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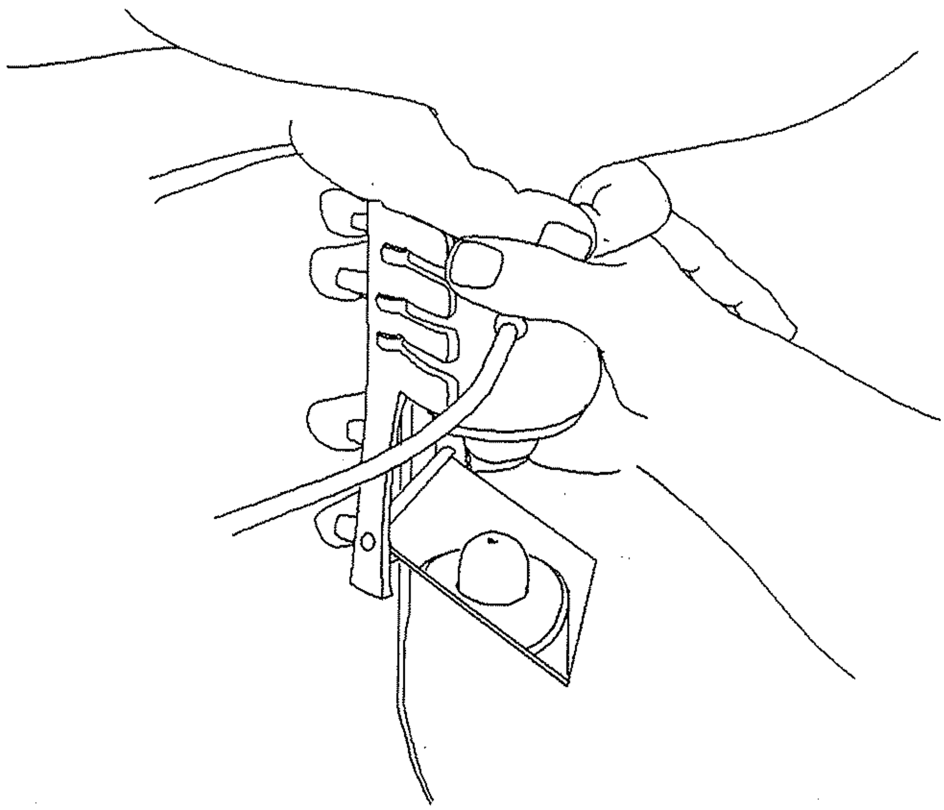
UTVECKLING OCH TEST AV EN MÄTMETOD FÖR SFINCTERTONUS HOS KOR

THE MEASUREMENT OF SPHINCTER TONE IN COWS
- DESIGN AND TEST OF A NEW MEASURING TECHNIQUE

David Landau



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Uppsala June 1995 **David Landau**

Summary

A new method for measuring the bovine teat canal sphincter (TSC) has been developed at the Department Of Agricultural Engineering in co-operation with the Department of Animal hygiene, Swedish University of Agricultural Sciences (SLU). The device registers the first measurement when a contact between the device and the teat wall is established, and the second measurement is taken when the first drop of milk appear. The measurements with the device described in this report take a short time and the measurements can be made before or after milking without any risk of inserting pathogenic material into the sensitive teat canal.

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1 Introduction

The closed teat canal is a final protection for the bovine mammary gland from an invasion by pathogenic material. The teat musculature is involved in the teat canal closure by regulating the tone around the teat canal sphincter. This tone in the teat canal sphincter (TCS) together with the keratin acts as a seal against a pathogenic material from without.

To be able to measure the tone of the teat canal sphincter, several methods have been used since 1942. In all the methods except one, a foreign object has been inserted into the sensitive teat canal and might influence the measurement value and carries a risk of introducing pathogens into the teat canal.

A new measurement method has been developed at the Department of Agricultural Engineering together with the Department of Animal hygiene, Swedish University of Agricultural Sciences (SLU). This method is based on the idea from 1942. With this method there is no risk of introducing pathogens into the teat canal. The measurement takes a short time and it can take before and after milking. The measuring device takes the first measurement when a contact between the device and the cow teat is established, while pressure increasing in the device causes pressure increasing in the teat and opening the teat canal.

2 Biological and physical principles

2.1 The importance of measuring the tone in the teat canal sphincter

There are several reasons for measuring the tone in the teat canal sphincter (TCS): The velocity of the milk flow rate through a cow teat canal is on average 8 m/s during a suction phase (Hamann 1987), and is among other things dependent upon the radius of the teat canal. The muscle tone regulates the diameter of the teat canal. A low tone in the muscle usually means a wider teat canal diameter, which results in a high flowrate. The fast emptying of the udder cistern is a precondition for a lot of milk being transported away from the place of secretion into the teat cistern during the limited action period of oxytocin.

The majority of new infections of the udder are a result of a penetration through the teat canal (Hamann 1990, Galton 1990). The closed teat canal protects the bovine mammary gland from invasion by pathogenic material. The teat musculature is involved in teat canal closure (Williams & Mein 1980). The tone in the TCS together with the keratin acts as a primarily mechanical seal.

Milking technique might have an influence on the TCS and the teat. This can be one of the factors behind the stability of mastitis incidence. Mastitis was the second main reason for cows to be culled from herds. On average, the age of these cows was 61.7 months (SCB 1994). A new milking technique that takes both the physiological and ethological aspects into consideration, can be developed in the future.

2.2 Biological principals

2.2.1 Anatomy of the lactating quarter

The quarters are separated into the right and left halves by a medial suspensory ligament. There is no membrane which separates the fore and rear quarters on the same half. The largest portion of milk is secreted by the rear quarters. The mammary gland is composed of many lobes. These lobes contain many lobules which, in turn, contain the alveoli.

A duct system drains the milk from the alveoli through the lobes down to the gland cistern. The composition of the duct system is similar to that of a root system in plants. At the point where a duct branches off, the opening is usually narrow (Schmidt 1971). The duct gradually changes to a sinus-like form before getting narrow again and this prevents the milk from flowing through the force of gravity alone (Schmidt 1971). There are 10 to 12 ducts, eventually more in the rear quarters, which lead the milk into the gland cistern.

There is no relationship between the size of the cistern and the amount of milk secreted by the quarters. The gland cistern together with the adjacent teat cistern serve as collecting vessels for part of the milk between calf suckling or milking. This allows the udder to secrete larger volumes of milk. The size of the gland cistern varies between cows and even between quarters. The capacity of the gland cistern is between 100 to 400 grams of milk (Schmidt 1971).

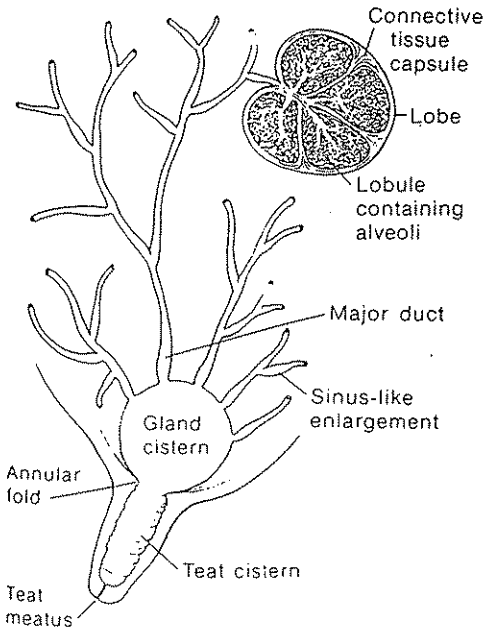


Figure nr: 1. A sketch of the duct system of one quarter (Schmidt 1971)

The teat cistern with the distal teat canal is located below the quarter cistern. The teat canal design is slightly conical in shape. The largest radius is near the quarter cistern (Johnston 1938, McDonald 1968b). Usually the rear teats have a larger teat canal diameter than the front teats.

The length of the teat canal is between 8 and 15 mm (Lefcourt 1982). During every lactation period the length and the diameter of the teat canal is increased, especially during the second lactation period (McDonald 1968a). To obtain an optimum flow of milk through the streak canal, the diameter of the teat canal should be about 2 mm during high flow (Williams & Mein 1980).

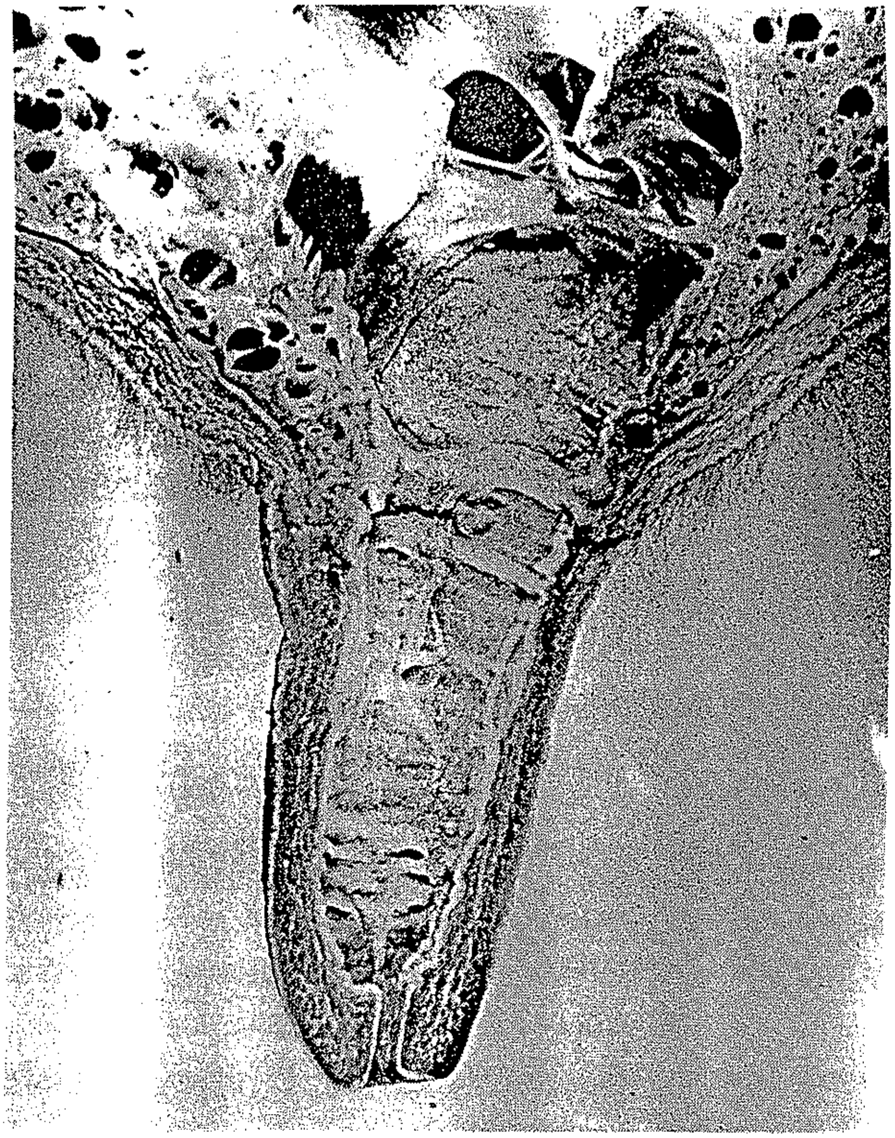


Figure nr: 2. section of the teat of bovine mammary gland (Schmidt 1971).

2.3 The muscle tone

2.3.1 Definition

Tone is a property of all muscles and is the result of neurogenic and / or myogenic activity control. The muscle is comprised of a contractile and an elastic element (fig.3). The tone is the momentary tension of the elastic element in the muscle. The contractile and the elastic elements in the muscle are able to act simultaneously, but they are also able to act independently of each other.

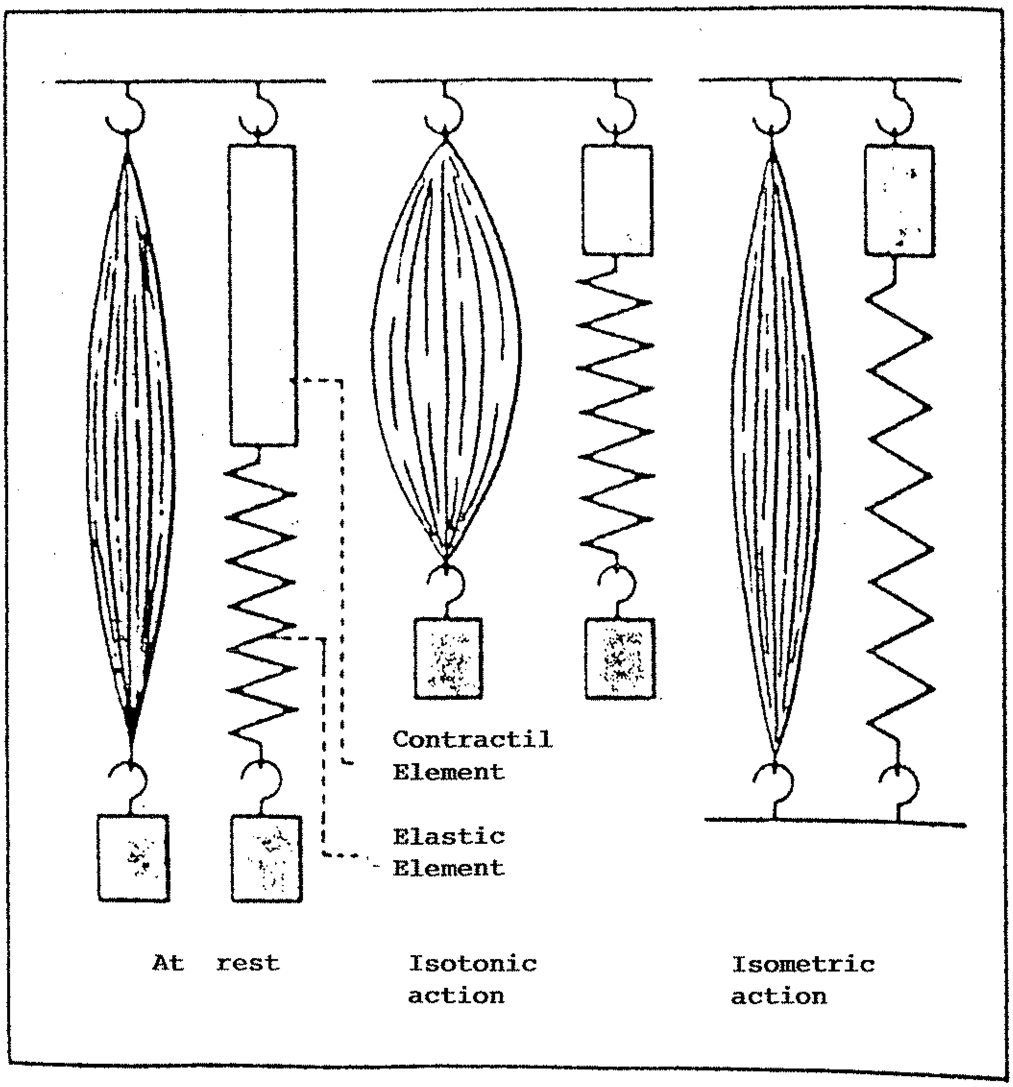


Figure nr: 3. The muscle during resting and contraction with the different elements (Szász-Jakobi, I.& Szász, I. 1968).

When only the contractile element acts, the muscle gets shorter and the tension remains constant. This contraction is called "isotonic" or equal in tone. Muscle activity without interference of elastic element happens only in tetanic muscle. The muscle gets shorter but the tone remains unchanged. Other synonyms for tetanic are striped, somatic or skeletal.

When the contractile element in the muscle does not act, but the elastic element is stretched, this action is called an "isometric" or equal in distance contraction and happens when the plastic contractile tone of a closed sphincter is dissolved. Such a pure isometric action is an exclusive property of smooth muscels. The classical smooth muscle action however comprises both elements.

A muscle can have a combined action of these two types of contraction. For example: when running or lifting a load. Such a combined action is also called "auxotonic contraction". The auxotonic contraction is a combined action which is devided into an initial isometric and following by isotonic contraction.

2.3.2 The differences between smooth and striped muscles

The contractions of the smooth muscles are weak and slow, but endurable. It is this endurability which can sustain the constant tension of the elastic element or a constant tone which is one of the main tasks of the smooth muscles. The smooth muscles preferentially act isometricaly and a change of the elastic element is always involved. The Smooth muscles are submitted to unconscious control carried out by the vegetative nerve system, i.e. nervous sympaticus and parasympaticus. Electrical excitement has almost no effect on the smooth muscle, while stretching might induce contractions.

The contraction of the striped muscle is fast and strong, but not endurable. It is easily excited by an electric current, but not easily excited mechanically. The striped muscle contractions are submitted to conscious control. They preferentially act by isotonic and auxotonic contraction.

2.4 Teat canal sphincter

2.4.1 Anatomical principles

The teat canal is composed of 5 to 7 convex epithelial projections which together form a star- shaped slit in when closed, and held closed by smooth circular sphincter muscles (Schmidt 1971).

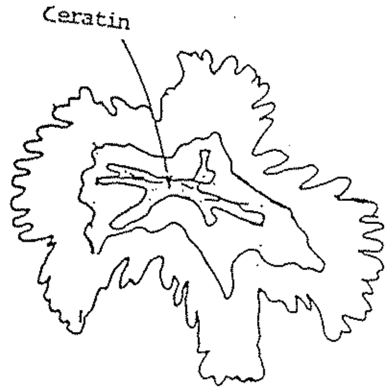


Figure nr 4. Cross-section of the teat canal. (Delwich 1981).

The TCS shuts an orifice like the rectal one. The area between the teat canal and teat wall and up to the udder cistern is furnished with smooth muscles. The muscle around the teat tip has a circular form which creates the sphincter. The muscle proximal to the Sphincter is straighter (Isaksson & Sjöstrand 1984).

After suckling or milking, the teat canal cannot close completely (Delwich 1981), and fresh keratin is rapidly secreted into the cavities of the teat canal(Williams & Mein 1980). Withholding keratin from the teat canal will render it almost defenceless against bacterial contamination (Delwich 1981).

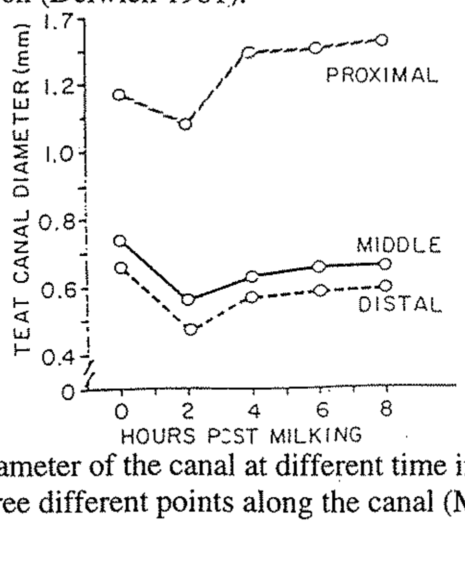


Figure nr 5. Mean diameter of the canal at different time intervals after milking. Measurements at three different points along the canal (McDonald 1975).

2.5 Functional models of smooth muscle activity in the teat

2.5.1 Between milk harvests

Rhythmic contractions have been observed in cows lying down, specially on those teats near the ground. These contractions have been observed more seldom on dry cows and never on heifers. The frequency of the contractions is higher directly after the cow has lain down and progressively decrease until they stop (Sambraus 1971). Lefcourt (1982) has proved that the frequency of spontaneous contractions increases with time after milking and that they can be 2 to 15 seconds apart. Eight hours after the last milking the contraction becames even longer than two minutes. Bernabè & Petters (1980) have observed the same kind of contractions after the application of oxytocin.

All these results demonstrate that rhythmic contractions occur when the tension in the muscle increases as a result of milk accumulation in the gland and teat cistern. The there on stretch - reactive contractions of the teat muscles are interpreted functionally as a relief of the sphincter, because they might pump back some milk from the teat- into the gland cistern.
A weak tone results in decreased ability of the sphincter to resist the pressure inside the teat cistern, so leaking of milk occurs between milking or suckling (Issaksson & Sjöstrand 1984).

2.5.2 During milk harvest - two models

Presence and function

Issaksson & Sjöstrand (1984) claim that there is no muscle activity during milking. The contraction appears after pre milking and udder preparation. After these contractions the teat becomes flaccid and milking can start. During this time the length and the width of the teat are increasing due to the milk which flows down from the gland cistern. The placidity of the teat remains for the whole milking or suckling.

Delwich et al. (1984) and Mayntz & Smårs (1987a and b) have opposed this theory. Independent from each other they showed that the flow-rate through the teat canal oscillated despite similar vacuum application (fig 6).

To prove that flow fluctuations are the result of muscle activity, Mayntz (1989) pharmacologically stopped the neurogenic as well as the myogenic activity in the TCS muscles. In one repetition a fluctationles milk flow of 6 ml/s was obtained on the treated teat, while on the control teat the milk flow oscillated around an average of 3 ml/s. This flow fluctuation occurs in conventional (Delwich et al. 1984) as well as in linerless milking (Delwich 1981, Mayntz et al.1990).

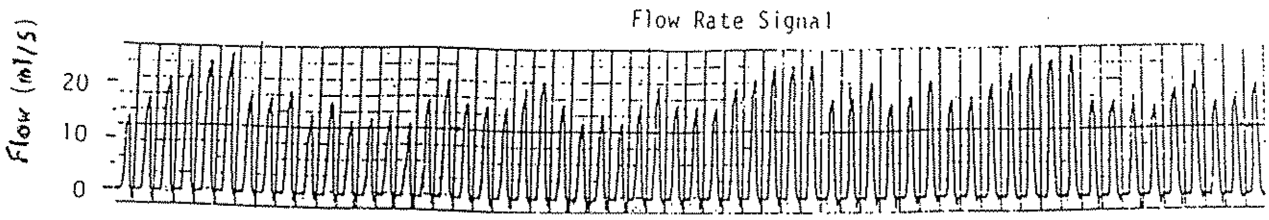


Figure nr 6. Milk flow oscillation on 1.0 Hz pulsation (Delwich 1981).

TCS activity during milking might have the following functions:

Auto stimulation

Smooth muscles in the teat wall are often found near the tactile nerve-receptors (Michel 1990). Therefore the muscle activity might result in an autostimulation.

Local circulation

Lefcourt (1982), Williams & Mein (1980) and Hamann (1990) noted that contractions of the smooth muscles may facilitate blood and lymph flow out of the teat walls in order to avoid teat congestion and oedema.

After milk

Ongoing activity of smooth muscle fibres at the proximal teat end might keep the passageway between the udder and the teat cistern open. Bothur & Wehowsky (1978) demonstrated that this passageway closes above the liner before the udder cistern is completely empty. The thereon following re-positioning of the teat cup higher on the teat keeps this closure permanent.

The closure mechanism

The teat canal is not completely closed after milking (Delwich 1981). Contractions of the teat have been observed directly after removing the opening forces (Williams & Mein 1980). The circular smooth muscle fibres around the teat ensure proper closing of the teat canal (Williams & Mein 1987).

2.6 Influence of milking technique

2.6.1 Forces applied to the teat

When the teat cups are applied to the cow's teats, the teats rapidly penetrate into the liner until they come to rest. The rest position is an equilibrium position which depends on the opposing forces in the liner. The forces which influence the teat are:

1. Vacuum inside the system which influence the liner to enfold the teat. This force is equal to

$$F = P * A \tag{1}$$

Where

F = The force [N]

P = The liner vacuum [kPa]

A = Cross-sectional area of the liner [m^2]

2. Gravity force which acts to pull the teat cups off [N].

3. Frictional force which is generated by the contact between the teat skin and the liner surface. This force limits the tendency for the teat cups to climb higher or to slide off during the milking. [N].

All these forces expose the teat to a shear-stress (Mein 1990).
The pressure on the teat skin is directly proportional to the vacuum level and the area in the liner as point 1 shows above. A vacuum of 50 kPa which is the level of the conventional milking technique today and a liner of 23 mm inner diameter, expose the fibrous layer in the teat skin to about 200 kPa stress and to a certain degree of stretching. A penetration of the teat into the liner by at least 20 mm, is necessary to open the teat canal (Mein 1990).

2.6.2 Effects on the teat canal

Hamann (1990) has shown that the wall thickness of the teat is different after machine milking compared to hand milking or calf suckling. After hand milking or calf suckling, the wall thickness decreases 6 to 9%, and takes 30 min to come back to its initial level. Machine milking with conventional liners increases the teat wall thickness 27% and it took 1 to 2 hours to get back to the initial wall thickness.

2.6.3 Effects on the instantaneous milk flow

The flow in the teat canal can be compared to a flow through a circular cylinder (Thompson 1978). In this case Poiseuille´s law can be used:

$$\frac{dq}{dt} = \frac{\pi}{8} * \frac{r^4}{\eta} * \frac{\Delta p}{l} \qquad (2)$$

Where:

$\frac{dq}{dt}$ = Volume of flow per unit time [m^3/s]

Δp = Pressure difference across the teat canal [Pa = $N*m^{-2}$]

η = Coefficient of viscosity [Ns / m]

l = The length of teat canal [m]

r = The radius of the teat canal [m]

If the TCS reacts during milking, then the following formula can be use for instantaneous milk flow:

$$\frac{dq}{dt}_i = \Delta p * t_i \qquad (3)$$

Where:

$\frac{dq}{dt}_i$ = Volume of flow per unit time at time i [m^3/s]

Δp = Pressure difference in the teat canal [Pa]

t_i = The tone in the muscle at time i.

So if the flow rate through the teat canal differs between consecutive applications of a constant pressure difference, probably the diameter of the teat canal was different. Following these assumptions it is likely that the sphincter's action is controlled nervo- and / or myogenically at least partially independent from external physical conditions. Smooth muscle activities however, always comprise a change of tone.

Pressure differences can be applied to the teat by varying both form and frequency. Mayntz & Smårs (1987a) compared three extreme vacuum profiles which were applied to the teat in linerless milking. Two different edges of pulsation were used. The results obtained showed that the flow in the three-edged pulsation was about 1.7 times higher than flow in the four-edged pulsation. The most appropriate frequency throughout the synchronising experiment was, according to Delwich et al. (1984), somewhere between 0.1 and 0.3 Hz. These results denote that a higher flow can be reached with the same pressure difference if the vacuum is applied when the smooth muscle is relaxing. Muscle contraction however decreases milk flow. Consequently, the flow rate is not only a result of pressure difference and the teat canal diameter, but it is the result of pressure difference and a teat canal diameter which changes instantaneously along with changing contraction and muscle tone.

A further experiment carried out by Mayntz et al. (1990), showed that the optimal frequency might be 0.12 Hz. The function of the vacuum level is to open the streak canal and to transport the milk through it. The lowest vacuum level for milk transport was 18 kPa, if the teat canal is open enough, while the vacuum pressure needed to open the canal is around 35 kPa (Mayntz et al. 1990). To allow a complete contraction, the length of the massage phase is 3 to 3.5 s compared to 0.15 s in the conventional system's massage phase.
The Mayntz et al. (1990) experiments showed which type of pressure increase might fit any tone. A rapid pressure increase was more suitable for a low tone in the sphincter, while a slow pressure increase was suitable for a high tone in the sphincter.

2.6.4 Role of pulsation

Pulsation of the liner has the following functions:

1. To limit the development of oedema and congestion in the teat during milking (Hamann 1990).

2. Maintain a high of milk flow rate from the teat within each pulsation cycle (Williams et al. 1981)

3. Counter the possible ill-effects of pain on the cow (Thiel & Mein 1977).

4. Counter the possible ill-effects of the milking vacuum on teat lesions (Mein et al.1983).

5. Counter the possible ill-effects of high milk velocity through the teat canal Williams & Mein 1980).

6. Stimulate milk ejection (Whittlestone 1978).

7. Effect the keratin level and quality (Williams & Mein 1980).

8. Stimulate (Woolford & Phillips 1978).

A milking technique which stimulates and supports muscle activity during milking, might dispense with the need for some of these functions, with muscle activity.

2.7 Measurements of sphincter tone

2.7.1 Measuring forces or distances

The streak canal has been expanded in a mechanical way in two different experiments. Stettler (1973) has used an instrument of cylindrical shape and divided into four equal parts. The diameter of the cylinder could change between 2.0 and 4.0 mm. The instrument was inserted into the streak canal and the forces which were needed to expand the canal were registered. The measurements were made on rapid stretches as well as on slow stretches of the streak canal.

The second experiment was carried out by Williams & Mein (1980). With the help of an instrument, tiny probes were placed in the streak canal and then drawn apart from each other. The forces and the distances between the probes were measured. The results of the experiment are shown in fig 7. The tension is a membrane constant with the expression unit force / length unit. A peak tension of up to 70 gr/cm has been registered during a teat contraction. This corresponds to an increase in pressure within the streak canal of 20 to 30 kPa. The conclusion which Williams & Mein (1980) drew from the experiment was that the contractions task is to shut the streak canal whenever the opening forces are removed.

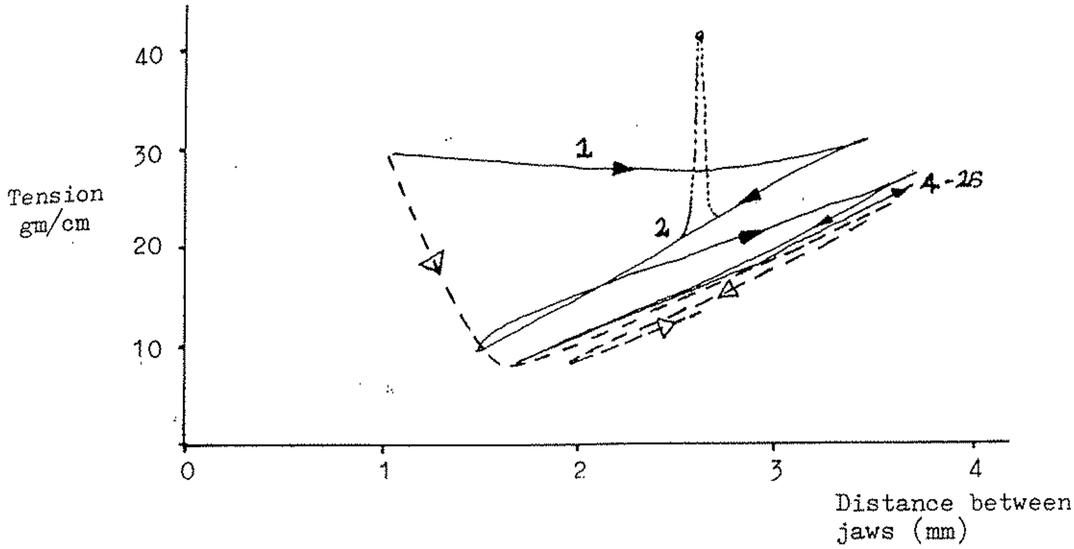


Figure nr 7. Length- tension plot for a typical teat canal Before milking(solid line) and after milking (dashed line). The contraction is represented by the dotted line. (Williams & Mein 1980)

The smooth muscle in the bovine teat react with contractions on a stretch. The results based on muscle stretching might be influenced by is reaction. Williams and Mein(1980) could even register these contractions (fig 7).

2.7.2 Measurement of pressure thresholds

Espe & Canon (1942) carried out an experiment with an ordinary blood pressure device. The pressure cuff was modified to fit the cows teat. A rubber line squeezed the base of the teat to prevent the milk from flowing back into the udder cistern, then the cuff was attached around the teat. The cuff was pumped up until a squirt of milk came out of the steak canal. The pressure was recorded when the milk appeared. The pressure that the cuff applied to the teat is probably the same as the pressure which is needed to open the streak canal.

The use of a blood pressure device for measuring the pressure threshold proved to be a method in which it was difficult to repeat the results. The reason for this difficulty was the squeezing of the teat at the teat base with the rubber line. This squeezing could possibly change the reaction in the tissue because of the influence on the local circulation (Espe & Canon 1942).

A second method was used by Mein (1987) to investigate how much pressure is applied by the collapsing liner on the teat canal. In this experiment, a thin probe was fastened at the opening of the teat canal with the help of glue. A hose that was three meters long was connected to one side of the probe. The hose was pulled through a hole in the short milking tube and filled with milk. The teat cup was applied to the teat with the liner kept in collapsed position. The other end of the hose was lifted until milk from the hose flowed into the teat. The height which was needed to open the streak canal is converted into pressure according to Bernoulli's theory:

$$P = \rho * g * h \tag{4}$$

Where:

P = The pressure in the teat canal [kPa]

ρ = Milk density =1012.5 [kg/m^3]

g = The gravity force [m/s2] = 9.82

h = Difference between fluid level [m]

The pressure needed to open the streak canal varied between 5 to 12 kPa. The conclusion from this experiment was that the main advantage of the pulsation is in collapsing the liner, to create a massage on the teat of 10 kPa during 0.15 sec.

2.7.3 Measurement of the pressure variations

Lefcourt (1982) has used two different pressure transducers to measure the pressure variations in the teat canal. The measurements were made for twenty minutes, and measurements were taken at 0, 3, 4, 5, 8, and 15 hours after the last milking-session. The measurements showed spontaneous contractions in the sphincter which varied between 0-20 contractions per minute. The frequency of contractions increased with time after milking. Furthermore, Lefcourt observed that the contraction were peristaltic and a touch or squeezing the tip of the teat were resulted in more contractions in the teat cistern.
To insert an instrument into the teat canal, as this technique demands, possibly result in a stretch - reactive muscle contraction which could influence the results.

2.8 Critical evaluation and conclusions

Hygiene problems

The main problem is maintaining hygiene during the measurements. All the measurement methods, with the exception of Espe and Cannon's method (1942), involve the introduction of foreign objects into the teat canal. There these methods are linked to hygiene problems.
The risk is even greater with the pressure threshold method which Mein (1987) used. The fluid which is injected into the teat may itself be colonised or transport pathogens from the distal parts of the teat canal into the teat.
Ideally to minimise the risk of introducing pathogens into the teat canal, only methods which do not introduce foreign object into the streak canal should be used.

Risk of artefactual results

In all the methods described in this essay where a foreign object is introduced into the teat canal, this might influence the result. Smooth muscles react to stretching with contraction, which in an isometric contraction results on changes of the tone in TCS. Williams & Mein (1980) could also record such an event(fig. 6).

Technical difficulties

The measurement method described by Mein(1987) demands a straight line between the probe and the teat canal. The probe has to be an extension of the teat canal. Most teat canals however are not directed straight downwards. The real direction of an actual teat canal is unknown.

The problem with Espe and cannon's methods was fitting the cuff to the teat. The problem can be explained by variation of the size of the teat cistern among cows. This method is suitable only on cows with long teat cisterns and with enough space for the blood pressure device as well as the rubber line which prevents the flow of milk back into the udder cistern.

Problem with interpreting the results

Every individual has its own specific tone which is dependent upon age, yield, lactation phase stadium, breed and heat cycle. Therefore a registration e.g. after milking does not represent an absolute value but a momentary value related to the actual individual.

This problem can be solved in two different ways:
The first way is to obtain a long series of measurements, so that a mean tone can be calculated. Than all measurements can be compared to this mean tone.

The second way is to take relative measurements e.g. on one quarter before and after a milking. In this case only the differences between two measurement would be taken in evaluation.
The effect of a treatment would be reflected in the size and direction of the difference.

3 Design of the new measuring method

3.1 Principles of function

The device has been designed to fit the teat and to facilitate easy handling. The construction of the device, and the principles used in its construction and use, are shown below:

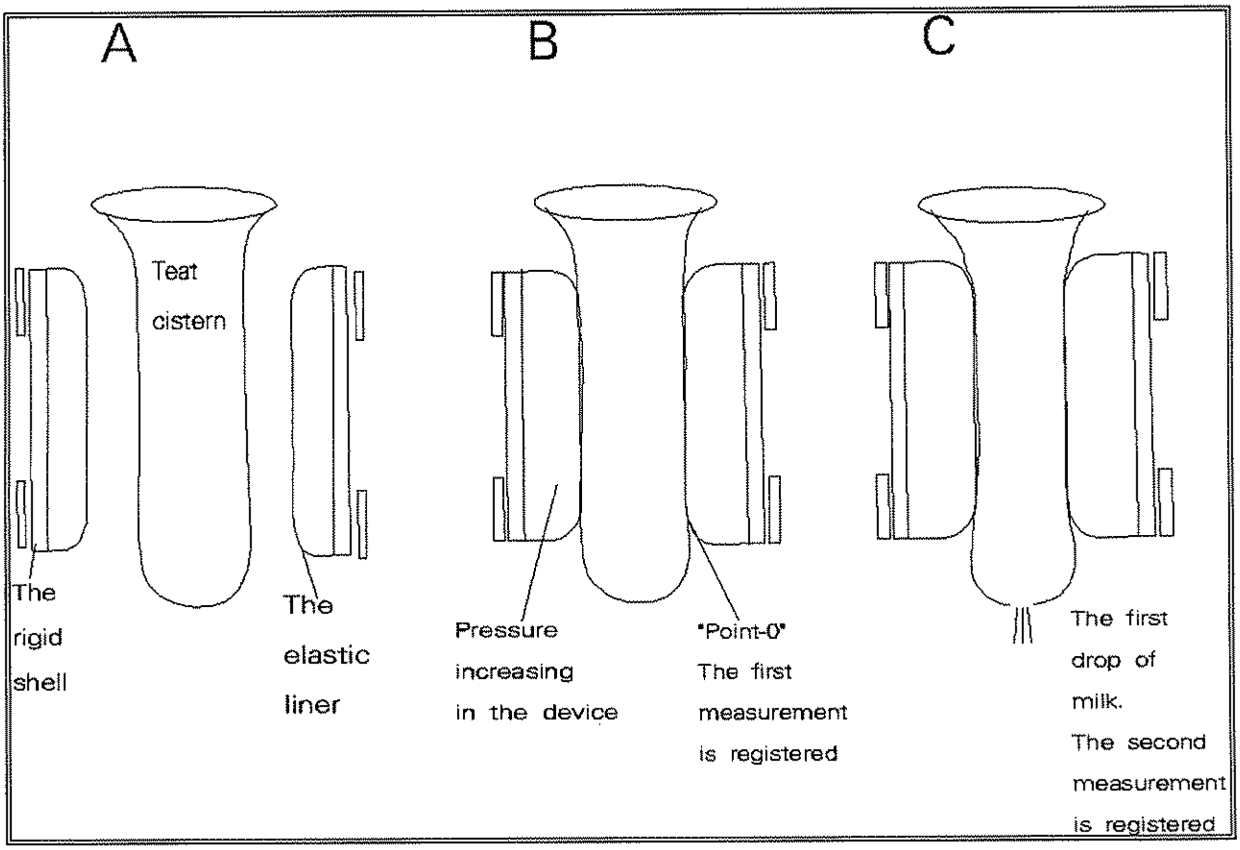


Figure no: 8. The measurement principle of the device.

A. The initial phase
The pressure in the device begins to increase between the rigid shell wall and the elastic liner. In this phase, the device can still be moved up and down along the teat i.e. there is no friction between the teat wall and the elastic liner.

B. The active phase
The pressure in the device increases to the point where contact is established between the elastic liner and the teat wall. The device can no longer move vertically along the teat. This is also called "point 0", and the first recording of pressure in the device is made.

C. The end of the active phase
When the first drop of milk appears the second registration of pressure in the device is taken.

3.2 Hardware

3.2.1 The elastic liner

The following materials were tested for use as the elastic liner:

1. Condoms

The condoms were transparent, but expanded very quickly in all directions even when several layers were used.

2. Gloves

Surgical gloves and ordinary rubber gloves lost their shape and elasticity after the first use.

3. Latex

Latex tubes with wall thickness varying between 0.2 mm and 0,8 mm were tested. The result was an unwanted expansion above and below the rigid shell wall.

4. Cycle tube

Even though the cycle tube is not transparent it proved to be the best material in all other respects.

The uncertainty concerning the "point-0" is taken care of by the fact that during one experiment, only one single person handles the device.
Before using the cycle tube for measurements, it proved to be necessary to expand it several times in order to overcome the initial changes of elasticity of that type of material.

3.2.2 The rigid shell

The rigid shell was made of metal. The length of the rigid shells used in experiment was 37 mm with an inner diameter of 46 mm (fig 9).
The two openings in the rigid shell control the pressure inside the device.
The pressure/vacuum opening is connected to the source of pressure and to the transducer at the electronic box. Even quick releasing of pressure in the device to the vacuum pressure at the milking machine goes through this opening.

The second opening is equipped with a pressure release valve which is controlled by the long finger. This opening is specially constructed to release very small amounts of air pressure each time the control is pushed. The amount of release compressed air is dependent upon how long time the spring on the opening is pressed.

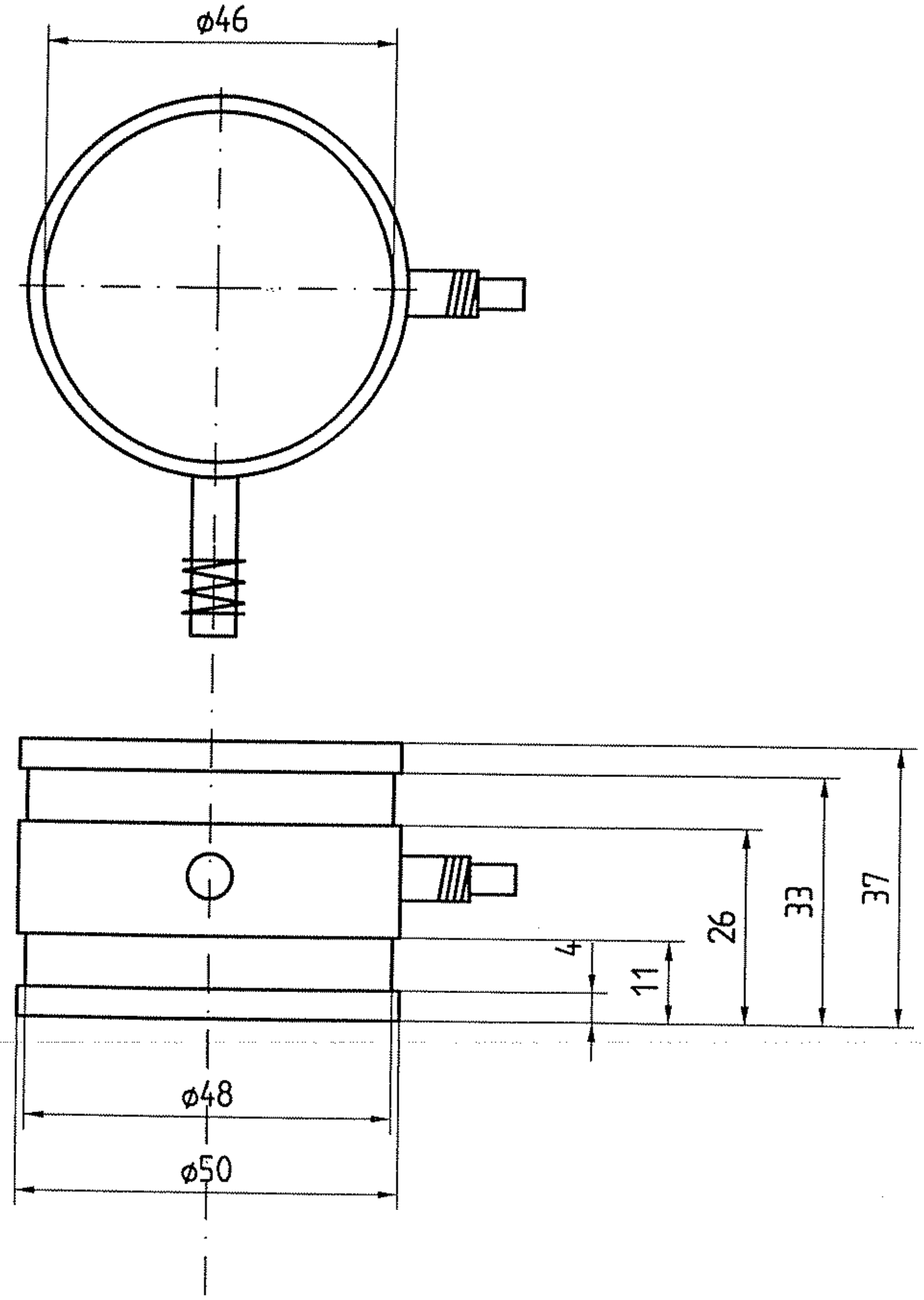


Figure no 9: The rigid shell

The two grooves on the upper and the lower end of the rigid shell hold the folded elastic liner in place with the help of two clamps the same size as the groove. These grooves both facilitate experimental use as well as tightened function.

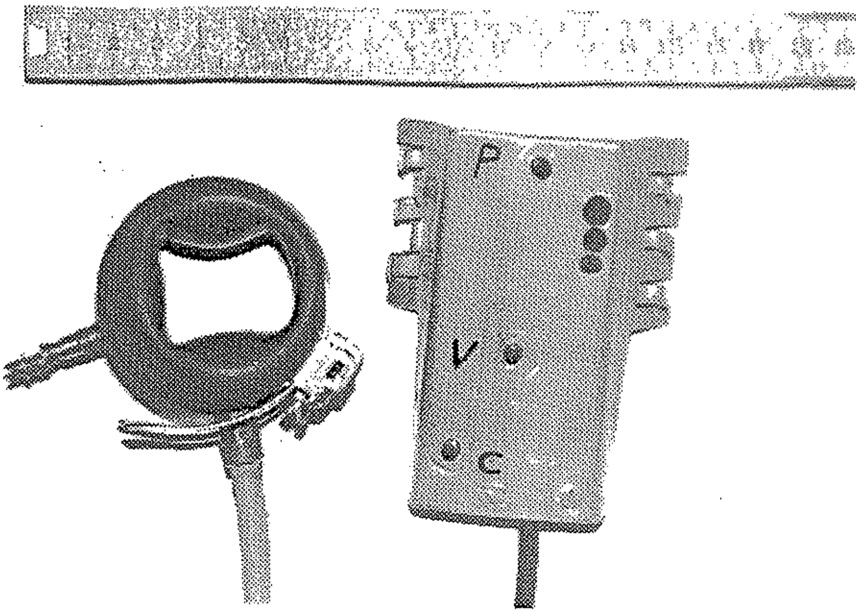


Figure nr: 10. The liner in open condition separated from the handle

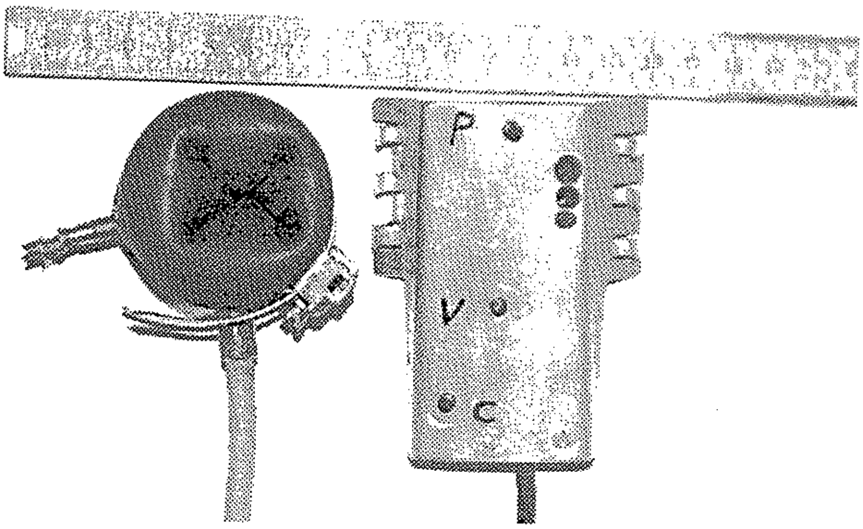


Figure nr: 11. The liner in closed condition separated from the handle

3.2.3 The handle

An ergonomic handle was designed for facilitate the experimental use. A mirror has been placed on a lower part of the handle. The position of the mirror is under the rigid shell in order to help the user to see the elastic liner and the teat during measurement. The mirror can help the user to see when to start or to stop a measurement (fig.12)

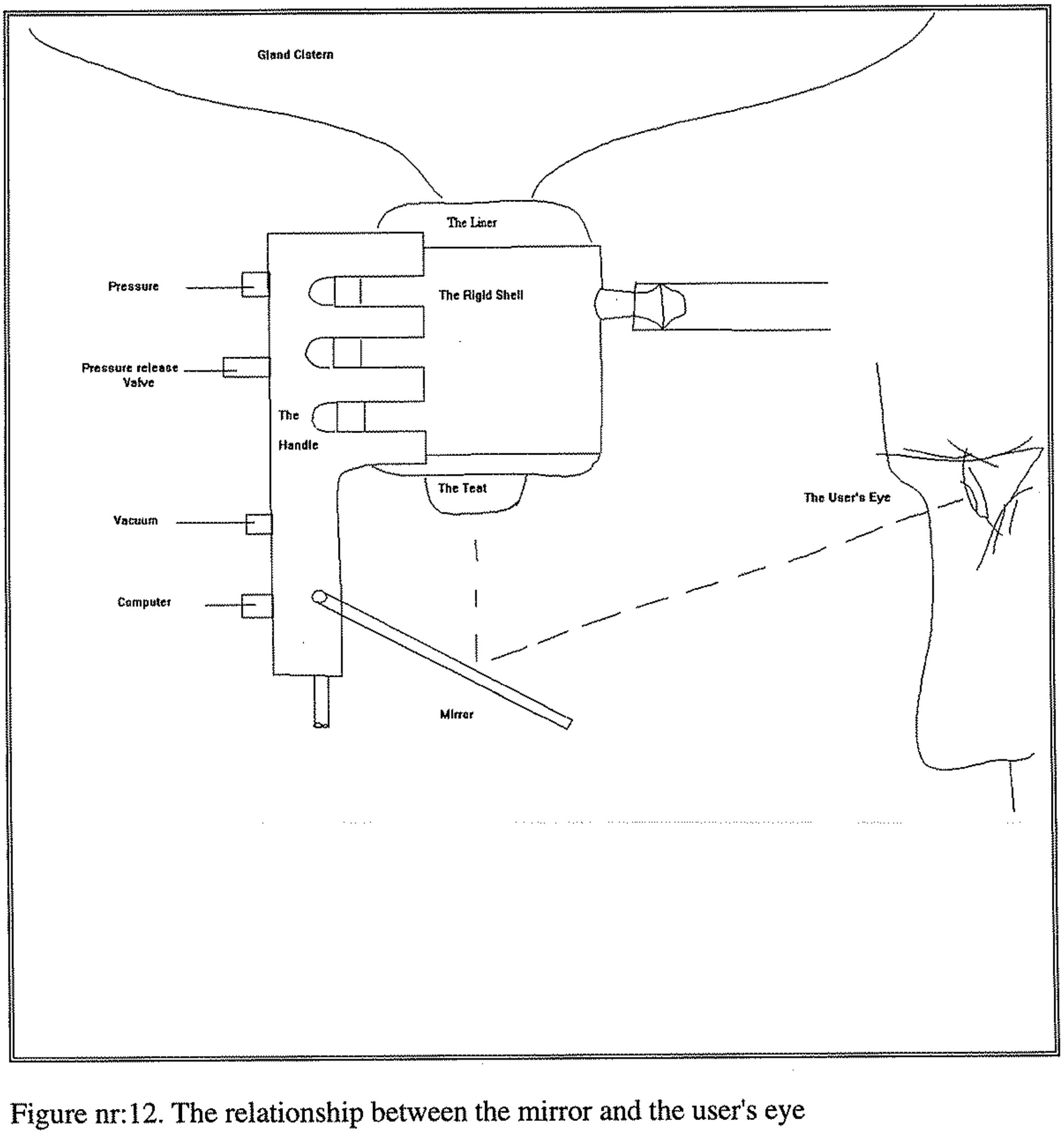


Figure nr:12. The relationship between the mirror and the user's eye

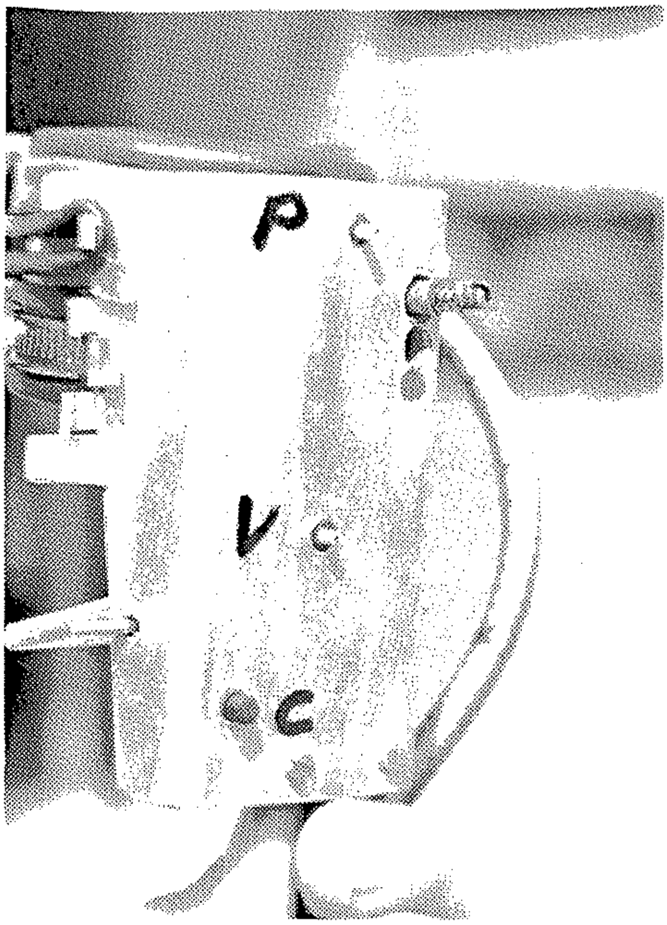


Figure nr 13. The handle

The upper button [P] on the handle is used to increase pressure in the device and is controlled with the index finger. This button works as an on/off switch. The pressure increases as long as the button is depressed and the process is stopped when the finger is removed from the button. The button works in conjunction with the Pressure/Vacuum opening on the rigid shell.

The middle or second button[V]is a vacuum button and be pressed by the middle finger. When pressing this button, all pressure is released immediately from the device from the Pressure/Vacuum opening .

The lower or third button [C]on the handle is used to send a signal to the computer indicating the first or final registration of pressure in the device. This button is controlled by the ring finger.

The handle itself is mobile. It can be attached to any rigid shell with the same diameter by two rubber bands. The handle and its component buttons are waterproof.

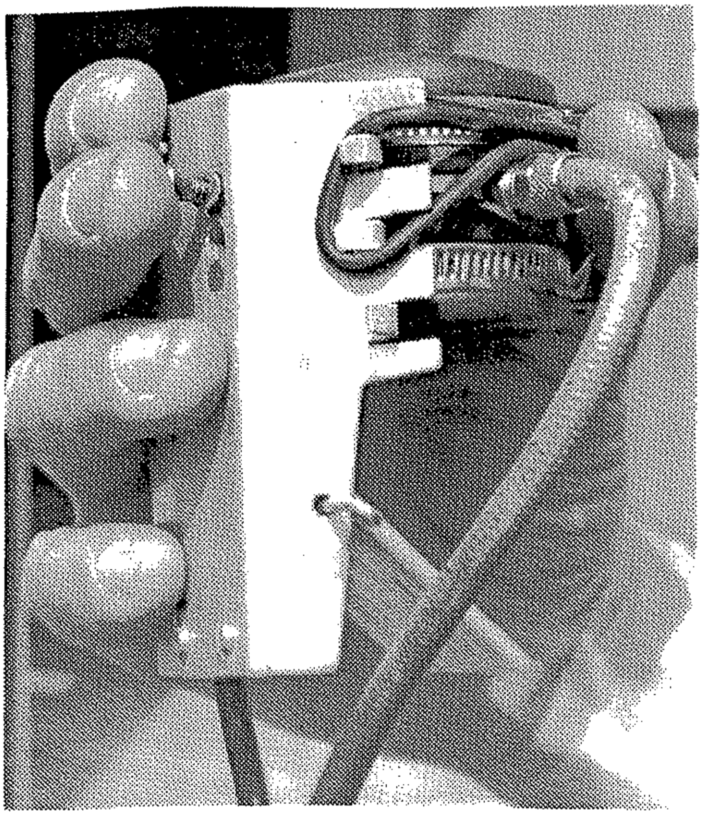


Figure no 14: The handle and the user's fingers.

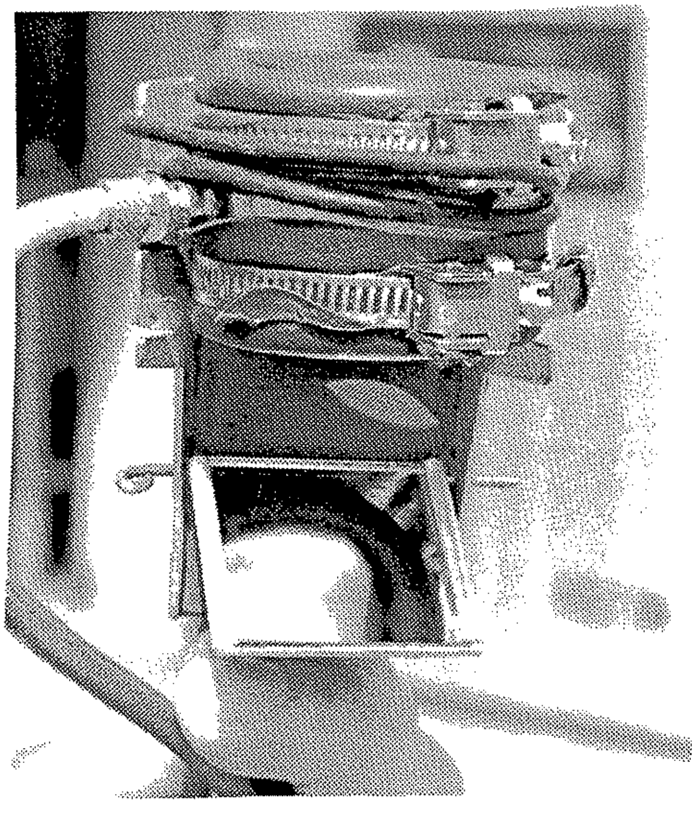


Figure no 15: The handle together with the device

3.2.4 Auxiliaries

A reference pressure transducer (RPT) is placed on the device. The RPT is a temperature compensated transducer and can be use as a control unit for calibration during intensive experimental use or during laboratory test. The RPT is connected to an IBM compatible PC with a special Analogue / Digital converter card.

The other parts of the equipment are a computer, compressor and 12 volt battery. The compressor is used as the source of compressed air, but a gas bottle can be use instead.

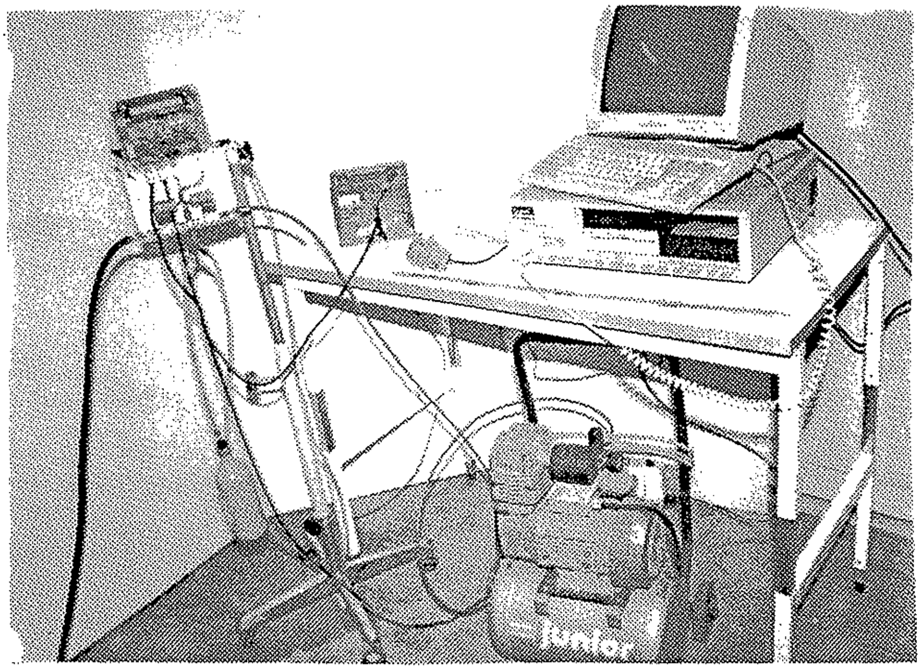


Figure no: 16. The complete measuring equipment fully essembled.

3.3 Software

The software for the equipment was written in Turbo Pascal. All programs are listed in appendix 1. All programs are user-friendly and have been modified during the development.
The followings programs were used with the equipment:

Program	Function	Need
Before measurements:		
1. Voltmeter.pas	For calibration of the RPT	analogue / digital card in the computer
2. Diagram.pas	For calibration of the device	analogue / digital card in the computer
During measurements:		
3. Sphincter. pas	The main program during measurements	
After measurements:		
4. Show. pas	To read the results from the measurements	

The program "Voltmeter.pas" allows the user to calibrate the RPT against a known pressure. The advantage by using the calibration of the RPT is to avoid using of Mercury Manometer in the bar.

The program "Diagram.pas" Shows two graphs on the screen and even prints out the diagram.
These programs are used both in laboratory testing and in the intensive measurements period. During the laboratory test the program shows the first graph as the pressure in the device, while the second graph shows the pressure in the laboratory teat. During an intensive measurements period the second graph shows the pressure in the RPT. If the device is calibrated, only one graph is shown on the screen and the measurement can start.

The "Sphincter pas" program is the program which is used during measurements. Before starting a measurement, the program asks the user the treatment, Cow number, Teat location. Time and date are shown automatically but can be changed if so desired. The program stores the first and second measurements and saves the results in another file (.DAT) in the computer hardware. The program sends all the signals to the computer port and guarantees that all signals originating in the measuring device arrive safely at the computer.

The program "show.pas" can be use when necessary to pick the results of the measurements.
The information is accessed according to a treatment number.
The user can easily change the result file i.e. according to date or treatment.

3.4 Operation

3.4.1 Pressure regulation

The tube with compressd air is comes from the compressor to valve nr one which is located under the electronic box (fig.17) (see also appendix 3). This valve controls the amount of compressed air that comes into to the device. The amount of compressed air can be easily adjusted as the wish of the user.

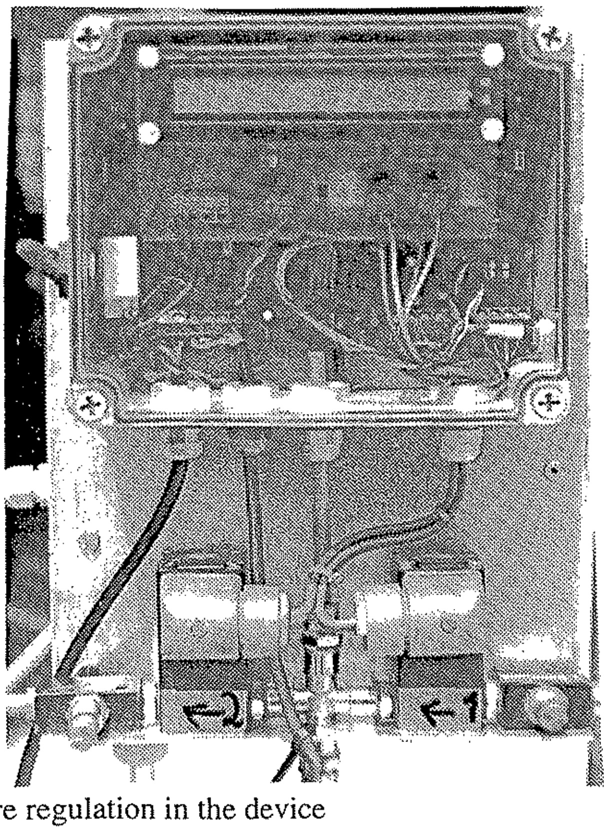


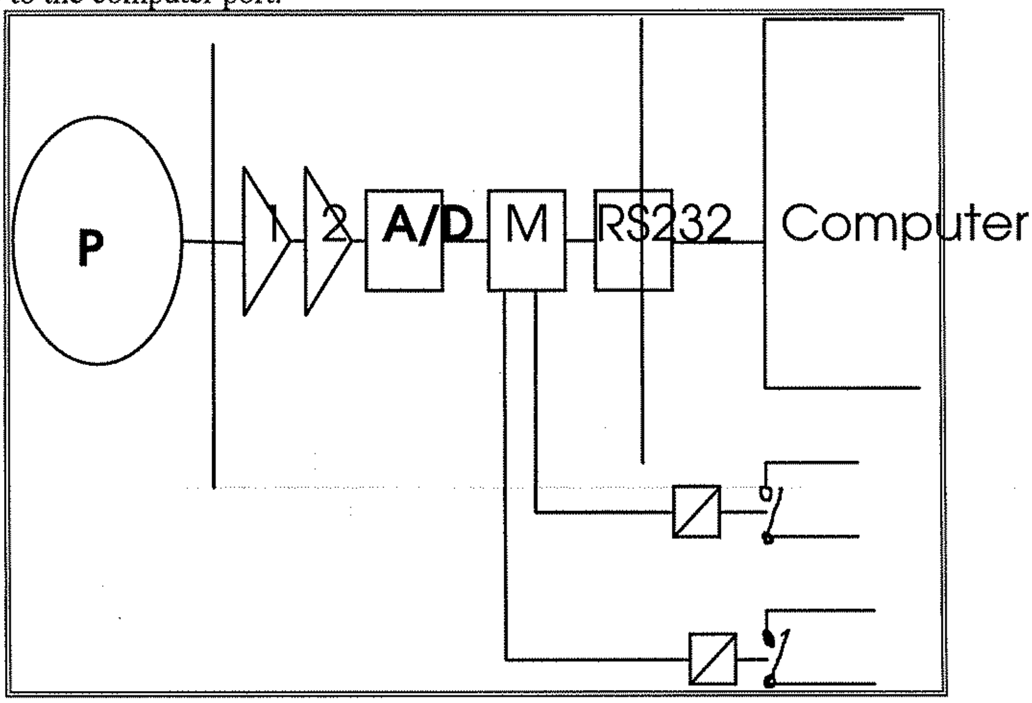
Figure nr: 17. Pressure regulation in the device

Valve nr two is a release valve. This valve release the pressure in the device instantaneously, at the end of each measurement or when otherwise desired by pressing the vacuum button on the handle. The valve is connected to a vacuum line in order to facilitate the instantaneous release of pressure and to maximise the inner diameter of the elastic liner.

3.4.2 Electronic regulation

A short description of the electronic regulation is given in fig. 18. A detailed description is given in appendix 2.

The amount of pressure that exists between the elastic liner and the rigid shell is transmitted to the pressure transducer (p) (see appendix 5) by an analogue signal. From the pressure transducer, the signal is amplified with the help of two amplifiers (1 and 2) in order to insure an offset adjustment. After the offset adjustment, the analogue signal is converted to a digital signal in the analogue-digital converter. A digital signal is then sent from the converter to the micro-processor which sends the results to the computer port.



Where:

P = Pressure transducer
1 & 2 = Amplifiers
A/D = Analogue / Digital converter
M = Microprocessor
Rs 232 = Communication

Figure no: 18. A diagram of the electronic regulation.

4 Calibration of the measuring device

4.1 Materials and methods

4.1.1 The reference pressure transducer

In order to prepare the measuring device for calibration, another pressure transducer has been used. The transducer of type MPX5050DP (see appendix 4) is temperature compensated and has been fasted on the back side of the measuring device. The reference pressure transducer has been connected to the analogue/digital card in the computer, and it even gets the supply voltage from this card.

The reference pressure transducer has been connected parallel with the rigid shell so the same pressure affects both, the pressure transducer on the measuring device as well as the reference pressure transducer. The reference pressure transducer as well as the pressure transducer in the device has been calibrated against an Hg manometer. When the reference pressure transducer was calibrated, the calibration of the measuring device could start. When the measuring device showed the same pressure as the reference transducer, the calibration was acceptable.

4.1.2 The laboratory teat

In order to establish a function between the increase of pressure in the device and the increase of pressure in the teat, a laboratory teat was used (fig. 19). The laboratory teat had a shape of a solid cylinder. The length of the experimental teat could be varied with the help of special claim while its inner diameter was 27 mm. The reference pressure transducer was connected to the experimental teat by a special rubber plug. Two metal probes were fitted to the plug. The first probe connected the experimental teat with the reference pressure transducer. The second probe was equipped with a one way valve and served for water injection in order to establish an initial pressure in the laboratory teat.

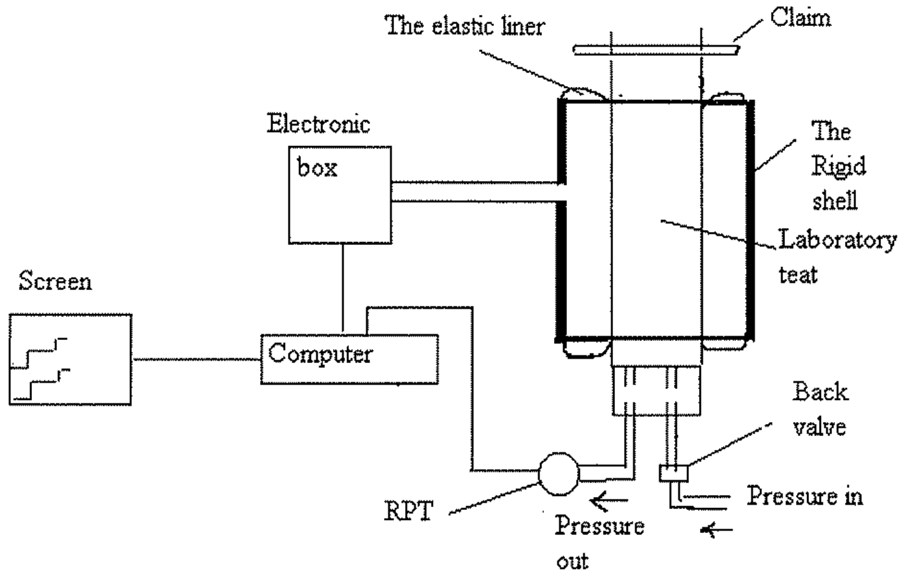


Figure nr:19. A sketch over the laboratory teat with the device

4.2 The laboratory test

The length of rigid shell was kept constant at 37 mm while the length of the laboratory teat was 60, 80 and 100 mm. Two different initial pressures inside the experimental teat were used in order to imitiate different diameters of natural teat. The lower initial pressure was kept as close to atmosphere as possible while the higher initial pressure was randomly chosen.

4.2.1 Carrying through

The rigid shell was placed around the laboratory teat and the pressure inside the device was increased until the contact between the elastic liner and the laboratory teat was established. The device could no longer be moved vertically along the experimental teat. This was the " point-0". From this moment the pressure increased in the laboratory teat when it was further increased in the device. The pressure between the rigid shell and the elastic liner as well the pressure inside the laboratory teat was shown on a graph.

Every test was repeated three times with the same initial pressure at a given teat length. The only differences between the three repetitions were the sizes of pressure increase in the device.

4.2.2 Correction of data

The pressure -increase in the device after "point-0" is the independent (X) while the consecutive pressure increase in the teat is the dependent variable (Y)
The Initial pressure at "point-0" in the teat in vivo is unknown and unmeasurable. Therefore all registration from the laboratory test had to be corrected before evaluation:

$$X_c = X - X_{(\text{"point-o"})} \tag{5}$$

$$Y_c = Y_{(m)} - Y_{\text{initial}} \tag{6}$$

Where:

$Y_{(m)}$ is the average of 5 independent registrations of y

4.2.3 The statistical model

If the thinking behind the correction of data was right, the pressure increase in the device should remain the single significant source of variance for the pressure increase in the teat..
All corrected data were subjected analysis of variance, by using the General Liner Model (GLM) of SAS (1990) program. The following model was applied for the analysis of variance

$$Y_c = \mu + \tau + \lambda + \pi + \varepsilon \tag{7}$$

Where:

Y_c : the pressure increase in the teat
μ : mean value
τ : pressure increase in the device
λ : length of the teat
π : initial pressure in the teat
ε : error

As a result of the data processing by GLM the length and the initial pressure of the laboratory teat became not significant for the laboratory test.

Class	Levels	Value
Length	3	6 8 10
P	2	1 2

Number of observations in data set = 615

Dependent Variable: YC

Source	DF	Sum of Squares	Mean Square	F-Value	Pr > F
Model	9	6878.24667	764.24987	5076.93	0.0001
Error	605	91.07301	0.15053		
Corrected Total	614	6969.32187			

R-Square	C.V.	Root MSE	YC Mean
0.986932	9.433317	038799	4.11294

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Xc	1	195.727275	195.727275	1300.22	0.0001
Xc^2	1	82.821525	82.821525	550.19	0.0001
Length	2	0.050420	0.025210	0.17	0.8458
P	1	0.389141	0.389141	2.59	0.1084
Xc*Length	2	13.708203	6.554101	45.53	0.0001
Xc^2*Length	2	0.67424	0.337122	2.24	0.1074

The reason for the unlinearity (X^2) in the model can be explained as an effect of the spherical form of the liner during expansion, and the difference between the inner and outer radius of the elastic liner (Fung 1977).

After backward elimination the final model became:

Number of observations in data set = 219

Dependent Variable: YC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	8607.65672	4303.82836	87744.27	0.0001
Error	217	10.64378	0.04905		
Uncorrected Total	219	8618.30050			

R-Square	C.V.	Root MSE	YC Mean
0.998765	4.420954	0.22147	5.00959

Note: No intercept term is used: R-square is not corrected for the mean.

Dependent Variable: Yc

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Xc	1	242.442603	242.442603	4942.80	0.0001
Xc^2	1	57.305845	57.305845	1168.32	0.0001

	Parameter Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
Xc	0.1924864043	70.31	0.0001	0.00273788
Xc^2	0.0030439946	34.18	0.0001	0.00008906

The estimated regression became $Y = 0.1925*Xc + 0.0030*Xc^2$

The result has been inserted into a graph for depicting each length of the rigid shell and is shown in figure 20 below.

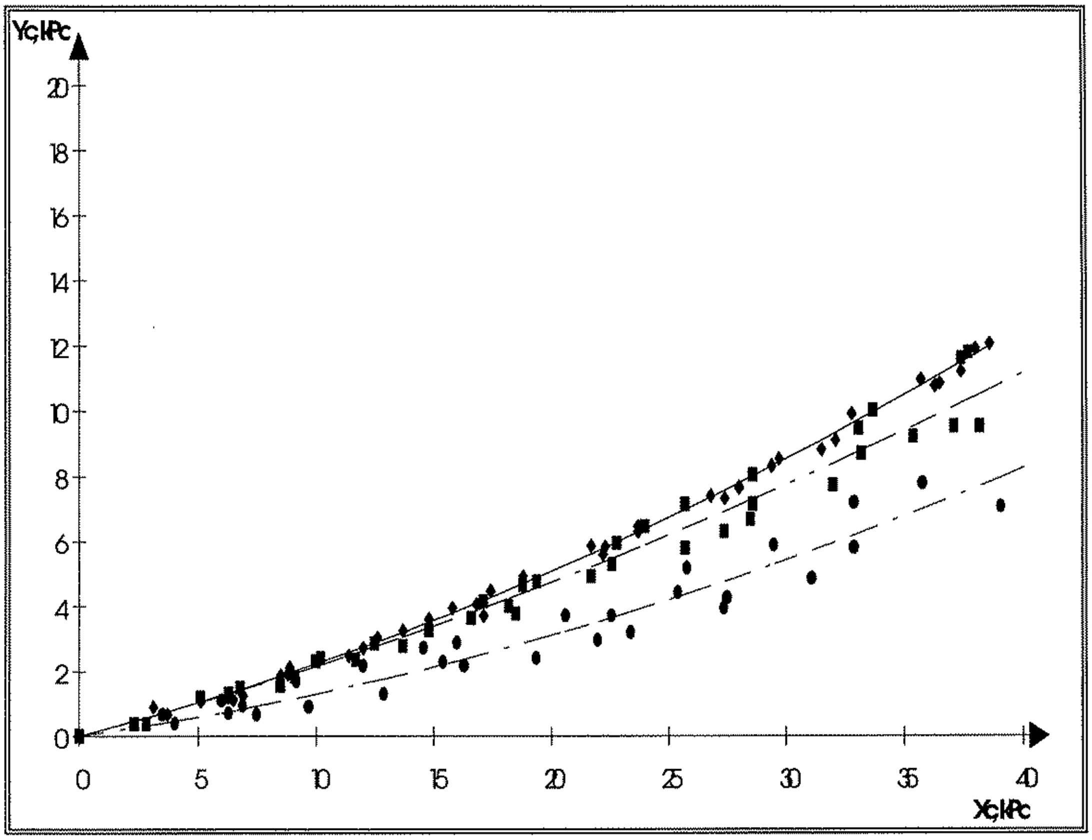


Figure no 20. The graph over the measured and calculated values on each teat length. Where:

(✧) Depicts the Y measured for the experimental teat with a length of 6 cm. The regression for this curve is Y = 0.1925*Xc+0.0030*Xc^2.

(▪) Depicts the Y measured for the experimental teat with a length of 8 cm. The regression for this curve is Y = 0.1946*Xc+0.0021*Xc^2.

(●) Depicts the Y measured for the experimental teat with a length of 10 cm. The regression for this curve is: Y = 0.1041*Xc+0.0025*Xc^2.

The regression for each teat length differed and the longer the teat, the slower is the increase of the regression curve. It was noticed that the part of the experimental teat which had no side support from the elastic liner, buldged out with increasing pressure inside.
Therefore a new laboratory test for the measuring device has been made but with an experimental teat exactly as long as the rigid shell. A new analysis of variance has been done for the second test with a the following result:

Number of observations in data set = 16

Dependent Variable: Yc

Source	DF	Mean Squares	Sum of Square	F Value	Pr > F
Model	2	956.5424329	478.27121	935.56	0.0001
Error	14	7.1569671	0.5112119		
Uncorrected Total		16	963.6994000		

	R-Square		C.V.	Root MSE	YC Mean
	0.992573		11.25748	0.714991	6.35125000

Source	DF	Type III SS	Mean Square	F- Value	Pr > F
Xc	1	35.59632188	35.59632188	69.63	0.0001
Xc^2	1	1.53771247	1.53771247	3.01	0.1048

Parameter	Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
Xc	0.3013934927	8.34	0.0001	0.03611867
Xc^2	0.0021683677	1.73	0.1048	0.00125025

The final calibration curve for the device became (fig. 21):

$$\mathbf{Y = 0.3014 * Xc + 0.0022 * Xc^2} \qquad (8)$$

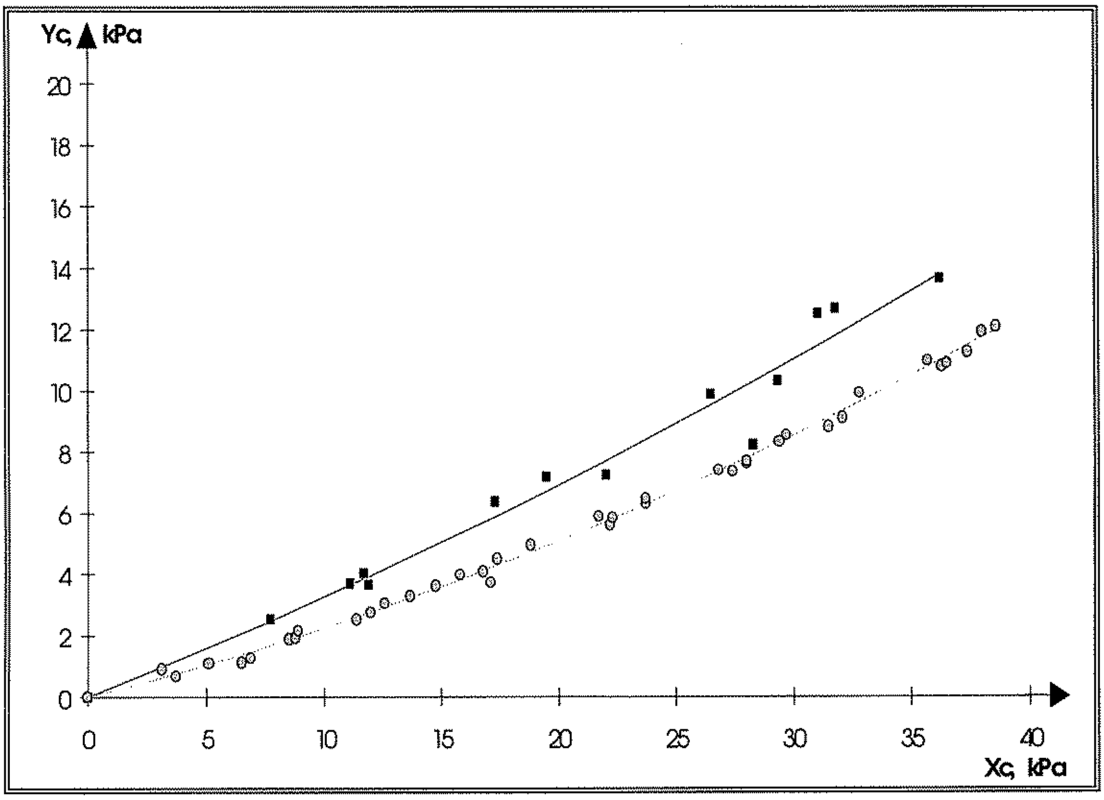


Figure no: 21. The calibration curve from the same length of rigid shell as the experimental teat, compared to the old result with a longer experimental teat than the rigid shell.

Where:

The straight line depicting the final calibration curve for the device.
$Y=0.3014*Xc+0.0022*XC^2$

(▪) Depicts the measured values from the new test with the same length.
The dotted line depicting the old calibration curve with a longer experimental teat then the rigid shell.

(●) Depicts the measured values from the old test with a longer experimental teat then the rigid shell.

4.3 Discussion

Even the final calibration curve remains non- linear. Therefore the actual " point- 0" value during an experiment must be stored in order to calculate the correct pressure increase in the teat.

To avoid the unwanted expansion during measurement in practical experiment, the tested teat has to be about 3 cm longer than the rigid shell. The tested teat has to be closed on the teat base above the rigid shell to prevent milk from flowing back to the udder cistern, while the teat canal have to be free from the liner pressure to avoid shutting off the teat canal. This method uses the hand for shutting the passage way between the udder and the teat cistern (fig 21). This is done in order to:
1. Minimise the influence on local blood circulation, especially the veneous one and,
2. To be able to judge during measurement whether the blockage was successful or not.

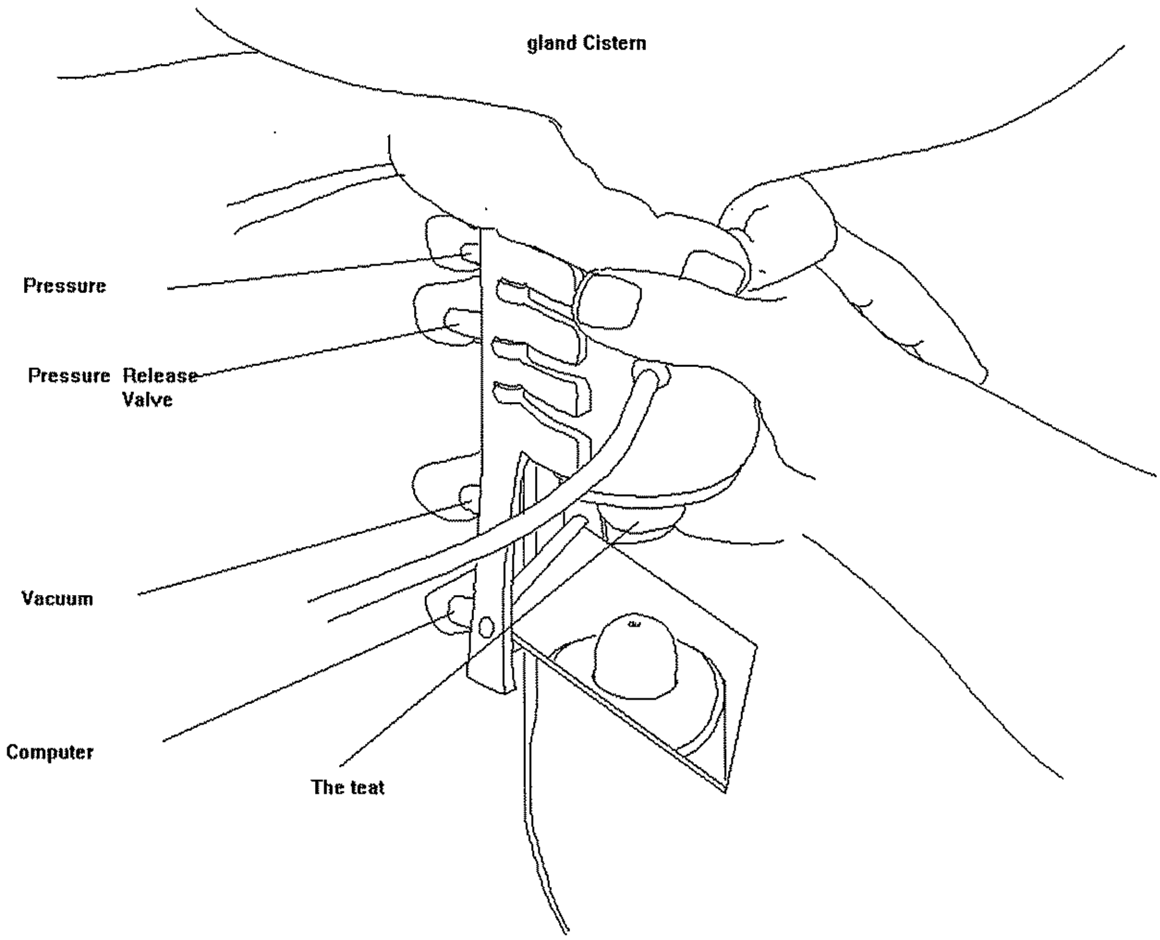


Figure nr:22. The way of measuring the tone on the TCS with the device, by closing the passage way between the udder and teat cistern

5 Practical use

The experimental work with the device took place at the National Institute of Animal Science, Dep. of Research in Cattle and Sheep, Foulum, Denmark during March 1995. Thirteen randomly chosen Holstein-Friesian cows with a teat length varying between 6.5 and 7 cm were used for the experiment. Measurements were carried out the right front teat. The results of the measurements are given in appendix 6.
The first days were used for testing the device and to let the user and the cows get accustomed with the measurements, while the next two weeks were used for sampling data. The aim of the experiment was to find out the number of appropriate sub samples per experimental unit.

5.1 Times of measurement

Three different measurements were taken at morning (**M**) and evening (**E**) milking, before pre milking (**A**), after pre-milking (**B**) and after milking (**C**). Measurement B took place as soon the dairy man pre-milked the cow while measurement C took place as soon the cluster was automatically removed from the cow at the end of the milking.

5.2 Data handling

The pressure increase in the device was inserted into the calibration curve (formula nr 8) and the pressure increase in the teat was calculated. All the results of pressure increase in the teat are shown in appendix 6.

5.3 Statistical methods

The following model was applied for each measurement

$$Y = \mu + \tau_i + o + \delta_j + \varepsilon \qquad (9)$$

Where:

Y : = the pressure increase in the teat
μ: = mean value
τ_i := treatment i = a, b, c
o: = time (M, E)
δ_j: = cow, j = 1, 2, 3, .., n
ε : = error

Measurements where milk dropped from the teat during the test or, tests where the finale measurement exceeded 50 kPa in the device were excluded. Only the cow variable was shown to be significant, as expected.

5.4 Repeatability

To be able to decide the number of repetitions per cow which is needed for a future experiment with the device, a new variance analysis has been done. The model was changed to:

$$Y = \mu + \delta_j + \xi_{ij} + \zeta_{ijn} \tag{10}$$

Where:

Y:= pressure increase in the teat
μ:= mean value
ξ_{ij}: = error between cows
ζ_{ijn}:= error within a cow

All measurements with the same treatment, at the same time and with the same number of repetitions were pooled, and a new variance was calculated.
The information about number of repetitions was taken from the following model:

$$W = \sigma_e^2 / MSe \tag{11}$$

Where:

W:= repeatability

$\sigma_e^2 = MSe - s_j^2 / n$ = The variance in the error
MSe = Mean square for error in the variance analysis
s_j2 = Variance between repeated measurements within a cow
n = Number of measurements   n= 3, 4,5,.., n

The result of W (W < 1) gives the amount of information which probably can be got from the experiment. The results refer to the number of sub samples within a treatment.

Repeatability (W)

Trea-tments	AM		BM		CM		AE			BE	CE		
Num-ber of cows	3	3	2	6	4	4	2	2	2	4	3	3	7
Sub-sample													
11	/	/	/	/	/	/	/	/	/	/	0,97	/	/
10	/	/	/	/	/	/	/	/	/	/	0,97	/	/
9	/	/	/	/	/	/	/	/	/	/	0,96	/	/
8	/	/	/	/	/	/	/	/	/	/	0,96	/	/
7	/	/	/	/	0,96	/	0,93	/	/	/	0,95	0,94	/
6	/	/	/	/	0,95	0,96	0,92	0,91	/	/	0,94	0,93	/
5	0,94	/	0,91	/	0,93	0,95	0,91	0,90	0,90	/	0,93	0,92	0,97
4	0,92	0,89	0,89	0,96	0,92	0,94	0,88	0,88	0,89	0,95	0,92	0,89	0,96
3	0,90	0,81	0,80	0,95	0,89	0,92	0,85	0,86	0,87	0,94	0,87	0,88	0,95

5.5 Discussion

The results show the precision of the estimated value which can be achieved by an additional measurement decreases rapidly from 4 sub samples onwards. A future user of this method however, should not use less than 5 sub samples to avoid unsuccessful measurements.

There are two types of cows which are not suitable for this method of measurements. The first type is the cows who leak milk before milking or on touching the teat. The second type of cows not suitable for this method is cows with a very high tone in the muscle. The result of cow nr 2174 did not come into consideration for this reason (this cow even had the cluster on for a longer time during milking than other cows on the bar).

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7. Appendix

Appendix 1: All the program which were used with the device

1. Voltmeter
2. Diagram
3. Sphincter
4. Show

Appendix 2. The electronic box

Appendix 3. Pressure regulation

Appendix 4. The referens Pressure transducer (RPT) MPX5050

Appendix 5. Pressure transducer in the electronic box (MPX100)

Appendix 6. The results of the measurements

Voltmeter (for calibration of RPT)

```
PROGRAM voltmete;
 USES  CRT;
 var
  s      : char;
  volt_i, flode, tryck  : integer;
   flode_kPa, tryck_V    : REAL;


(*******************************************************************
****)

 PROCEDURE tryck_P;  (* kannal 0 *)
  BEGIN
    PORT(.$309.) := 0;          (* flags clear byte                *)
    PORT(.$300.) := 0;
    PORT(.$301.) := 0;         (* bit 0 - 4 = '0'   : kannal        *)
    PORT(.$302.) := 0;         (* bit 1 =     '1'   : trygger       *)
    REPEAT
    UNTIL (port(.$300.) > 63) AND (port(.$300.) < 128);
    tryck      := PORTW(.$303.);
    tryck_v := tryck/191.49
             (* 1 eller 204.8  =    skala faktor   *)
  END;


(*******************************************************************
****)

 PROCEDURE kannal_5;  (* kannal 0 *)
  BEGIN
    PORT(.$309.) := 0;          (* flags clear byte                *)
    PORT(.$300.) := 0;
    PORT(.$301.) := 5;         (* bit 0 - 4 = '5'   : kannal 1       *)
    PORT(.$302.) := 0;         (* bit 1 =     '1'   : trygger       *)
    REPEAT
    UNTIL (port(.$300.) > 63) AND (port(.$300.) < 128);

    flode      := PORTW(.$303.);
    GOTOXY (40, 20); WRITE('Spänningen på referens ( V )=  ',FLODE, '     ');
    GOTOXY (40, 24); WRITE ('(siffran deviderat med 191.49)');
    flode      := flode -90 ;

    flode_kPa := flode*0.06172      (*för MPX 5050*)
  END;
(*******************************************************************
****)
```

```
PROCEDURE referens;  (* kannal 2 *)
VAR
  volt2  : INTEGER;
 BEGIN
  PORT(.$309.) := 0;          (* flags clear byte              *)
  PORT(.$300.) := 0;
  PORT(.$301.) := 2;         (* bit 0 - 4 = '2'   : kannal  2     *)
  PORT(.$302.) := 0;         (* bit 1 =    '1'   : trygger       *)
  REPEAT
  UNTIL (port(.$300.) > 63) AND (port(.$300.) < 128);
  volt2     := PORTW(.$303.);
 END;
(*****************************************************************
****)


Begin;
  clrscr;
  s := ' ';
  repeat
    CLRSCR;
    GOTOXY (5, 5);
    write('S = sluta > :  ');

    GOTOXY (10, 10);  write('Trycket på referens (kPa):      ');

    s := ' ';
    WHILE NOT KEYPRESSED DO
      BEGIN
        referens;
        kannal_5;
        GOTOXY (50, 10); WRITE(FLODE_kPa:6:2);
        referens;
         tryck_P;

        DELAY(1000);
      END;
      s := readkey;
  UNTIL (s = 's') OR (s = 'S');
 END.
```

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Diagram (for calibration)

```
PROGRAM  diagram;
USES CRT, DOS,printer, GRAPH, inmat,
    Unit_A0,  Unit_A1;

const
 Port_5 : word = 1; { COM1 }
 BaudRateCode : word = 4;  { 1200 baud }
 ParityCode : word = 0;     { no }
 DataBitCode : word = 3;   { 8 databits }
 StopBitCode : word = 0;   { 1 stopbit }

 borjaY = 320;
 borjaX = 50;

VAR
  sluta  : Boolean;
  ch      : CHAR;



 X, Y : byte;
 InByte : array [1..1] of byte;
 OldBaudRateCode, OldParityCode,
 OldDataBitCode, OldStopBitCode, OldCTS,
 I, J, K, KeyW, ErrCode, IqSize, OqSize, PStat, NRead : word;
 Queue : array [1..2052] of char;
 Strng : string[255];

 Tryck, tryck_test_pasc : REAL;
 tryck_test_int,tryckIn, count         : INTEGER;



 xPos, yPosSomRitas,
 y_MinnePosTryck_givare_1, y_MinnePosTryck_givare_2  :INTEGER;

 spen_a : array [1..200] of integer;
 ring_a : array [1..200] of integer;
 rakna_array : integer;
 summa_spen, summa_ring : REAL;


(**********************************************************************
****)
```

```
PROCEDURE OpenPort;
{ This routine saves the current transmission parameters whereafter
 the serial port is opened with new parameters. }
begin
 ErrCode:= __OpenA1(Port_5,1024,1024,0,0,@Queue);
 if ErrCode=_Port_Open_Already then
 begin
  ErrCode:= __CloseA1(Port_5);
  ErrCode:= __OpenA1(Port_5,1024,64,0,0,@Queue);
 end;
 ErrCode:= __RetOpA1(Port_5,1,OldBaudRateCode);
 ErrCode:= __RetOpA1(Port_5,2,OldParityCode);
 ErrCode:= __RetOpA1(Port_5,3,OldDataBitCode);
 ErrCode:= __RetOpA1(Port_5,4,OldStopBitCode);
 ErrCode:= __RetOpA1(Port_5,9,OldCTS);
 ErrCode:= __SetOpA1(Port_5,1,BaudRateCode);
 ErrCode:= __SetOpA1(Port_5,2,ParityCode);
 ErrCode:= __SetOpA1(Port_5,3,DataBitCode);
 ErrCode:= __SetOpA1(Port_5,4,StopBitCode);
 ErrCode:= __SetOpA1(Port_5,9,1);
 ErrCode:= __IFlshA1(Port_5);
 ErrCode:= __OFlshA1(Port_5)
end;

(*****************************************************************
****)

PROCEDURE ClosePort;
{ This routine closes the current port and
 restores old transmission parameters }
begin
 ErrCode:= __SetOpA1(Port_5,1,OldBaudRateCode);
 ErrCode:= __SetOpA1(Port_5,2,OldParityCode);
 ErrCode:= __SetOpA1(Port_5,3,OldDataBitCode);
 ErrCode:= __SetOpA1(Port_5,4,OldStopBitCode);
 ErrCode:= __SetOpA1(Port_5,9,OldCTS);
 ErrCode:= __CloseA1(Port_5)
end;

(*****************************************************************
****)

FUNCTION ReadPort:boolean;
begin
 ErrCode:= __IqSizeA1(Port_5,IqSize,PStat);
 if IqSize=0 then
 begin
  ReadPort:= False; Exit
 end;
 ErrCode:= __RdChA1(Port_5,Ch,IqSize,PStat);
 if Ch<>'D' then
```

```
 begin
  ReadPort:= False; Exit
 end;
 while IqSize<7 do ErrCode:= __IqSizeA1(Port_5,IqSize,PStat);
 ErrCode:= __RdSta1(Port_5,7,@Strng[1],NRead,IqSize,PStat);
 Strng[0]:= chr(5);
 ReadPort:= True
end;
(*********************************************************************
****)

 PROCEDURE meny;
  BEGIN
    ramar;
    flushKey;
    GOTOXY(15,1); WRITE('PROGRAM FOR TCS MEASUREMENT ');
   END;
(*********************************************************************
***)
(*********************************************************************
****)

 PROCEDURE ritaEnKoordinata;
 VAR
    n1, i, i1,  v1 :INTEGER;
    s2 : STRING(.50.);
  BEGIN
   FOR i1:= 1 TO 200 DO
     BEGIN
       spen_a (.i1.) := 0;
       ring_a (.i1.) := 0;
     END;
     rakna_array := 0;
     summa_spen  := 0;
     summa_ring  := 0;

   CLEARDEVICE;
   SETTEXTSTYLE(2,0,6);

   OUTTEXTXY(200, 20, 'TEST,     s = sluta  p= print');

   LINE(borjaX, borjaY,  715, borjaY);   (* HORISONTAL LINJE *)
   LINE(borjaX, borjaY,   borjaX, 50);   (* VERTICAL LINJE  *)

    v1 := borjaY;
    n1 := 0;
    FOR i := 1 TO 5 DO
     BEGIN
       n1  := n1 + 10;
       v1  := v1-50;    (* 1 kPa = 5 verticala punkter *)
```

```
      LINE((borjaX - 9), v1, (borjaX ), v1);
      STR(n1,s2);
      OUTTEXTXY((borjaX - 30), (v1-10), s2);
    END;

   v1 := borjaY;
   n1 := 0;
   FOR i := 1 TO 50 DO
    BEGIN
      n1  := n1 + 1;
      v1  := v1-5;    (* 1 kPa = 5 verticala punkter *)

      IF n1 = 5
       THEN
        BEGIN
         LINE((borjaX - 6), v1, (borjaX ), v1);
         n1 := 0;
         SETLINESTYLE(1,0,1);
          LINE(borjaX, v1, 715, v1);
         SETLINESTYLE(0,0,1);

        END
       ELSE LINE((borjaX - 3), v1, (borjaX ), v1);
    END;


  SETLINESTYLE(0,0,1);
 END;
(************************************************************)

 PROCEDURE initieraGrafic;
  VAR
   grDriver, graficMode : INTEGER;
  BEGIN
   grDriver := DETECT;
   INITGRAPH(grDriver,graficMode,'');
   SETTEXTSTYLE(3,0,1)
  END;
(************************************************************)

 PROCEDURE slutaGrafic;
  BEGIN
   CLOSEGRAPH;
  END;
(************************************************************)

 PROCEDURE initieraRitaVar;
  BEGIN
   xPos   := borjaX;
   y_MinnePosTryck_givare_1 := borjaY;
   y_MinnePosTryck_givare_2 := borjaY;
```

```
 END;
(************************************************************)



 PROCEDURE initieraNagraRitaVar;
 BEGIN
   xPos   := borjaX;
 END;
(************************************************************)

(*******************************************************************
****)

 PROCEDURE referens;  (* kannal 2 *)
 VAR
   volt2  : INTEGER;
 BEGIN
   PORT(.$309.) := 0;          (* flags clear byte                  *)
   PORT(.$300.) := 0;
   PORT(.$301.) := 2;         (* bit 0 - 4 = '2'    : kannal   2       *)
   PORT(.$302.) := 0;         (* bit 1 =      '1'    : trygger          *)
   REPEAT
   UNTIL (port(.$300.) > 63) AND (port(.$300.) < 128);
             (*bit 7 ='0'   : Ana. to dig. conversion is complete    *)
             (*bit 6 ='1'   : Data has not been retrieved            *)
   volt2      :=  PORTW(.$303.);       (* lõsa två byte från  port 303  *)
 END;

(*******************************************************************
***)

 PROCEDURE mata_tryck_givare_1;  (* kannal 5 *)
 BEGIN
   referens;
   PORT(.$309.) := 0;
         (* flags clear byte                  *)
   PORT(.$300.) := 0;
   PORT(.$301.) := 5;         (* bit 0 - 4 = '5'    : kannal           *)
   PORT(.$302.) := 0;         (* bit 1 =      '1'    : trygger          *)
   REPEAT
   UNTIL (port(.$300.) > 63) AND (port(.$300.) < 128);
             (*bit 7 ='0'   : Ana. to dig. conversion is complete    *)
             (*bit 6 ='1'   : Data has not been retrieved            *)
   tryck_test_int  :=  PORTW(.$303.);      (* läsa två byte från  port 303  *)
   tryck_test_int  := tryck_test_int - 90;
                            (* + 20;*)(*f÷r Jensen*)

   tryck_test_pasc :=  tryck_test_int*0.06172          (* /10.2 f÷r Jensen*)

     (* 90 och 0.06172 from kalibrerings   *)
```

```
END;


(*******************************************************************
****)


PROCEDURE lasaRitaTryck;
 VAR
   summa_spen, summa_ring : REAL;
BEGIN
      xPos := xPos + 1;

      mata_tryck_givare_1;
      yPosSomRitas := borjaY - ROUND(tryck_test_pasc * 5 );

      SETLINESTYLE(1,0,1);
      LINE((xPos - 1), y_MinnePosTryck_givare_1,   xPos,yPosSomRitas);
      count := count + 1;
      summa_spen  :=  summa_spen  + tryck_test_pasc ;

      IF count = 10 THEN
       BEGIN
        CIRCLE(xPos, yPosSomRitas, 3);

        rakna_array := rakna_array + 1;
        spen_a (.rakna_array.) := ROUND(summa_spen/(10*100));
                    (* genom 100 för att få kilopascal*)

        summa_spen := 0;

       END;

      SETLINESTYLE(0,0,1);
      y_MinnePosTryck_givare_1 := yPosSomRitas;


      while not ReadPort do;
      Val(Strng,Tryck,ErrCode);

      yPosSomRitas := borjaY - ROUND((Tryck/100) * 5);
                  (* 1 kPa = 5 vertikala punkter *)
      SETLINESTYLE(2,0,1);
      LINE((xPos - 1), y_MinnePosTryck_givare_2,   xPos,yPosSomRitas);
      SETLINESTYLE(0,0,1);
      y_MinnePosTryck_givare_2 := yPosSomRitas;

      IF count = 10 THEN
       BEGIN
        count := 0;
```

```
        ring_a (.rakna_array.) := ROUND(summa_ring/10);
        summa_ring := 0;
       END;


  END;
(**************************************************************)
PROCEDURE skriva_ut;
VAR
  i5, x : INTEGER;
BEGIN
 i5 := 0;
 x  := 0;
 WRITELN(LST); WRITELN(LST);
 writeln(lst, '    ring   spen , kPa     ');
 writeln(lst, '======================= ');

 WHILE i5 <= rakna_array DO
   BEGIN
    i5 := i5 + 1;
    x  := x + 1;
    WRITE(LST,spen_a (.i5.):3, '- ', ring_a (.i5.):3, ' ---   ');
    IF x = 3  THEN
     BEGIN
      x := 0;
      WRITELN(LST);
     END;
   END;
END;


(**************************************************************)


PROCEDURE mata;

BEGIN
  ritaEnkoordinata;
  initieraRitaVar;
  initieraNagraRitaVar;
  flushkey;

 WHILE NOT sluta DO
    BEGIN
      lasaRitaTryck;
      ch := ' ';

      IF xPos > 717 THEN
         BEGIN
          FLUSHKEY;
          ch := readChar;
```

```
          If (ch = 'p') OR (ch = 'P')
           THEN
            BEGIN
             printaSkarmen;
             skriva_ut;
            END
           ELSE
            BEGIN
            ritaEnKoordinata;
            xPos := borjaX;
            END;
        END;
      IF KEYPRESSED  THEN   ch := readChar;
      If (ch = 's') OR (ch = 'S')  THEN sluta := TRUE;
      If (ch = 'p') OR (ch = 'P')  THEN
           BEGIN
            printaSkarmen;
            skriva_ut;
            flushkey;
           END;
    END;


  END;


(**********************************************************************
**)
(*** SparaObs
***********************************************************)



(**************************************************************)

(**************************************************************
*    Hõr  börjar huvudProcedur
***************************************************************)

 BEGIN
   sluta      := FALSE;
   count      := 0;
   openport;
   flushkey;
   initieraGrafic;
   mata;
   closeport;
   slutaGrafic;
 END.
```

Sphincter (The main program during measurements)

```
PROGRAM  sfinkter;
USES CRT, DOS,printer, GRAPH, inmat:
    Unit_A0,  Unit_A1;

const
  StopDelay = 1000; { in milliseconds }
  Direction : word = 1; { receive }
  Port : word = 1; { COM1 }
  BaudRateCode : word = 4;  { 1200 baud }
  ParityCode : word = 0;     { no }
  DataBitCode : word = 3;   { 8 databits }
  StopBitCode : word = 0;   { 1 stopbit }


TYPE
  matning_record = RECORD
        Behandling   : CHAR;
        Konr         : INTEGER;
        Spenn        : STRING(.2.);
        datum        : STRING(.6.);
        Tid          : STRING(.5.);
        braMatnning  : BOOLEAN;
        initTryck    : REAL;
        SlutTtryck   : REAL;
        END;


VAR matning_var   : matning_record;
   matning_file    : FILE OF matning_record;
   Filnamn : anyStr;
   sluta  : Boolean;

   ch      : CHAR;

   borjaX, borjaY,  xPos,
   yPos, y_MinnePosTryck,
   yPosSomRitas                  :  integer;


  X, Y : byte;
  InByte : array [1..1] of byte;
  OldBaudRateCode, OldParityCode,
  OldDataBitCode, OldStopBitCode, OldCTS,
  I, J, K, KeyW, ErrCode, IqSize, OqSize, PStat, NRead : word;
  Queue : array [1..2052] of char;
  Strng : string[255];
  Tryck : real;
```

```
PROCEDURE OpenPort;
{ This routine saves the current transmission parameters whereafter
 the serial port is opened with new parameters. }
begin
 ErrCode:= __OpenA1(Port,1024,1024,0,0,@Queue);
 if ErrCode=_Port_Open_Already then
 begin
  ErrCode:= __CloseA1(Port);
  ErrCode:= __OpenA1(Port,1024,64,0,0,@Queue);
 end;
 ErrCode:= __RetOpA1(Port,1,OldBaudRateCode);
 ErrCode:= __RetOpA1(Port,2,OldParityCode);
 ErrCode:= __RetOpA1(Port,3,OldDataBitCode);
 ErrCode:= __RetOpA1(Port,4,OldStopBitCode);
 ErrCode:= __RetOpA1(Port,9,OldCTS);
 ErrCode:= __SetOpA1(Port,1,BaudRateCode);
 ErrCode:= __SetOpA1(Port,2,ParityCode);
 ErrCode:= __SetOpA1(Port,3,DataBitCode);
 ErrCode:= __SetOpA1(Port,4,StopBitCode);
 ErrCode:= __SetOpA1(Port,9,1);
 ErrCode:= __IFlshA1(Port);
 ErrCode:= __OFlshA1(Port)
end;

(**********************************************************************
****)

PROCEDURE ClosePort;
{ This routine closes the current port and
 restores old transmission parameters }
begin
 ErrCode:= __SetOpA1(Port,1,OldBaudRateCode);
 ErrCode:= __SetOpA1(Port,2,OldParityCode);
 ErrCode:= __SetOpA1(Port,3,OldDataBitCode);
 ErrCode:= __SetOpA1(Port,4,OldStopBitCode);
 ErrCode:= __SetOpA1(Port,9,OldCTS);
 ErrCode:= __CloseA1(Port)
end;

(**********************************************************************
****)

FUNCTION ReadPort:boolean;
begin
 ErrCode:= __IqSizeA1(Port,IqSize,PStat);
 if IqSize=0 then
 begin
  ReadPort:= False; Exit
 end;
 ErrCode:= __RdChA1(Port,Ch,IqSize,PStat);
```

```
 if Ch<>'D' then
 begin
  ReadPort:= False; Exit
 end;
 while IqSize<7 do ErrCode:= __IqSizeA1(Port,IqSize,PStat);
 ErrCode:= __RdSta1(Port,7,@Strng[1],NRead,IqSize,PStat);
 Strng[0]:= chr(5);
 ReadPort:= True
end;
(*******************************************************************
****)

 PROCEDURE meny;
  BEGIN
    ramar;
    flushKey;        (* tömma tangentsbords buffer    *)

    GOTOXY(15,1); WRITE('PROGRAM FOR TCS MEASUREMENT ');
    GOTOXY(5,3); WRITE('THIS TREATMENT: ');
    GOTOXY(5,6);  WRITE('SIGN TREATMENT   <A-B-C-D-E>:');
    GOTOXY(5,8);  WRITE('SIGN COW NR       <1-9999>:');
    GOTOXY(5,10);  WRITE('SIGN TEAT      <RF-RB-LF-LB>:');
    GOTOXY(5,12); WRITE('MONTH - DAY  <två siffor / return>:');
    GOTOXY(5,14); WRITE('HOUR- MIN    <två siffor / return>:');
   END;
(*******************************************************************
***)

  PROCEDURE lasaFilNamn;
   VAR
    klarFilNamn, braFilNamn   : BOOLEAN;
    radNr, kollaNr, code,koNr_p      : INTEGER;
    ch1                   : CHAR;
    term4                  : tecken;
    behand, manad,
    dagStr, arStr, koNrStr, spenn, timma, min  : STRING(.30.);
    arw, manadW,dagW,dagNamn, koNr   : WORD;
    timmar_w, minuter_w, sek_w, cent_w  : WORD;

  BEGIN
   meny;
   klarFilNamn := FALSE;
   filNamn    := '';
   radNr      := 1;
   behand     := '';
   koNrStr    := '0';
   spenn      := 'RF';
   koNr_p      := 0;

   GETDATE(arW,manadW,dagW,dagNamn);
```

```
STR(dagW,dagStr);
IF LENGTH(dagStr) = 1 THEN dagStr := '0' + dagStr;
STR(manadW,manad);
IF LENGTH(manad) = 1 THEN manad := '0' + manad;
STR(dagW,dagStr);
GETTIME(timmar_w, minuter_w, sek_w, cent_w);
STR(timmar_w, timma);
STR(minuter_w, min);

 WHILE NOT klarFilNamn DO
  BEGIN
    CASE radNr OF
        {$V-}    (* TYPKONTROLL UNDER KOMPILERING LÄGGS AV *)
        1 : BEGIN
              inputstr(behand,       1,  42,  6, FALSE,  ch1);
              IF (behand = 'a') OR (behand = 'A') OR
                (behand = 'b') OR (behand = 'B') OR
                (behand = 'c') OR (behand = 'C') OR
                (behand = 'd') OR (behand = 'D') OR
                (behand = 'e') OR (behand = 'E')
                  THEN  radNr := radNr
                  ELSE
                    BEGIN
                     radNr := radNr - 1;
                     behand := ''; beep;
                    END;
           END;
        2 : BEGIN
              inputstr(koNrStr,       3,  42,  8, TRUE,  ch1);
               VAL(koNrStr, kollaNr,code);
               IF((kollaNr < 1) OR (kollaNr > 9999))
                   THEN
                     BEGIN
                      radNr := radNr - 1;
                      koNrStr := '0'; beep;
                     END
                  ELSE koNr_p := kollaNr;
           END;

        3 : BEGIN
             inputstr(spenn,       2,  42, 10, FALSE,  ch1);
              IF (spenn <> 'RF') AND (spenn <> 'RB') AND
                (spenn <> 'LF') AND (spenn <> 'LB') THEN
                 BEGIN
                   spenn := ' ';
                   beep;
                   radNr := radNr - 1;
                 END;

             END;
        4 : BEGIN
```

```
        inputstr(manad,        2, 42, 12, TRUE, ch1);
        VAL(manad, kollaNr, code);
         IF (kollaNr < 1) OR (kollaNr > 12)
             THEN
              BEGIN
               radNr := radNr - 1;
               manad := ' '; beep;
              END;
         IF LENGTH(manad) = 1 THEN manad := '0' + manad;

      END;
    5 : BEGIN
        inputstr(dagStr,       2, 46, 12, TRUE, ch1);
        VAL(dagStr, kollaNr,code);
         IF (kollaNr < 1) OR (kollaNr > 31)
             THEN
              BEGIN
               radNr := radNr - 1;
               dagStr := ' '; beep;
              END;
        IF LENGTH(dagStr) = 1 THEN dagStr := '0' + dagStr;

      END;
    6 : BEGIN
        inputstr(timma,        2, 42, 14, TRUE, ch1);
        VAL(timma, kollaNr,code);
         IF (kollaNr < 0) OR (kollaNr > 24)
             THEN
              BEGIN
               radNr := radNr - 1;
               dagStr := ' '; beep;
              END;
        IF LENGTH(timma) = 1 THEN timma := '0' + timma;
      END;
    7 : BEGIN
        inputstr(min,       2, 46, 14, TRUE, ch1);
        VAL(min, kollaNr,code);
         IF (kollaNr < 1) OR (kollaNr > 60)
             THEN
              BEGIN
               radNr := radNr - 1;
               dagStr := ' '; beep;
              END;
      END;

    8 : BEGIN
         GOTOXY(10,24);
         WRITE('IS EVERY OKEY ? <Y= YES>  <upp pil = NO>  ');
         term4 := (.'j', 'J', ^E .);
         REPEAT
          ch1 := readChar;
```

```
            IF NOT (ch1 IN term4) THEN beep;
           UNTIL ch1 in term4;
           IF (ch1 = 'y') OR (ch1 = 'Y') THEN
           klarFilNamn := TRUE;
          END;
        END;      (* end of case *)
     (*$V+*)    (* TYPKONTROLL UNDER KOMPILERING LÄGGS PÅ *)

    CASE ch1 OF
      ^X, ^M  : BEGIN
              radNr :=  radNr + 1;
              IF radNr > 8  THEN radNr := 8;
             END;
         ^E  :  BEGIN
              radNr :=   radNr - 1;
              IF radNr < 1 THEN radNr := 1;
            END;
      END;         (* END OF CASE *)
     END;         (* END OF WHILE *)

     matning_var.Behandling   := behand(.1.);
     matning_var.Konr         := koNr_p;
     matning_var.Spenn        := spenn;
     matning_var.Tid          := timma +'-'+ min;
     matning_var.datum        := manad +'-'+ dagStr;
     matning_var.braMatnning  := TRUE;

 END;


(***********************************************************)


 PROCEDURE mata;
 VAR
 slutamata :BOOLEAN;
  tid_vid_slut_matning, nuTid           : REAL;
  initial_Tryck,slutTryck, i            : INTEGER;
  konrStr                    : anyStr;

  BEGIN
    flushKey;                  (* tömma tangentsbords buffer     *)
    slutamata := FALSE;

    while not ReadPort do;
    Val(Strng,Tryck,ErrCode);
    Writeln('FIRST MEASUREMENT ', (Tryck/100):10:2, '  kPa');
    matning_var.initTryck     := Tryck;

    while not ReadPort do;
```

```
    Val(Strng,Tryck,ErrCode);
    Writeln('SECOND MEASUREMENT ', (Tryck/100):10:2, '  kPa');

    nuTid :=  meml(.$40:$6C.)/18.2;;
    WHILE NOT slutaMata DO
      BEGIN
        tid_vid_slut_matning := meml(.$40:$6C.)/18.2;
        IF tid_vid_slut_matning > (nuTid + 10)
          THEN slutaMata  := TRUE
          ELSE
           BEGIN
            IF ReadPort THEN
              BEGIN
                Val(Strng,Tryck,ErrCode);
                Writeln('NEW FINAL MEASUREMENT ', (Tryck/100):10:2, '  kPa');
                nuTid :=  meml(.$40:$6C.)/18.2;;
               END;
           END;
       END;

    matning_var.slutTtryck   := Tryck;
  END;


(*******************************************************************
**)
(*** SparaObs
*********************************************************)


PROCEDURE SparaObs;

VAR Fel : Byte;
BEGIN
   Assign(matning_file, 'c:\x-jobb\x-practi\uprepp.dat');
    (*$I-*) Reset(matning_file);
   Fel := IOResult;
   IF Fel = 0 THEN Seek(matning_file, FileSize(matning_file))
           ELSE ReWrite(matning_file);
   Write(matning_file, matning_var);
   Close (matning_file);

END;


(*** ******************************************************)


PROCEDURE initieraMatDataRecord;

 VAR i : integer;
```

```
BEGIN

        matning_var.Behandling  := ' ';
        matning_var. Konr       := 0;
        matning_var. Spenn      := '';
        matning_var. Tid        := '';
        matning_var. braMatnning  := true;
        matning_var.initTryck    := 0;
        matning_var. SlutTtryck  := 0;

END; (*SparaObs*)


(***********************************************************)

 PROCEDURE  meny_spara;
   VAR i: integer;
  BEGIN
   ramar;
   flushKey;
   GOTOXY(10,10);
   WRITE('VOULD YOU LIKE TO SAVE THE MEASUREMENT       <Y=Yes
N=NO>:');
   ch := ' ';
   REPEAT
      GOTOXY(57,10);    ch := readkey;
   UNTIL (ch='Y') OR (ch='y') OR (ch='n') OR (ch='N');

   If (ch = 'Y') OR (ch = 'y')  THEN
     BEGIN

       SparaObs;
     END;


   GOTOXY(10,14);
   WRITE('VOULD YOU LIKE TO CONTINUE WITH NEW MEASUREMENT
<Y=YES  N=NO>:');
   ch := ' ';
    GOTOXY(57,14);    ch := readChar;
   If (ch = 'n') OR (ch = 'N')  THEN
    BEGIN
     sluta := TRUE;
   END;
  END;


(***********************************************************
*     Här  börjar huvudProcedur
***********************************************************)
```

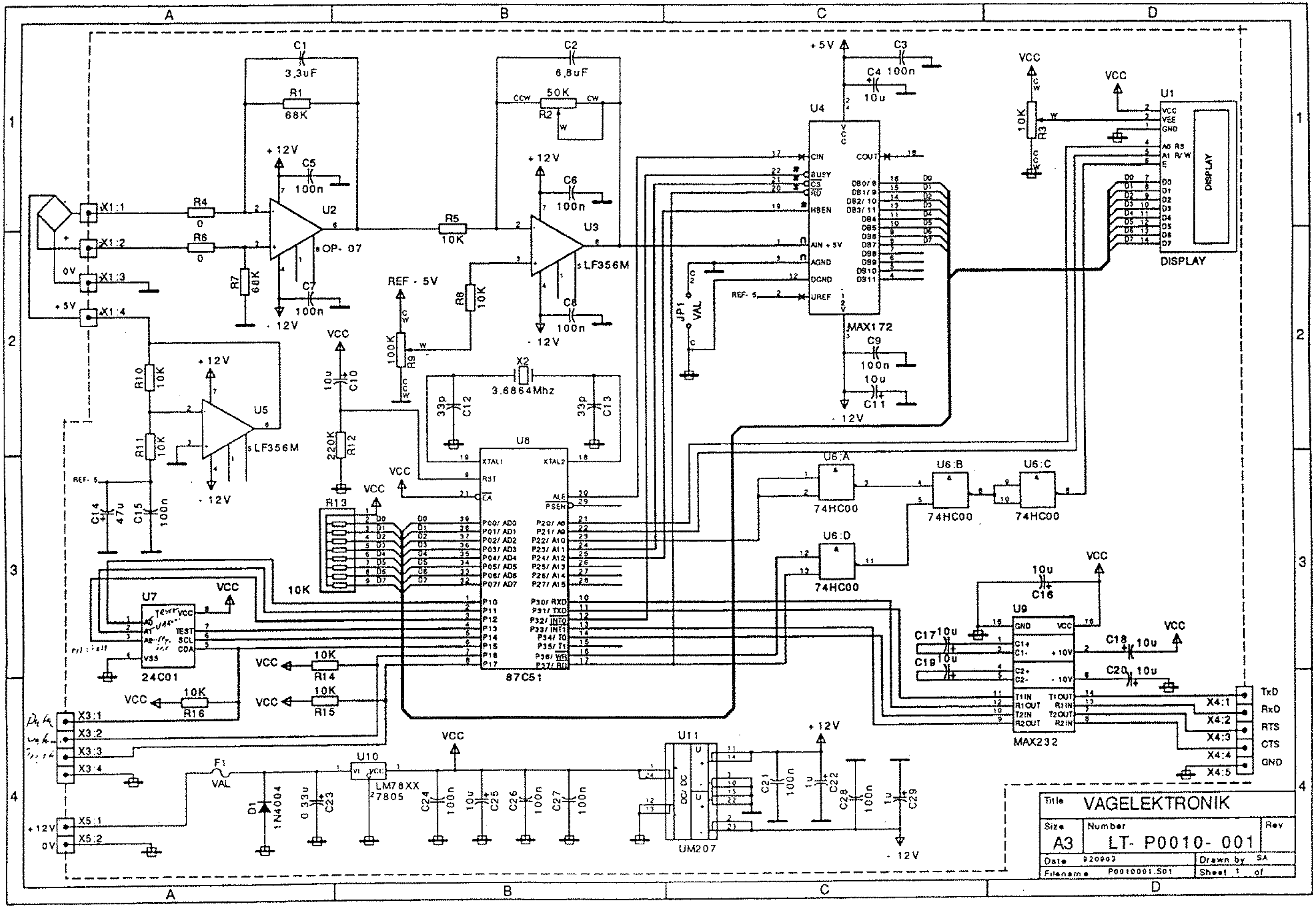
```
BEGIN
   sluta       := FALSE;
   openport;

  WHILE NOT sluta DO
   BEGIN
      meny;
      initieraMatDataRecord;
      lasaFilNamn;
      clrscr;
      mata;
      meny_spara;
    END;
    closeport;
END.
```

Show (to read the results after the test)

```
PROGRAM  visa;
USES CRT, DOS, PRINTER, inmat;
TYPE
 matning_record = RECORD
        Behandling   : CHAR;
        Konr         : INTEGER;
        Spenn        : STRING(.2.);
        datum        : STRING(.6.);
        Tid          : STRING(.5.);
        braMatnning  : BOOLEAN;
        initTryck    : REAL;
        slutTryck    : REAL;
     END;

VAR  matning_var : matning_record ;
   matning_Fil    : FILE OF matning_record;
   Filnamn : anystr;
   Tecken, Tecken1 : Char;
   ch1     :CHAR;
   sluta   :BOOLEAN;
   recordNr,maxAntalRec : INTEGER;

CONST FilOppet : Boolean = False;

(* *****************************************************)

PROCEDURE OppnaFil_1;

VAR
  Temp: AnyStr;
  ch2  :CHAR;
  slutaslinga:BOOLEAN;
BEGIN
 slutaslinga := FALSE;
 temp := '';
 WHILE NOT slutaslinga DO
  BEGIN

    filNamn := 'c:\x-jobb\x-prakti\'+ 'upprep.DAT';
    Assign(matning_Fil, FilNamn);
     Reset(matning_Fil);
    IF IOResult <> 0
     THEN
      BEGIN
            END
     ELSE  slutaslinga := TRUE;
    If keypressed THEN
      BEGIN
```

```
      ch2 := READKEY;
      IF ch2 = CHR(27) THEN  slutaslinga := TRUE;
     END;
 END;
 FilOppet := True;
 maxAntalRec := FILESIZE(matning_Fil);
 GotoXY(28,12); Write('                    ');

END;
(*****************************************************************)

PROCEDURE PrintObs1;

BEGIN
WriteLn(Lst,'***********************************************************
*******');
Write  (Lst, 'rec Nr: ', recordNr:3,   ' Treat:', matning_var.Behandling);
Write  (Lst, ' Cow Nr: ',matning_var.koNr);
WriteLn(Lst, '  TEAT: ',   matning_var.Spenn, ' bra mätning:
',matning_var.braMatnning);
Write  (Lst, '  init Pressure: ', (matning_var.initTryck/100):5:2 );  (* omvandling till
kPa*)
WriteLn(Lst,'  Final Pressure:', (matning_var.slutTryck/100):5:2 );

WriteLn(Lst,'*********************************************************');
WriteLn(Lst);
END;
(*****************************************************************)
PROCEDURE Read_WRITE_RecordNr;
VAR x, y  :INTEGER;
tryck_kpa: REAL;
BEGIN
       Read(matning_Fil, matning_var);
       ramar;
        GotoXY(3,4);   Write('Obs Nr      : ', recordNr);
        GotoXY(3,6);   Write('Treatment  : ', matning_var.Behandling);
        GotoXY(3,8);   Write('CowNr    : ', matning_var.koNr);
        GotoXY(3,10);   Write('Teat        : ', matning_var.spenn);
        GotoXY(55,4);  Write('Date       : ', matning_var.datum);
        GotoXY(55,6);  Write('Time        : ', matning_var.tid);
        tryck_kpa := matning_var.initTryck;
        gotoxy(3,14); write('Init pressure = ', (tryck_kpa/100): 6:2);
        tryck_kpa := matning_var.SlutTryck;
        gotoxy(3,16); write('Final Pressure = ', (tryck_kpa/100): 6:2);
END;
(*****************************************************************)

 PROCEDURE rullaMATNING_1;
  VAR
   ch : CHAR;
   tmp :anyStr;
```

```
  fel:integer;
BEGIN
  ch := ' ';
  GOTOXY(6,24);
  WRITE('<rtn>=Next b=Back h=Hopa p=Print f=finish: ');
  CH := READKEY;
  CASE ch OF
       'F', 'f' : sluta:= TRUE;
       'p', 'P' : PrintObs1;
       'b', 'B' :
              BEGIN
                recordNr := recordNr - 1;
                IF recordNr < 1 THEN
                  BEGIN
                    recordNr := recordNr + 1;
                    WRITE(CHR(7));
                   END;
                END;
                   ELSE
            BEGIN
                 recordNr := recordNr + 1;
                 IF recordNr >  maxAntalRec THEN
                    BEGIN
                     recordNr := recordNr - 1;
                     WRITE(CHR(7));
                    END;
                END;
      END;
END;
(*****************************************************)
BEGIN
 Ramar;
 sluta := FALSE;
 recordNr := 1;
 oppnaFil_1;
 WHILE NOT sluta DO
  BEGIN
    Read_Write_RecordNr;  (* läser proceduren som skriver resultat*)
    rullaMATNING_1;
 END;
        CLOSE(matning_Fil);
          END.
```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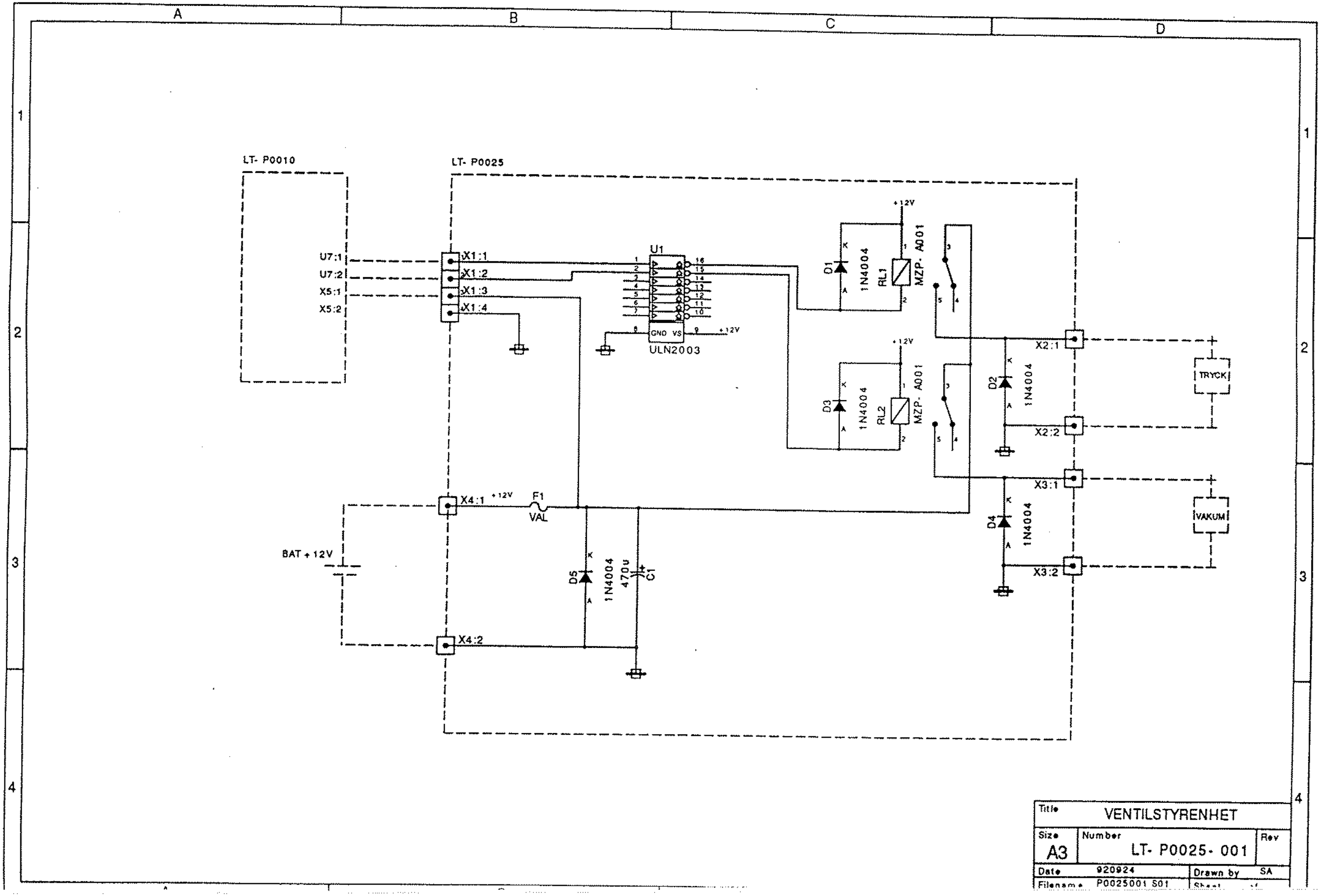
Size A3
Number LT- P0010- 001
Date 920903
Filename P0010001.S01
Drawn by SA
Sheet 1 of
Rev
U1 DISPLAY
U2 OP- 07
U3 LF356M
U4 MAX172
U5 LF356M
U6:A 74HC00
U6:B 74HC00
U6:C 74HC00
U6:D 74HC00
U7 24C01
U8 87C51
U9 MAX232
U10 LM78XX 7805
U11 UM207
X2 3.6864Mhz
JP1 VAL
F1 VAL
D1 1N4004
TxD
RxD
RTS
CTS
GND
REF - 5V
VCC
+ 12V
- 12V
+ 5V
0V

Appendix 3. Pressure Regulation

1:1



Appendix 4. Pressure Transducer MPX100

73-085-05 MPX5050DP Tryckgivare

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

Advance Information

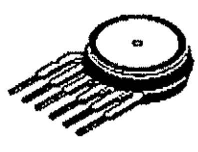
0 to 7.3 PSI On-Chip Signal Conditioned, 0.5 V to 4.5 V Output, Temperature Compensated & Calibrated, Silicon Pressure Sensors

- Ideally Suited for Microprocessor or Microcontroller Based Systems
- Temperature Compensated over 0°C to +85°C.
- Patented Silicon Shear Stress Strain Gauge
- Full Scale Output Calibrated: 0.5 V to 4.5 V (typical)
- Easy to Use Chip Carrier Package Options
- Available in Differential and Gauge Configurations

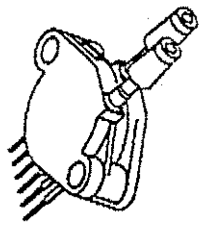
MPX5050 SERIES

Motorola Preferred Devices

0–7.3 PSI
X-ducer™
SILICON
PRESSURE SENSORS



BASIC CHIP
CARRIER ELEMENT
CASE 867-04



DIFFERENTIAL
PORT OPTION
CASE 867C-03

Pin Number					
1	2	3	4	5	6
V_{out}	Ground	V_S	N/C	N/C	N/C

NOTE: Pins 4, 5 and 6 are internal device connections. Do not connect to external circuitry or ground

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Overpressure	P_{max}	700	kPa
Burst Pressure	P_{burst}	1000	kPa
Supply Voltage (Note 10)	V_{Smax}	6.0	Vdc
Storage Temperature	T_{stg}	–50 to +150	°C
Operating Temperature	T_A	–40 to +125	°C

The MPX5050 series piezoresistive transducer is a state-of-the-art, monolithic silicon pressure sensor designed for a wide range of applications, but particularly for those employing a microcontroller or microprocessor with A/D inputs. This patented, single element X-ducer combines advanced micromachining techniques, thin-film metallization and bipolar semiconductor processing to provide an accurate, high level analog output signal that is proportional to applied pressure.

Figure 1 shows a schematic of the internal circuitry integrated on-chip to provide temperature compensation, offset and span calibration and signal conditioning.

X-ducer is a trademark of Motorola Inc.

This document contains information on a new product. Specifications and information herein are subject to change without notice.

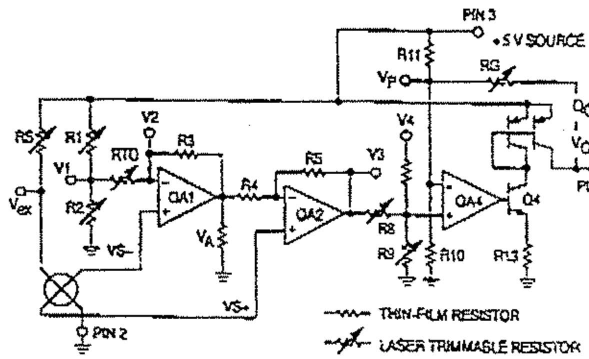


Figure 1. Fully Integrated Pressure Sensor Schematic

1:1

Appendix 5. Referens Pressure Transducer (RPT) MPX5050

MOTOROLA
SEMICONDUCTORS
TOULOUSE, FRANCE

MPX100

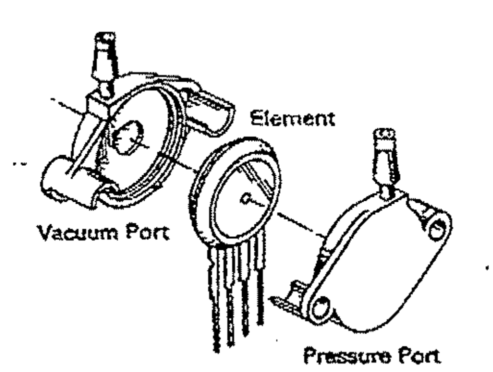
X-ducer SILICON PRESSURE SENSOR

0 TO 100 kPa

0 TO 100 kPa PRESSURE TRANSDUCER

. . . a silicon piezoresistive pressure sensor providing a very accurate and linear voltage output — directly proportional to the applied pressure. It is designed for automotive, industrial, medical and other applications.

- 0 to 100 kPa Differential Pressure Range
- ±0.05% Full Scale Linearity
- Unique Silicon Shear Stress Strain Gage
- Easy to Use X-ducer Package
- Absolute and Differential Types Available
- Basic Element, Single and Dual Ported Devices Available



XIMUM RATINGS

Rating	Symbol	Value	Unit
erpressure	P_{max}	400	kPa
pply Voltage	$V_{S\,max}$	6.0	Vdc
rage Temperature	T_{stg}	−50 to +150	°C
erating Temperature	T_A	−40 to +125	°C

VOLTAGE OUTPUT versus APPLIED DIFFERENTIAL PRESSURE

The voltage output of the X-ducer is directly proportional to the differential pressure applied.

The ABSOLUTE Basic Elements and ABSOLUTE Ported Elements have a built in reference vacuum of approximately 0 kPa. The output voltage increases with increasing pressure relative to ambient pressure (≈ 100 kPa) applied to the pressure side. Care should be taken to limit positive pressure to approximately 300 kPa relative to ambient so that the totoal differential overpressure range of 400 kPa is not exceeded. Conversely, the output voltage will decrease as vacuum, relative to ambient, is drawn. Vacuum down to the 0 kPa reference can be measured with the indicated accuracy.

The output voltage of the Differential Element, Differential Ported and Gage Ported sensors increases with increasing pressure applied to the pressure side relative to the vacuum side. Similarly, output voltage increases as increasing vacuum is applied to the vacuum side relative to the pressure side of the Differential units.

The output voltage of the Gage Vacuum Ported sensor increases with increasing vacuum (decreasing pressure) applied to the vacuum side with the pressure side at ambient.

ORDERING INFORMATION:

MPX Series "X-ducer" silicon pressure sensors are available in absolute, differential, and gage configurations. Devices are available in the BASIC ELEMENT package or with pressure port fittings which provide mounting ease and barbed hose connections.

Device Type	Options	Package Style	Device Number
Basic Element	Absolute	Case 344-03	MPX100A
	Differential	Case 344-03	MPX100D
Ported Element	Absolute	Case 350-01	MPX100AP
	Differential	Case 352-01	MPX100DP
	Gage	Case 350-01	MPX100GP
	Gage Vacuum	Case 350-02	MPX100GVP

Appendix 6. The results of the measurements

First measuring at evening milking before pre-milking (AE)

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
22-03-95	1401	3.48	15.89
23-03-95	1401	3.06	5
24-03-95	1401	4.1	7.31
25-03-95	1401	6.18	5.13
26-03-95	1401	3.46	9.49
27-03-95	1401	4.04	7.27
28-03-95	1401	3.92	7.39

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2214	6.88	22.52
23-03-95	2214	3.18	0
24-03-95	2214	11.64	11.11
25-03-95	2214	9.62	0
27-03-95	2214	6.2	15.33
28-03-95	2214	5.6	17.39

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2113	9.38	4.89
23-03-95	2113	7.02	10.26
24-03-95	2113	11.96	4.35
26-03-95	2113	7.82	13.39
27-03-95	2113	6.34	6.7
28-03-95	2113	6.66	8.13

Day	Cow	St. pres. ı the devic (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2033	0	0
23-03-95	2033	2.84	0.75
24-03-95	2033	4.88	4.97
25-03-95	2033	2.74	2.16
27-03-95	2033	4.1	3.15
28-03-95	2033	2.96	0.8

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
22-03-95	1386	8.68	1.92
23-03-95	1386	0	0
24-03-95	1386	5.9	2.33
25-03-95	1386	7.4	0
26-03-95	1386	7.46	3.79
27-03-95	1386	7.96	6.12
28-03-95	1386	8.06	1.98

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2036	9	9.35
23-03-95	2036	7.6	8.99
24-03-95	2036	7.04	2.26
25-03-95	2036	7.54	6.41
26-03-95	2036	7.52	12.46
27-03-95	2036	6.4	7.66
28-03-95	2036	6.26	2.56

Day	Cow	St. pres. ı the devic (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2218	9.98	9.07
23-03-95	2218	4.5	5.72
24-03-95	2218	8.44	6.86
25-03-95	2218	11.38	3.37
27-03-95	2218	7.98	2.74
28-03-95	2218	9.42	5.44

Day	Cow	St. pres. ı the devic (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2174	0	0
23-03-95	2174	0	0
24-03-95	2174	6.44	0
25-03-95	2174	11.88	0.68
26-03-95	2174	9.36	0.67
27-03-95	2174	12.1	0
28-03-95	2174	8.72	0

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
22-03-95	2283	0	0
23-03-95	2283	0	0
24-03-95	2283	7.84	2.58
25-03-95	2283	9.66	6.17
27-03-95	2283	5.62	4.65
28-03-95	2283	11.82	0.85

Measuring at evening milking between pre-milking and puting on (BE)

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	1401	7.7	6.34
25-03-95	1401	5.82	5.74
26-03-95	1401	6.34	3.97
27-03-95	1401	4.8	5.81
28-03-95	1401	5.16	4.44

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	1386	8.1	0
25-03-95	1386	10.64	0
26-03-95	1386	5.8	0.6
27-03-95	1386	8.84	1.04
28-03-95	1386	9.58	3.05

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2214	6.06	2.69
25-03-95	2214	7.56	13.67
27-03-95	2214	4.76	9.24
28-03-95	2214	6.02	5.83

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2036	8.26	0.43
25-03-95	2036	11.28	4.6
27-03-95	2036	6.78	12.14
28-03-95	2036	8.1	3.29

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2113	6.12	3.97
25-03-95	2113	9.74	9.3
27-03-95	2113	9.56	7.36
28-03-95	2113	7.66	4.63

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2033	6.08	5.54
25-03-95	2033	2.62	0
27-03-95	2033	5.76	2.22
28-03-95	2033	8.68	0

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2174	9.18	0
25-03-95	2174	0	0
27-03-95	2174	6.78	1.73
28-03-95	2174	8.6	0

Day	Cow	St. pres. i the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2218	10.42	1.2
25-03-95	2218	10.58	3.62
27-03-95	2218	7.82	0.43
28-03-95	2218	5.66	2.79

Day	Cow	St. pres. ı the devic (kPa)	Pres. incr. in the teat (kPa)
24-03-95	2283	13.18	0
25-03-95	2283	9.62	1
27-03-95	2283	5.78	3.45
28-03-95	2283	13.66	0

First measuring at evening milking after taking off (CE)

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
13-03-95	1401	6.1	9.98
14-03-95	1401	7.84	9.74
15-03-95	1401	9.66	8.9
21-03-95	1401	10.3	12.92
22-03-95	1401	4.6	7.7
23-03-95	1401	5.44	11.43
24-03-95	1401	8.12	6.24
25-03-95	1401	9.98	9.14
26-03-95	1401	5.92	13.41
27-03-95	1401	5.68	10.1
28-03-95	1401	4.88	8.94

Day	St. pres. Cow	Pres. incr. in the dev (kPa)	pres.incr. in the teat (kPa)
21-03-95	2036	7.26	6.66
22-03-95	2036	6.4	5.49
23-03-95	2036	6.1	4.97
24-03-95	2036	8.64	10.77
25-03-95	2036	7.84	10.17
27-03-95	2036	5.54	7.06
28-03-95	2036	6.66	10.58

Day	St. pres. Cow	Pres. incr. in the dev (kPa)	pres.incr. in the teat (kPa)
11-03-95	2214	5.12	11.02
13-03-95	2214	6.14	17.85
14-03-95	2214	9.9	4.96
15-03-95	2214	8.42	4
21-03-95	2214	7.08	10.96
22-03-95	2214	7.2	10.6

Day	St. pres. Cow	Pres. incr. in the dev (kPa)	pres.incr. in the teat (kPa)
10-03-95	1386	10.52	2.12
11-03-95	1386	4.72	4.99
13-03-95	1386	6.66	1.33
14-03-95	1386	6.48	5.92
15-03-95	1386	11.92	3.75
21-03-95	1386	9.92	4.07
22-03-95	1386	8.84	2.66
23-03-95	1386	7.84	13.16
24-03-95	1386	7.9	5
25-03-95	1386	8.18	2.87
26-03-95	1386	7.6	2.35
27-03-95	1386	6.76	3.79
28-03-95	1386	8.18	1.57

Day	St. pres. Cow	Pres. incr. in the dev (kPa)	pres.incr. in the teat (kPa)
21-03-95	2113	6.84	10.98
22-03-95	2113	9.38	4.89
23-03-95	2113	8.32	5.29
24-03-95	2113	9.4	6.56
25-03-95	2113	10.98	8.78
26-03-95	2113	9.46	8.64
27-03-95	2113	7.48	6.5
28-03-95	2113	8.94	8.28

23-03-95	2214	5.28	5.6
24-03-95	2214	10.58	5.2
25-03-95	2214	7.22	3
26-03-95	2214	4.08	6.97
27-03-95	2214	7.6	5.67
28-03-95	2214	4.62	6.57

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
21-03-95	2218	6.58	5.36
22-03-95	2218	14.6	4.16
23-03-95	2218	6.58	1.46
24-03-95	2218	9.12	3.49
25-03-95	2218	6.62	8.78
27-03-95	2218	8.56	2.11
28-03-95	2218	8.4	3.66

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
21-03-95	2283	8.44	5
22-03-95	2283	9.06	1.72
23-03-95	2283	8.18	1.43
24-03-95	2283	9.16	3.67
25-03-95	2283	11.78	0
27-03-95	2283	7.54	1.42
28-03-95	2283	8.12	2.09

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
10-3-95	1608	4.26	15.67
11-3-95	1608	7.3	3.29
13-3-95	1608	11.58	3.38
14-3-95	1608	7.46	2.5
15-3-95	1608	12.7	0.74

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
22-03-95	2033	5.16	2.48
23-03-95	2033	2.84	3.05
24-03-95	2033	10	1.32
25-03-95	2033	7.76	3.98
27-03-95	2033	4.62	1.7
28-03-95	2033	2.7	6.03

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
22-03-95	2174	7.68	4.63
23-03-95	2174	8.1	3.3
24-03-95	2174	8.02	1
27-03-95	2174	6.34	3.05
28-03-95	2174	10.02	1.31

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
9-3-95	1481	6.92	9.54
10-3-95	1481	3.88	2.64
13-3-95	1481	10.08	4
14-3-95	1481	6.18	11.52
15-3-95	1481	2.62	4.6

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
9-3-95	2116	12.78	15.49
11-3-95	2116	8.66	3.02
13-3-95	2116	10.76	4.09
14-3-95	2116	8.54	20.5
15-3-95	2116	8.94	8.66

Day	St. pres. Cow	Pres. incr. ı the devic (kPa)	pres.incr. in the teat (kPa)
10-3-95	2270	2.78	0.95
11-3-95	2270	9.82	1.6
13-3-95	2270	7.48	6.72
14-3-95	2270	8.72	1.66
15-3-95	2270	8.2	2.06

First measuring at morning milking before pre-milking (AM)

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
23-03-95	1401	6.74	4.35
24-03-95	1401	7.46	2.27
27-03-95	1401	5.04	9.03
28-03-95	1401	6.04	12.05
29-03-95	1401	6.68	4.23

Day	Cow	St. pres. in the dev (kPa)	Pres. incr. in the teat (kPa)
23-03-95	1386	0	0
24-03-95	1386	8.9	1.78
27-03-95	1386	9.52	1.07
28-03-95	1386	8.84	0.93
29-03-95	1386	6.42	6.24

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
23-03-95	2214	0	0
24-03-95	2214	7.64	12.24
26-03-95	2214	7.94	18.81
27-03-95	2214	6.28	0
28-03-95	2214	5.14	14.96
29-03-95	2214	5.9	7.7

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
23-03-95	2036	0	0
24-03-95	2036	6.28	0
26-03-95	2036	5.28	1.16
27-03-95	2036	9.34	9.92
28-03-95	2036	6.26	0.46
29-03-95	2036	5.56	0.77

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
23-03-95	2113	7.24	1
24-03-95	2113	8.4	4.82
27-03-95	2113	7.76	12.73
28-03-95	2113	6.64	6.27
29-03-95	2113	6.1	6.41

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
23-03-95	2218	0	0
24-03-95	2218	9.9	7.36
26-03-95	2218	9.64	5.6
27-03-95	2218	7.56	4.03
28-03-95	2218	9.36	7.21
29-03-95	2218	7.88	0.65

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
23-03-95	2033	3.22	5.68
24-03-95	2033	6.1	0
26-03-95	2033	0.9	4.32
27-03-95	2033	4.12	0
28-03-95	2033	2.8	7.48
29-03-95	2033	6.64	0

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
23-03-95	2283	0	0
24-03-95	2283	9.84	0
26-03-95	2283	7.28	0
27-03-95	2283	14.16	4.38
28-03-95	2283	7.12	0.44
29-03-95	2283	5.04	2.54

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
23-03-95	2174	0	0
24-03-95	2174	12.9	0.62
27-03-95	2174	9.44	2.41
28-03-95	2174	8.3	0
29-03-95	2174	9.18	0

Measuring at morning milking between pre-milking and puting on(BM)

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
24-03-95	1401	8.8	6.79
27-03-95	1401	3.1	7.33
28-03-95	1401	6.78	3.22
29-03-95	1401	5.54	6.01

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
24-03-95	1386	7.66	1.23
27-03-95	1386	9.36	1.26
28-03-95	1386	10.26	2.36
29-03-95	1386	7.92	2.43

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
24-03-95	2214	7.56	0
26-03-95	2214	4.28	4.63
27-03-95	2214	5.88	6.78
28-03-95	2214	7.34	4.58
29-03-95	2214	6.98	5.47

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
24-03-95	2036	7.16	2.36
26-03-95	2036	7.7	5.7
27-03-95	2036	8.66	4.18
28-03-95	2036	7.32	9.98
29-03-95	2036	4.92	2.41

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
24-03-95	2113	7.12	4.21
27-03-95	2113	6.84	8.07
28-03-95	2113	6.66	14.86
29-03-95	2113	5.08	7.84

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
24-03-95	2218	8.46	6.49
26-03-95	2218	5.96	9.89
27-03-95	2218	10.12	4.11
28-03-95	2218	7.44	2.06
29-03-95	2218	7.1	3.03

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
24-03-95	2033	6.14	2.35
26-03-95	2033	6.06	1.18
27-03-95	2033	5.9	4.49
28-03-95	2033	5.64	0
29-03-95	2033	6.36	4.12

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
24-03-95	2283	9.34	0
26-03-95	2283	7.36	0.86
27-03-95	2283	10.58	0.79
28-03-95	2283	7.5	0
29-03-95	2283	11.6	0

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
24-03-95	2174	7.96	5.65
27-03-95	2174	8.92	2.01
28-03-95	2174	7.08	1.98
29-03-95	2174	8.72	1.13

First measuring at morning milking after taking off(CM)

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
22-03-95	1401	9.9	7.93
23-03-95	1401	9.48	5.41
24-03-95	1401	6.14	7.54
27-03-95	1401	7.48	6.23
28-03-95	1401	6	5.59
29-03-95	1401	5.7	10.5

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
22-03-95	1386	7.1	6.43
23-03-95	1386	8.68	4.1
24-03-95	1386	11.8	4
27-03-95	1386	9.9	1.64
28-03-95	1386	3.66	5.09
29-03-95	1386	8.18	1.57

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
22-03-95	2214	5.16	6.06
23-03-95	2214	8.8	3.6
24-03-95	2214	5.08	4.62
26-03-95	2214	4.08	6.97
27-03-95	2214	5.36	5.53
28-03-95	2214	5.22	7.44
29-03-95	2214	7.94	3.9

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
22-03-95	2036	6.84	8.19
23-03-95	2036	7.78	3.28
24-03-95	2036	9.04	8.53
26-03-95	2036	4.56	6.27
27-03-95	2036	8.68	8.6
28-03-95	2036	9.98	3.29
29-03-95	2036	7.3	2.61

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
22-03-95	2113	9.7	3.78
23-03-95	2113	7.84	5.76
24-03-95	2113	6.82	8.64
27-03-95	2113	6.92	4.92
28-03-95	2113	10.36	6.46
29-03-95	2113	11.8	6.09

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
22-03-95	2218	8.74	7.65
23-03-95	2218	5.56	5.83
24-03-95	2218	7.22	1.53
26-03-95	2218	6.82	6.85
27-03-95	2218	7.52	4.78
28-03-95	2218	6.24	2.34
29-03-95	2218	6.98	5.47

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
22-03-95	2033	7.46	3.99
24-03-95	2033	5.26	1.94
26-03-95	2033	3.26	4.94
27-03-95	2033	5.08	3.38
28-03-95	2033	4.68	3.63
29-03-95	2033	7.88	4.45

Day	Cow	St. pres. ı the devic (kPa)	pres.incr. in the teat (kPa)
22-03-95	2283	7.02	4.5
23-03-95	2283	7.46	3.04
24-03-95	2283	8.86	1.03
26-03-95	2283	6.8	2.94
27-03-95	2283	7.3	2.94
28-03-95	2283	6.2	2.23
29-03-95	2283	7.3	2.61

Day	Cow	St. pres. in the dev (kPa)	pres.incr. in the teat (kPa)
23-03-95	2174	7.02	3.04
24-03-95	2174	9.16	1.85
27-03-95	2174	9.3	8.26
28-03-95	2174	5.9	7.86
29-03-95	2174	7.98	0.84