps massage the teat, preventing congestion of blood and body fluids in the teat skin and tissue.

The closing patterns of the inflations vary among manufacturers. Some have all four inflations of a claw closing at once (simultaneous), while others have an alternating pattern, only two inflations close at a time (www.milkingmanagement.co.uk). Alternating pulsation (either side to side or front to back) is preferable over simultaneous pulsation because the alternating feature minimizes cyclic vacuum fluctuations at the teat end (www.omafra.gov.on.ca).

The pulsator which is usually fixed on the bucket lid admits air intermittently and this passes along the long pulse tube to the teatcup chambers. To control the vacuum at a predetermined level, air is also admitted to the system through a vacuum (FAO).

Some terms related with the pulsator, please see in the appendix A.

Teat cup shell and teat cup liner

These two components form the pulsating chamber which allows milk to be removed from the teat. The shell size used should correspond to the inflation size. Most companies recommend the use of narrow to intermediate bore liners, 3/4 inch or less in internal diameter (FAO, www.omafra.gov.on.ca, and www.milkingmanagement.co.uk).

Many types of teat-cup shell and liner combinations are available. Make sure that the shell and liner are compatible. A liner should be replaced immediately if it becomes damaged. Material wise a few different types may have to be tried in order to find the best type suited for that individual herd. The liners should be replaced as per manufacturer's recommendation (www.omafra.gov.on.ca).

In the bucket or direct-to-can machine, the milk enters the teatcups and travels through the short milk tubes to the claw where air is admitted and the milk and air travel along the long milk tube to the bucket. The milk remains in the bucket and the air separates to pass up the vacuum tube to the vacuum pipeline.

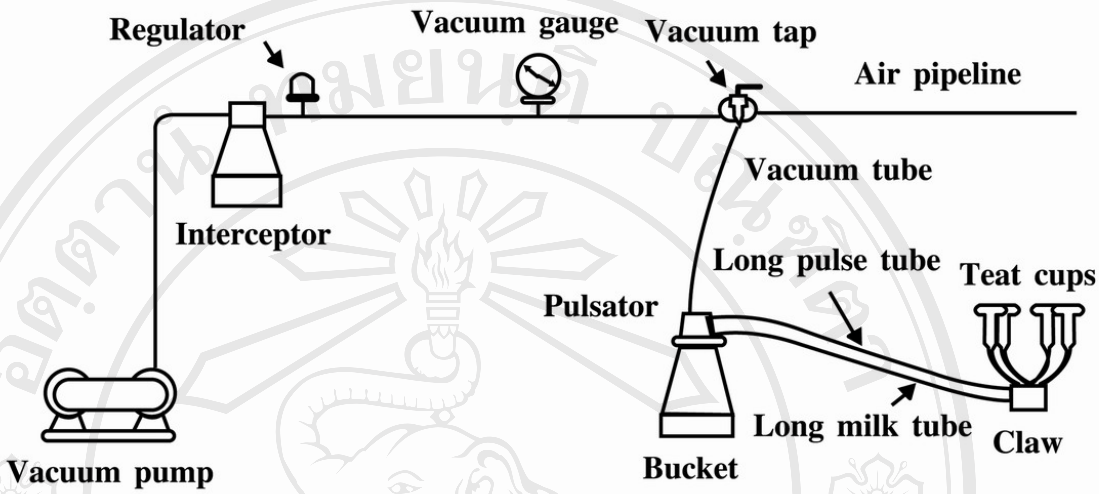

Figure 1 The bucket type of milking machine system consist of three main components as vacuum production, vacumm pipeline, and milking unit. (Mein, G.A., 1991.)

2. The principle of bovine teat

The teat functions as the only exit for the mammary secretion and the only means for the calf to receive milk. Usually, only one teat drains one gland. No hair, sweat glands or sebaceous glands are found on the teats of the cow. Teat size and shape are independent of the size, shape or milk production of the udder. Average size for the fore teats is about 6.6 cm. (2.6 in.) long and 2.9 cm. (1.1 in.) in diameter, and for the rear teats is 5.2 cm. (2.1 in.) long and 2.6 cm. (1.0 in.) in diameter (www.classes.aces.uiuc.edu).

The teat is very important part of mastitis occurrence. Because, an udder infection comes in one way through the teat end. The cow's first line of defense is the teat canal and its structure. The second line of defense is somatic cells, whose job is to attach and engulf bacteria (www.wcds.afns.ualberta.ca/Proceedings/1995/wcd95093.htm).

The teat canal is not so much a single channel from teat end to teat cistern as a delicate web of tiny channels that open at the base of the teat into a common channel. It is within the walls of this web that the strongest defense against incoming bacteria exists. A small protein called ubiquitin acts as a general antiseptic in the teat canal against a wide range of bacteria. In a healthy teat, this lining also produces the keratin plug that mechanically traps debris and bacteria. The healthy sphincter muscle that surrounds these structures is really an active valve that resists distention, tending to always contract closed (www.wcds.afns.ualberta.ca/Proceedings/1995/wcd95093.htm).

Teat wall

1. Outer skin - tightly attached to underlying tissue containing venous plexuses (these can engorge to divide the teat sinus and gland sinus). There is a prominent vascular ring around the base of the teat which lies in the annular mucosal fold. This layer includes a layer of smooth muscle - circular and longitudinal. The circular muscle forms a sphincter around the teat canal.

2. Inner epithelium - cuboidal in the teat sinus, stratified squamous in the teat canal. Boundary between the two epithelia forms a puckered edge - the rosette of furstenburg. After milking a fatty plug of material forms in the teat canal. This plug is thought to prevent ingress of bacteria. The inner epithelium of the teat forms many longitudinal folds which are eliminated as the sinus distends with milk. (http://137.222.110.150/calnet/mammary2/page2.htm)

The teat anatomy composes of the teat canal, Fürstenburg's rosette, the teat cistern, and the some part of gland cistern, from outside to deeper side respectively (figure 2).

The teat canal is located at the end of each teat. The canal, which is approximately ¼ to ½ inch in length, is made up of extensions of the skin that lies close together. The teat canal is held closed by sphincter muscles.

The teat canal functions as the only orifice of the gland between the internal milk secretory system and the external environment. The teat canal is the main barrier against infection. It lies with a skin-like epidermis. The teat canal is kept closed by sphincter muscles around the streak canal (www.classes.aces.uiuc.edu).

The cells that line the teat canal contain keratin. The keratin is a waxy substance similar to ear wax. This substance helps to seal the teat end between milking. Keratin also has properties that inhibit the growth of bacteria.

Fürstenburg's rosette is located directly above the teat canal. It is made up of loose folds of membrane that smooth out as milk accumulates in the udder. This aids in blocking the escape of milk between milking (www.milkquality.org). It may fold over the canal opening due to pressure when the udder is full. This can be damaged by improper milking or by improper use of mastitis infusion nozzles. It may be a major point of entry for leukocytes leaving the teat lining and entering into the teat cistern (www.classes.aces.uiuc.edu).

The teat cistern is the cavity inside the teat that holds from 1/2 to 1 1/2 ounces of milk, depending on the size of the teat. The teat cistern is continuous with the gland cistern. The teat cistern is lined with numerous longitudinal and circular folds in the mucosa, which form pockets on the inner lining of the teat (http://classes.aces.uiuc.edu). The teat cistern is the holding chamber where milk accumulates before it is removed through the teat end during milking. It refills continuously during milking. This is where the first milk to be removed accumulates between milking (www.milkquality.org).

The gland cistern joins to the teat cistern at the base of the udder. The gland cistern, which can vary greatly in capacity, functions as a collecting vessel for milk from the major milk ducts that flow into it. The gland cistern fills rapidly during milk letdown.

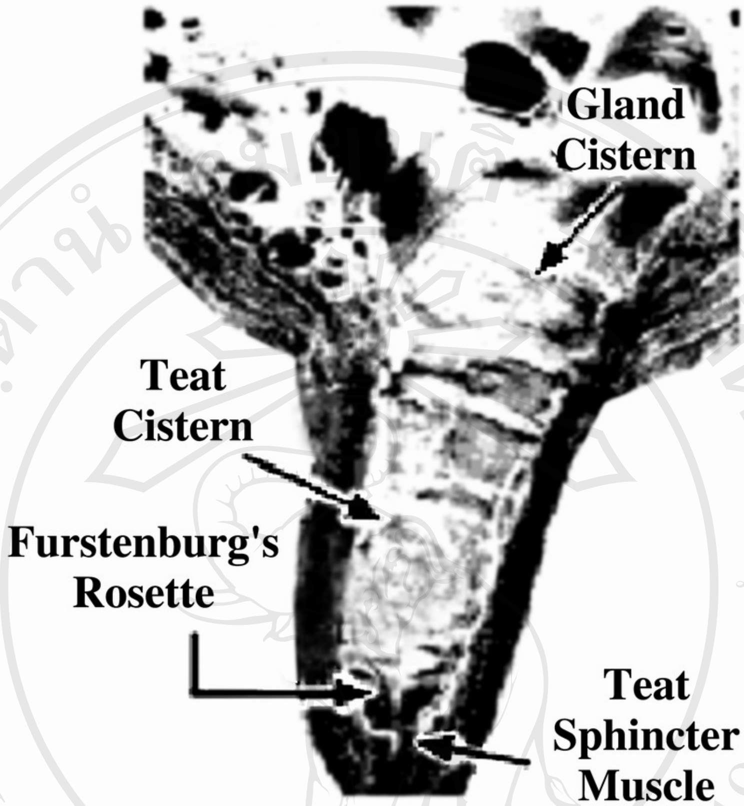

Figure 2 The bovine teat anatomy consists of the teat canal, Fürstenburg's rosette, the teat cistern, and the gland cistern.

(www.milkquality.org/Course/ch1/ch1sec2i.html)

3. The principle of somatic cell count (SCC)

The somatic cell count (SCC) is commonly used as a measure of milk quality. Somatic cells are simply animal body cells present at low levels in normal milk. Normally, SCC are based on the number of cells per milliliter (ml.) of milk. High levels of these cells in milk indicate abnormal, reduced-quality milk that is caused by an intramammary infection or mastitis.

The majority of the cells in a somatic cell count are leukocytes (white blood cells), and some are cells from the udder secretory tissue (epithelial cells). The epithelial cells are part of the normal body function and are shed and renewed in normal body processes. The white blood cells serve as a defense mechanism to fight disease or infection, and assist in repairing damaged tissue (www.ianrpubs.unl.edu).

Milk industry routinely checks on somatic cell counts to help ensure a quality product. Somatic cell counts levels are monitored to assure compliance with state and federal milk quality standards. Today, most markets pay a premium for low SCC and good quality milk. In Thailand, milk collecting centers have a penalty of SCC greater than 500,000 cells /ml (Department of Livestock Development, 1999).

One would also expect that the SCC in the bucket milk would be related to the number of quarters infected and the amount of milk being produced by each quarter. However, if all quarters of a cow are uninfected, one would generally expect SCC below 200,000 cells/ml. in the bucket milk (www.ces.uga.edu).

A mastitis control program must be adopted through an awareness of the status of udder health in the herd. Awareness can be heightened by milk price premiums based on milk quality, and/or penalty programs for high somatic cell counts (SCC) in bulk milk (www.wcds.afns.ualberta.ca).

The predominant factor affecting herd or individual cow SCC level is intramammary infections. The causes of infections are many and the method of transmission is virtually never a single factor, but a combination of many factors (www.ianrpubs.unl.edu). Since mammary gland infection is multi- factorial, the epidemiological principle of sufficient cause is bearing on whether or not exposure to mastitis pathogens will cause mammary gland infection.

The factors affecting SCC are as follows: intramammary infection, teat or udder injury, age of cow, stage of lactation, season, stress, day to day variation, technical factors and management factors (www.gov.on.ca).

However, the mastitis prevention work has so far been a little bit too much focused at the bulk tank somatic cell count and cow milk somatic cell count. These figures have been very easily available and the farmers have been very much focused on the losses due to quality payment scheme instead of concentrating at avoiding new infections.

4. The principle of ultrasound

The principle for ultrasound, or ultrasonography, is the same as for underwater sonar or echo sounding (www.amershamhealth.com). Diagnostic ultrasound employs pulse, high frequency more than 20,000 Hz (range of 1 to 10 Megahertz), that are reflected back from body tissues and processed by the ultrasound machine to create characteristic images.

Ultrasound travels in the form of a longitudinal wave, in which particle motion is along the same direction as the wave is traveling. These waves are generated by the ultrasound transducer. Longitudinal waves transfer energy through the motion of regions of compression and rarefaction within the wave. Because it is in wave form, ultrasound physics is governed by many of the same principles as basic wave physics (www.urmc.rochester.edu).

When an ultrasound wave meets an interface of differing echogenicity, the wave is reflected, refracted and absorbed. Only reflected sound waves (echos) can be sensed by the transducer and processed. How much is reflected depends on the densities of the respective tissues or acoustic impedance between adjacent structures and thus the speed of the sound wave as it passes through them (www.cvm.tamu.edu).

The sound waves are propagated to the surrounding medium at a characteristic speed (approximately 1,540 m./sec. in soft tissues), the thickness, size and location of various soft tissue structures in relation to the origin of the ultrasound beam can be calculated at any point in time. The time taken for the reflected wave to return indicates how deep the tissue lies within the body. In this way, one obtains a picture of the relative locations of the tissues in the body (www.amershamhealth.com).

The frequency of the ultrasound beam used influences the quality of the resulting image to a great degree. Higher frequency ultrasound waves have a longer near field and less divergence in the far field; they permit better resolution of small structures. However, more energy is absorbed and scattered by the soft tissues so that higher frequencies have less penetrating ability. Conversely, a transducer producing lower frequencies will provide greater depth of penetration but less well defined images. Frequencies generally used for veterinary large animals range from 3.5 to 7.5 MHz.

The tissues that strongly reflect ultrasound are hyperechoic (white color) or of increased echogenicity. Poorly reflecting tissues are hypoechoic (gray color), while fluid, which does not reflect sound, is anechoic (black color) or sonolucent (www.cvm.tamu.edu).

Application of coupling gel to provide an air free contact between skin and transducer is necessary. Because of ultrasound waves loss of energy to penetrate through air gap. In all cases the transducers, whether fixed of moving, must be surrounded by a coupling medium and be in intimate contact with the skin.

Ultrasound has become very important for non-invasive observation of soft tissues structures in real-time. It is an interactive diagnostic technique, which requires much experience to find the right view for proper diagnosis (www.urmc.rochester.edu).

General requirements

There are three requirements for diagnostic medical ultrasounography; generation of a beam, reception of the returning echo, and processing of the signal display. (figure 3)

The transducer is responsible for the generation of an ultrasound beam and detection of returning echoes. When an echo is received, the induced signal is electronically processed to enhance the signal for viewing purposes.

All the subsystems are controlled by a master synchronizer. An electronic signal from the master synchronizer to the transmitter initiates the process. A pulsed ultrasound beam is generated and sent into the body. When an interface is encountered, the beam energy is reflected back toward the transducer. The returning echo converts to an electronic signal that is processed and displayed.

Any special amplification based on elapsed time, such as time gain compensation (TGC) and gating applied to the detected signals, also requires knowledge of the exact time of travel for the pulse (Hedrick, et al., 1995).

Ultrasonic transducer

A transducer is a device capable of changing one form of energy into another. For ultrasound purposes, the transducer is the sender and a receiver of ultrasonic pulses and echoes. This transducer can change electrical impulses into mechanical waves and vice versa. As a transmitter, the transducer employs a piezoelectric crystal to create the waves that enter the body (www.urmc.rochester.edu).

Alternatively, the piezoelectric effect enables the same transducer to receive an ultrasonic echo. Ultrasound wave returning strike the crystal and induce electrical signals. These are processed and ultimately displayed.

For diagnostic medical applications the almost universally used material in transducers is lead zirconate titanate, Barium lead titanate, barium lead zirconate, lead metaniobate, and lithium sulfate have also been used. The sound waves have a frequency between 1 and 10 MHz, depending on the application.

In this research, used the linear array transducer, multiple crystals are lined up along the face of the transducer in a linear fashion. Groups of crystals are stimulated together to form a beam which is displayed as a rectangle on the screen. These provide a longer skin/transducer contact area and a larger near field of view.

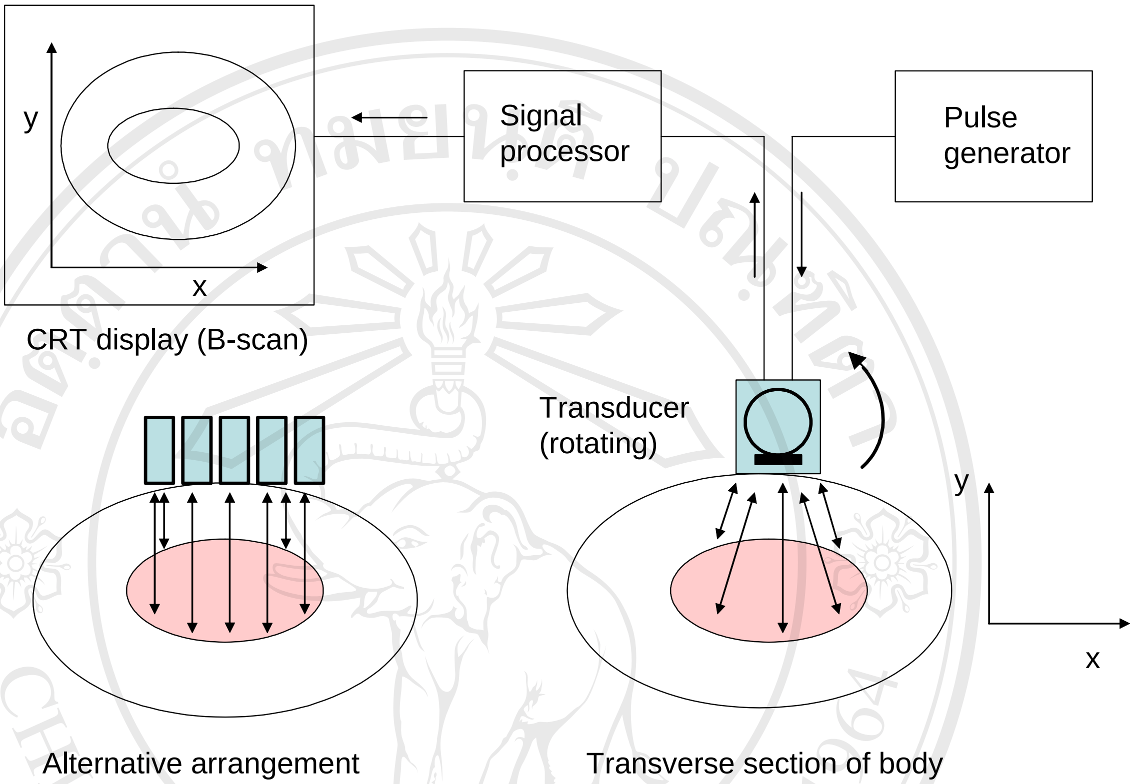

Figure 3 The Real-Time B mode scanners and their compartments.

(www.urmc.rochester.edu/smd/obgyn/programs/residency/residents/ultrasound_manual/docs/section02.pdf)