PRELIMINARY TESTING OF THE MILKO-SCOPE MK II MILK METER

by

Donald G. Anderson

7817225

P. O. Box 1372

Sussex, New Brunswick

E0E 1P0

Table of Contents

List of Figures

List of Tables

Abstract

This paper contains the preliminary tests for the approval of the Milko-Scope MK II. Included in procedure are a check of the meter's accuracy in measuring milk weights and butterfat samples along with an attempt to verify the manufacturer's pressure differential claim.

The results of this experiment show a bias error which exceeds C.M.R.B. standards while the random error was relatively small. The correlation of the butterfat reading of the meter and one collected from the pail was found to be very high indicating a representative sample collected by the meter.

The pressure differential could not be verified because of fluctuating readings due to overly-sensitive apparatus. The error found in the milk weight experimentation was attributed mainly to a foaming problem of the milk in the measuring chamber.

Acknowledgements

It is rare when a senior student is able to find a project title that is in their main field of interest. In this situation, there are several people to whom for that I have to thank. Greatly appreciated is the guidance and assistance given by my advisor Professor P. Jutras and director of D.H.A.S., Mr. Norman Campbell.

Special thanks must be given to Foss Electric (Canada) Ltd. and especially their president, Mr. Robin Flocktin for their constant help and support. Also, a special thank you to Mr. Kenneth Lingley, who was my able assistant in the data collection.

Introduction

The practice of milk recording in the dairy industry is nearly one hundred years old. Up until approximately twenty years ago, the main tool needed to record a cow's milk production was a reliable set of weight scales. Hand-milking followed by bucket-style machine milkers both used a set of scales to determine the official measurement.

As in all industries, the cost of labor necessitated the designing of work-saving equipment and thus, the milking parlor and pipeline milking systems evolved. Both systems are closed, so that the milk flows directly from the cow to the holding station. For milk to be measured in these systems, an inline measuring device needed to be developed. Two general types have proven the most reliable over the years, hence - the flow meter and weigh jar.

The weigh jar is nothing more than a large glass jar which has graduations marked on it. All the milk a single cow produces is collected in the jar and at the end of the milking the cow's milk weight can be read directly from the jar.

The flow meters available on the market today are of several different designs. A few catch a portion of the cow's milk and collect it in a graduated cylinder to be read at the end of the cow's milking. Another reads the milk weight on a circular dial. More advanced models available have an electronic readout and are attached to a computer where the milk weights for all cows are directly fed.

As milk systems have changed over the years, so has milk recording systems. Today, the monthly readings taken for a cow are curve-fitted to find a better, more accurate yearly production figure. Breed-Class-Average (B.C.A.) classifications have been recently updated to remove bias caused by date of calving. The new B.C.A. values give a better comparison of a cow calving in the summer to one that calves in the winter.

Dairy Herd Analysis Service (D.H.A.S.) is a milk recording system jointly sponsored by the Quebec Government and Macdonald College. This system not only carries out the measurement of milk production, calculation of herd B.C.A.'s and herd averages but also provides such information to the farmer as feeding, culling and breeding recommendations. These recommendations, to a large extent, are based on the milk measurements taken at the farm. It can be seen then, that the accuracy of these measurements is critical.

The Canadian Milk Recording Board (C.M.R.B.) is a federal unit which oversees the three main milk recording systems in Canada: (a) D.H.A.S. (b) Dairy Herd Improvement Association (D.H.I.A.) and (c) Record of Performance (R.O.P.). A committee of the C.M.R.B., the Milk Measuring and Milk Sampling Devices Committee (M.M.M.S.D.), was set up specifically to look into the accuracy and precision of all new milk metering and sampling devices that came on the market.

One of the first priorities of this committee was to establish an official set of guidelines and specifications of acceptability for all new devices and also to determine an official procedure by which all devices should be checked as to their accuracy.

The procedures and guidelines accepted by the committee follow closely those already established in the United States. Basically, the procedure is as follows: (a) The manufacturer of a new measuring device presents to the committee a set of data of tests done on one new meter. (b) The committee examines the data to determine if the data merits further testing (i.e. if the meter appears reasonably accurate). (c) If the meter is rejected, this model will not be sanctioned for official tests and therefore would not be economically feasible to produce. (d) If the committee decides to continue with further tests, five production models are selected randomly and further testing is carried out.

The procedure for both the manufacturer's and the committee's tests are similar. The meter is used to collect consecutive A.M. and P.M. yields on a minimum of 25 cows. Milk from each cow will pass through the meter and be collected in a bucket (See Fig. 1). The weight of the milk in the bucket is taken as the true milk weight. Each set of 25 cows (minimum) done by a meter is considered a test group.

Foss (Canada) Electric is an international company and one of the leaders in North America in the food analysis equipment industry. The milk meter tested in this experiment, the Milko-Scope MK II, was designed by Foss and has already been approved for official use in five countries.

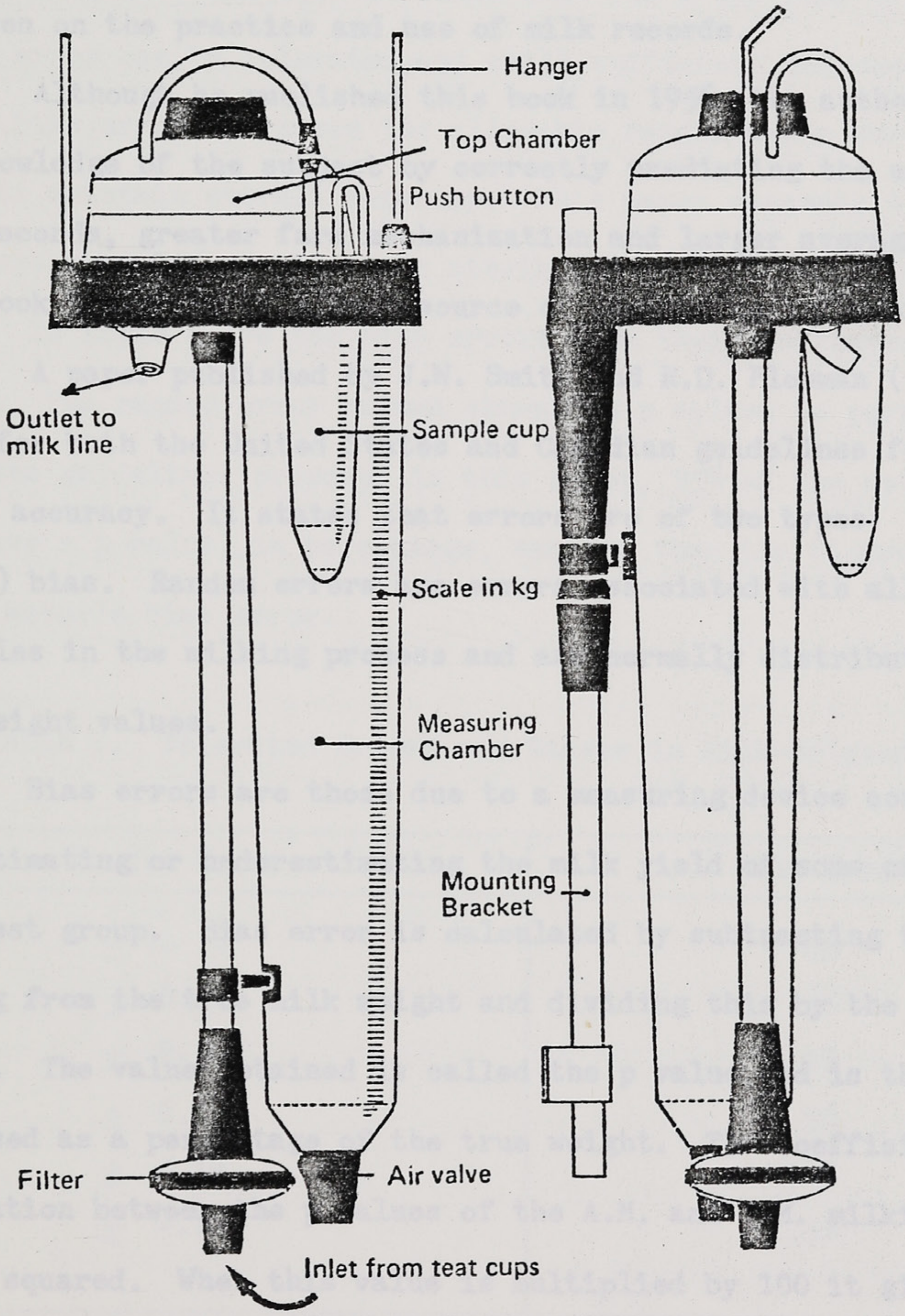
Some of the special features of the meter are its non-detachable collection tube which guards against vacuum loss, its butterfat sampler, the lightweight, crash-proof plastic design and as an option the inline filter to prohibit foreign material passing through the meter.

The milk inlet tube on themeter is connected to the milk claw and leads the milk into the top chamber. The top chamber contains the distributing plate, the knife and the outlet to the milk line. A constriction at the top ensures an adequate velocity of the milk stream when it hits the distributing plate. The distributing plate spreads the milk in a dome and the knife separates a part of the milk (approximately

4.7%) into the measuring chamber. The measuring chamber is scaled in order that an instant reading of the yield can be taken. The rest of the milk is transferred to the milk line.

There are two systems on this meter that can be used to collect a butterfat sample in the sampler cup. The proportional sample system provides a four ml per kg sample to the sample cup while the constant volume sample system gives samples of between five and eighty ml. The size of the sample in the constant volume system is adjustable (See Fig. 1).

Figure 1. The Milko-Scope MK II



Review of Literature

In the book, Milk and Butterfat Recording, Ashton (1956) provides information on the development, organization and financing of milk recording movements in various parts of the world. Also information is given on the practice and use of milk records.

Although he published this book in 1956, the author shows foresight and knowledge of the subject by correctly predicting the use of unofficial milk records, greater farm mechanization and larger average farm size. This book proved to be a good source of background information.

A paper published by J.W. Smith and R.D. Plowman (1968) is the basis for both the United States and Canadian guidelines for measuring device accuracy. It states that errors are of two types: (a) random and (b) bias. Random errors are errors associated with all the natural variables in the milking process and are normally distributed around the true weight values.

Bias errors are those due to a measuring device consistently overestimating or underestimating the milk yield of some or all cows in a test group. Bias error is calculated by subtracting the meter reading from the true milk weight and dividing this by the true milk weight. The value obtained is called the p value and is the error expressed as a percentage of the true weight. The coefficient of correlation between the p values of the A.M. and P.M. milkings is found and is squared. When this value is multiplied by 100 it gives the percentage of error of the meter which can be attributed to bias.

The bias error is associated with the repeatability of the meter. Therefore a high bias error indicates the meter will consistently read too low or too high for some or all cows. This should be serious discrimination. Through statistical analysis, a set of error guidelines was set up (See Table I). It shows that for a low bias error a high random error can be tolerated and still sufficient accuracy is attained. As the bias error increases the allowable random error must decrease in order to maintain overall accuracy. This paper suggests that a meter with more than 25% of its error attributed to bias not be approved.

In Table I are the bias errors with their corresponding random errors. The random error column shows the p values in percentages. Under the guidelines proposed in this paper, 95% of the meter readings must have a p value, in percentage, smaller than the figure corresponding to the meter's bias error.

TABLE I. Tolerated Errors and Biases in Milk-Weighed Devices

Random Error	Bias Error
± 10 %	0%
± 8.6%	1%
± 7.3%	4%
± 6.1%	9%
± 5.1%	16%
± 4.1%	25%

Objective and Scope

The criteria a farmer uses to decide which milk meter to buy differ slightly from that of the approval committee. The farmer has durability and price in the back of his mind but the choice usually comes down to which model is given the best dealer service. The C.M.R.B. looks for a measuring device to be durable, accurate, easy to operate, easily cleaned, and able to be adapted to most milking systems.

The objective of this paper will be to judge only the accuracy of the Foss Milko-Scope MK II with regards to milk weights and butterfat sampling. Also, the manufacturer's specification of vacuum loss across the meter will be inspected. Vacuum loss in milk measuring devices have tolerance limits as established by the International Committee for Recording the Productivity of Milk Animals. These standards are the official standards for European, British and Canadian dairy equipment and state that the milk meter must not cause a pressure differential between the milking pipeline and the claw of more than 3 cm Hg vacuum. Foss claims to have a maximum pressure differential in the Milko-Scope MK II of no greater than 2.3 cm Hg at a milk flow rate of 3 l/min.

Originally it was hoped that this experiment would encompass both stages of the approval of the meter. An original schedule had the preliminary tests (i.e. those to be done for the company for presentation to the C.M.R.B.) to be finished before the end of December 1979. However, delays in the shipping of the meters from Denmark postponed the initial testing until the end of January.

Due to the dates of the meetings of the C.M.R.B. the scope of this paper had to be altered. This project will not include any part of the second phase of the meter approval. The author of this paper may however be involved in the final testing at some later date. Therefore, this project will include the data collection and analysis of data for Foss to be presented to the C.M.R.B. Also, as part of this project only, the accuracy of the butterfat sampler will be tested and the manufacturer's vacuum loss claim will be checked.

Procedure

As previously discussed, the first stage of the approval of a milk meter is done by the manufacturer. Consecutive A.M. and P.M. yields on a minimum of 25 cows are collected using a single meter. The C.M.R.B. suggests a wide range of production levels among the cows tested to give an indication of the meter's overall accuracy.

Specifically, the first step in the meter approval is the 'water test'. This calibration check is a procedure carried out by D.H.A.S. technicians on all meters at farms before any official milk tests are done. The procedure for the water test is as follows: (1) The meter is connected to the milking system as shown in Fig. 2. The milking system vacuum of approximately 38 cm Hg is used to draw water from a water vessel, through the meter and is collected in a milk pail. An air bleed inlet (0.8 mm bore) is connected inline so that the velocity of the milk passing through the meter does not vary greatly fron an average milking flow rate. (2) The weight of the empty milk pail is recorded. (3) The vacuum line is connected and approximately 10 kg of water is drawn through the meter. Upon pulling the hose out of the water vessel the hoses are allowed to empty. (4) The reading of the measuring tube is recorded and the water is passed from the measuring chamber to the milk pail. (5) The vacuum line is disconnected and the water in the milk pail is weighed on the balance. The weight of the empty pail, as previously recorded, is subtracted to obtain the weight of the water. (6) The weight of water and measuring chamber reading are checked (See Table II) to determine if the meter falls within the

Figure 2. Apparatus for the Calibration Check

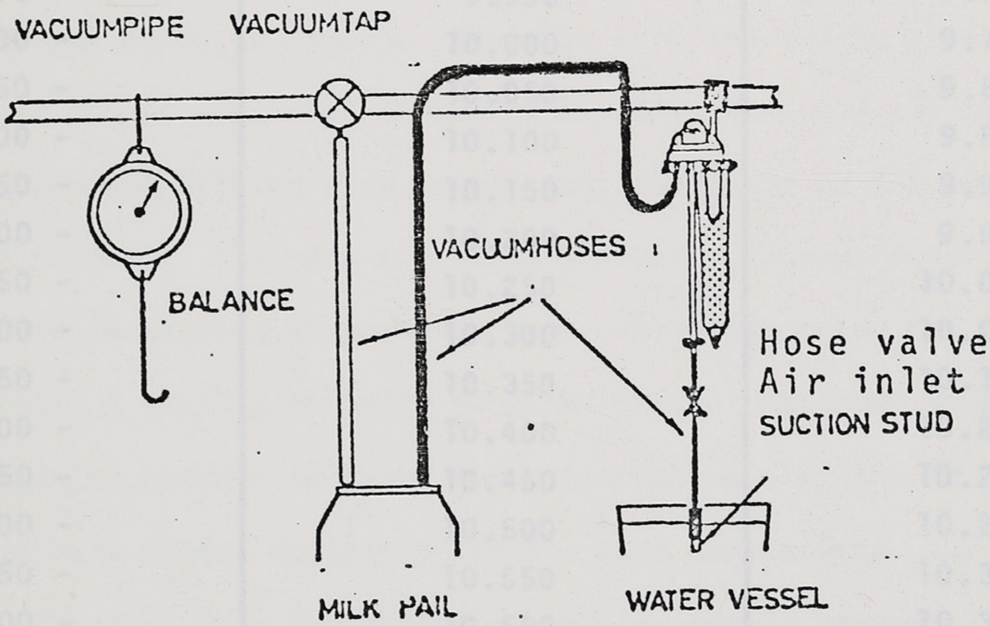


TABLE II. Allowable Deviations in the Calibration Check

Total amount of water, passing the Milko-Scope	Scale reading, 1% deviation	
	Max.	Min.
9.050 kg	9.450	9.200
9.100 -	9.500	9.250
9.150 -	9.550	9.300
9.200 -	9.600	9.350
9.250 -	9.650	9.400
9.300 -	9.700	9.450
9.350 -	9.750	9.500
9.400 -	9.800	9.550
9.450 -	9.850	9.600
9.500 -	9.900	9.650
9.550 -	9.950	9.700
9.600 -	10.000	9.750
9.650 -	10.050	9.800
9.700 -	10.100	9.850
9.750 -	10.150	9.900
9.800 -	10.200	9.950
9.850 -	10.250	10.000
9.900 -	10.300	10.050
9.950 -	10.350	10.100
10.000 -	10.400	10.200
10.050 -	10.450	10.200
10.100 -	10.500	10.250
10.150 -	10.550	10.300
10.200 -	10.600	10.350
10.250 -	10.650	10.400
10.300 -	10.700	10.450
10.350 -	10.750	10.500
10.400 -	10.800	10.550
10.450 -	10.850	10.600
10.500 -	10.900	10.650
10.550 -	10.950	10.700
10.600 -	11.000	10.750
10.650 -	11.050	10.800
10.700 -	11.100	10.850
10.750 -	11.150	10.900
10.800 -	11.200	10.950
10.850 -	11.250	11.000
10.900 -	11.300	11.050
10.950 -	11.350	11.100

required limits. Table II is a table of allowable 1% deviations with the difference in the specific weight of milk and water being taken into account. (7) This procedure is repeated three times and two of the three readings must lie within the specified limits.

If the meter is judged to fall within the required limits, the milking can proceed. If not, the meter must be sent to a local representative for repair or recalibration.

After the calibration check, the meter is connected into the milk line as shown in Fig. 3. The milk from the cow is passed through the meter and is collected in the milk pail. When the cow is finished milking and the milking claw is removed, the yield on the measuring chamber is read. The vacuum control button is depressed so that the milk in the measuring chamber is drawn out of the meter and into the milk pail. A small portion is retained in the butterfat sampler. When the measuring chamber is empty the butterfat sampler cup is removed and replaced by a clean, empty cup for the next sample (Fig. 4).

The milk from the butterfat sampler cup is poured into a sample bottle. The sample bottle contains a small preservative to insure the percentage butterfat remains constant until it is measured in a milk testing laboratory. These two values, the meter's measuring chamber reading and the butterfat percentage of the sample collected, will be considered the experimental values.

The milk from the cow, collected in the milk pail, is weighed on a balance and this weight is considered the true weight of the cow's yield. The milk in the pail is poured between pails three times to mix the milk. A butterfat sample is taken immediately and this is considered

Figure 3. Apparatus for the Accuracy Test

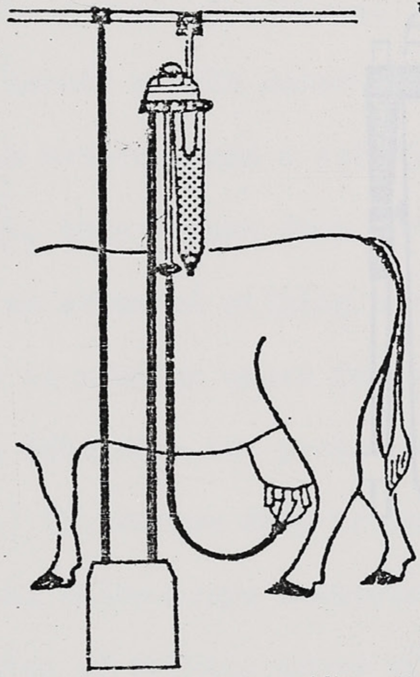
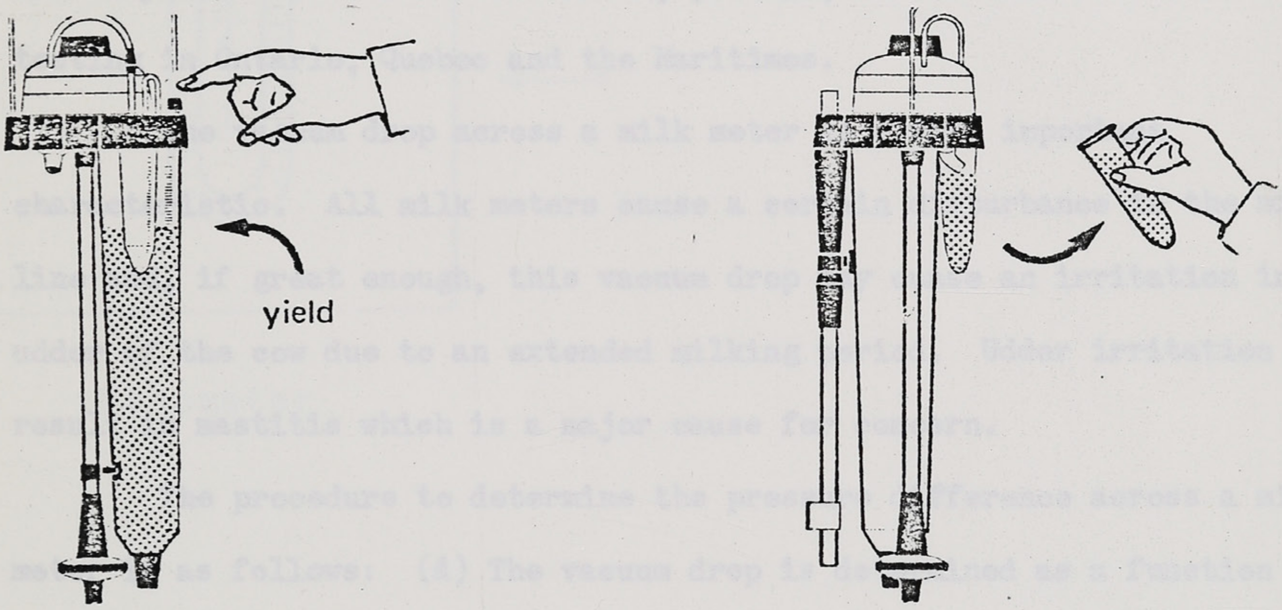


Figure 4. Steps in Meter Operation



to contain the true percentage butterfat of the cow's yield. This procedure conforms to those required by D.H.A.S.

The butterfat samples collected were tested at the D.H.A.S. milk laboratory on the Macdonald campus. The machine used to determine the percentage butterfat is the Milko-Scan. This machine is recognized as the most widely used piece of equipment of this type in Canada and is the only machine used for butterfat, protein, lactose and solids-non-fat testing in Ontario, Quebec and the Maritimes.

The vacuum drop across a milk meter is a very important characteristic. All milk meters cause a certain disturbance in the milk line and, if great enough, this vacuum drop may cuase an irritation in the udder of the cow due to an extended milking period. Udder irritation may result in mastitis which is a major cause for concern.

The procedure to determine the pressure difference across a milk meter is as follows: (1) The vacuum drop is determined as a function of the milking speed with the Milko-Scope connected. (2) The vacuum drop is determined as a function of milking speed without the Milko-Scope. See Fig. 5. The data collected from these two procedures were plotted to produce two curves (Fig. 6). The difference between curve I and curve II is the vacuum drop due to the Milko-Scope. Figures 5 and 6 have been supplied by Foss and this experiment will check their claim of a vacuum drop of 1.8 cm Hg at a milk flow rate of 3 l/min.

It must be noted that it is milk flow rate to be plotted against vacuum drop and not milk weight. To obtain the milk flow rate of the test cows, readings of the milk volume and pressure drop were taken at one minute intervals during the milking with the meter inline. This

Figure 5. Pressure Differential Test

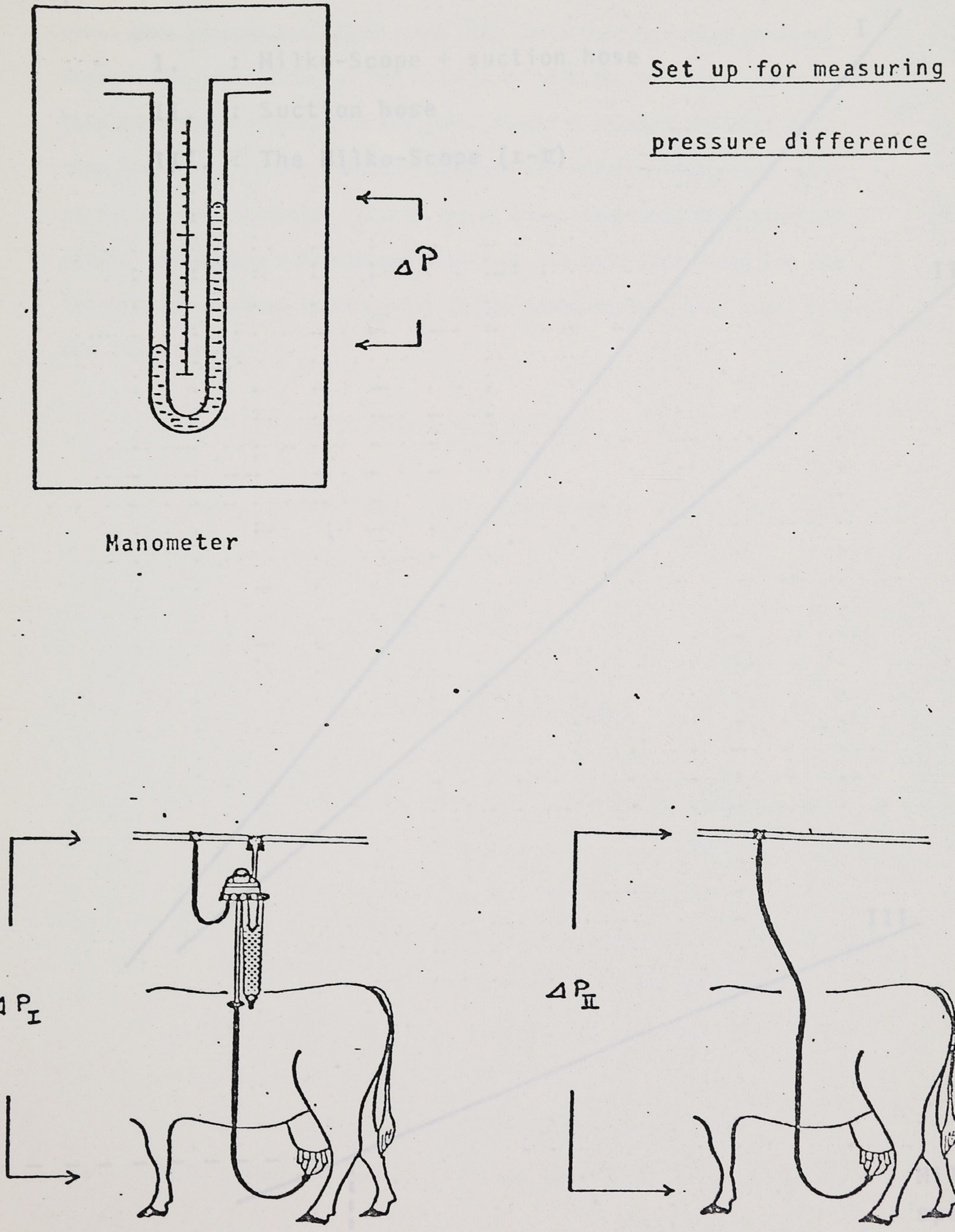
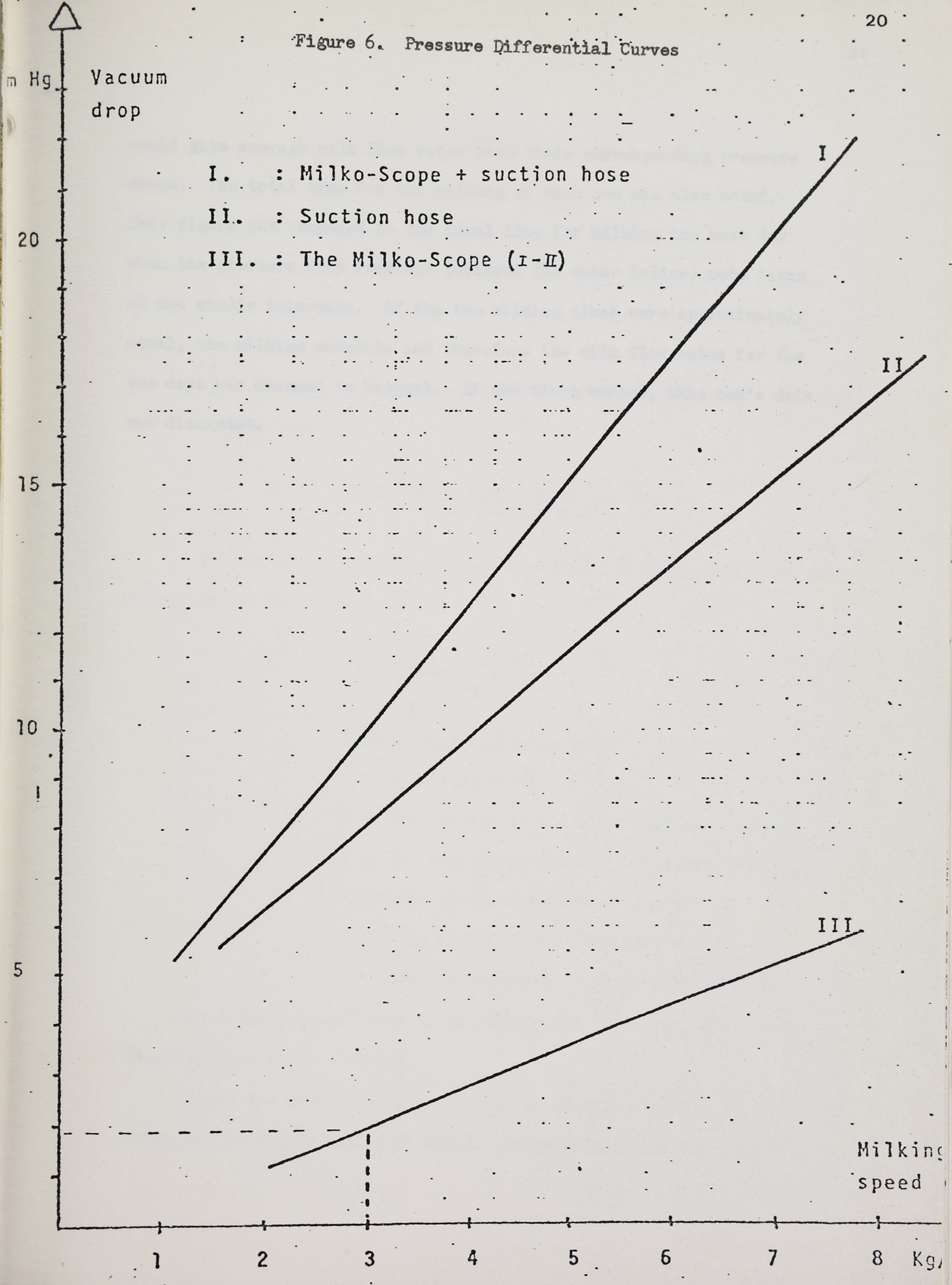


Figure 6. Pressure Differential Curves



would give average milk flow rates with their corresponding pressure drops. The total time for the milking of each cow was also noted. This figure was compared to the total time for milking the next day when the pressure drop readings (without the meter inline) were taken at one minute intervals. If the two milking times were approximately equal, the milking schedule and therefore the milk flow rates for the two days was assumed to be equal. If the times varied, this cow's data was discarded.

Results

As previously mentioned (See Table I) errors associated with the meter are of two types - bias and random. The bias error is calculated from the data and its value determines the maximum allowable random error. Any meter found to have a bias error of over 25% will not be approved.

In Table III, the p values for both the night and morning milkings were calculated where,

$$p = {}_2\frac{\text{true milk weight - meter reading}}{\text{true milk weight}}$$

The correlation between the sets of p values (night and morning) is represented by r where,

$$r = {}_2\frac{\Sigma(X - \bar{X}) \quad (Y - \bar{Y})}{n - 1 \; S_X \; S_Y}$$

X is a night milking p value

Y is a morning milking p value

$\bar{X}$ is the average of all night milking p values

$\bar{Y}$ is the average of all morning milking p values

S_X is the standard deviation of X's

S_Y is the standard deviation of Y's

n - 1 is the number of pairs of data minus 1

From this, r was found to be .686657 and therefore, r^2 = .4715 therefore, bias error = 47.15%.

Since the bias error was found to be greater than 25%, it falls outside the tolerable limits of error. An examination of the data in

TABLE III. Milk Weight Readings

Sample No.	Cow No.	Night Readings			Morning Readings		
		Meter Reading (kg)	Milk Weight (kg)	P Value	Meter Reading (kg)	Milk Weight (kg)	P Value
1	168	1.2	1.2	0.0000	1.6	1.7	0.0588
2	352	5.3	5.3	0.0000	9.7	9.9	0.0202
3	326	1.1	1.1	0.0000	1.2	1.1	-0.0909
4	363	4.5	4.8	0.0625	7.0	7.2	0.0277
5	279	5.1	5.2	0.0192	9.8	9.9	0.0101
6	231	2.5	2.6	0.0385	3.9	4.0	0.0250
7	370	4.1	4.3	0.0465	6.4	6.3	-0.0159
8	367	8.4	8.7	0.0345	11.6	11.9	0.0252
9	372	5.4	5.7	0.0526	9.1	9.5	0.0421
10	223	12.0	12.4	0.0323	15.6	15.8	0.0127
11	221	.8	.9	0.1111	1.4	1.4	0.0000
12	213	.3	.4	0.2500	.6	.5	0.2000
13	205	5.6	5.9	0.0509	11.3	12.0	0.0583
14	238	6.7	7.1	0.0563	9.8	10.3	0.0485
15	378	7.3	7.6	0.0395	10.6	11.2	0.0536
16	380	8.5	8.5	0.0000	8.8	9.0	0.0222
17	132	4.2	4.2	0.0000	5.5	5.6	0.0179
18	341	3.5	3.7	0.0540	7.1	7.4	0.0405
19	235	1.6	1.8	0.1111	5.2	5.5	0.0545
20	210	.7	.7	0.0000	1.4	1.3	-0.0769
21	240	4.5	4.6	0.0217	8.0	8.2	0.0244
22	215	6.6	6.9	0.0435	11.3	11.6	0.0259
23	193	8.7	8.8	0.0114	14.2	14.5	0.0207
24	174	9.1	9.3	0.0215	12.2	12.9	0.0543
25	260	6.0	6.1	0.0164	9.4	9.4	0.0000
26	225	2.1	2.1	0.0000	6.4	6.7	0.0448
27	226	10.6	11.0	0.0364	17.4	17.8	0.0225
28	193	8.6	9.0	0.0444	15.6	16.1	0.0303

Figure 7.

CORRELATION OF MILK WEIGHTS

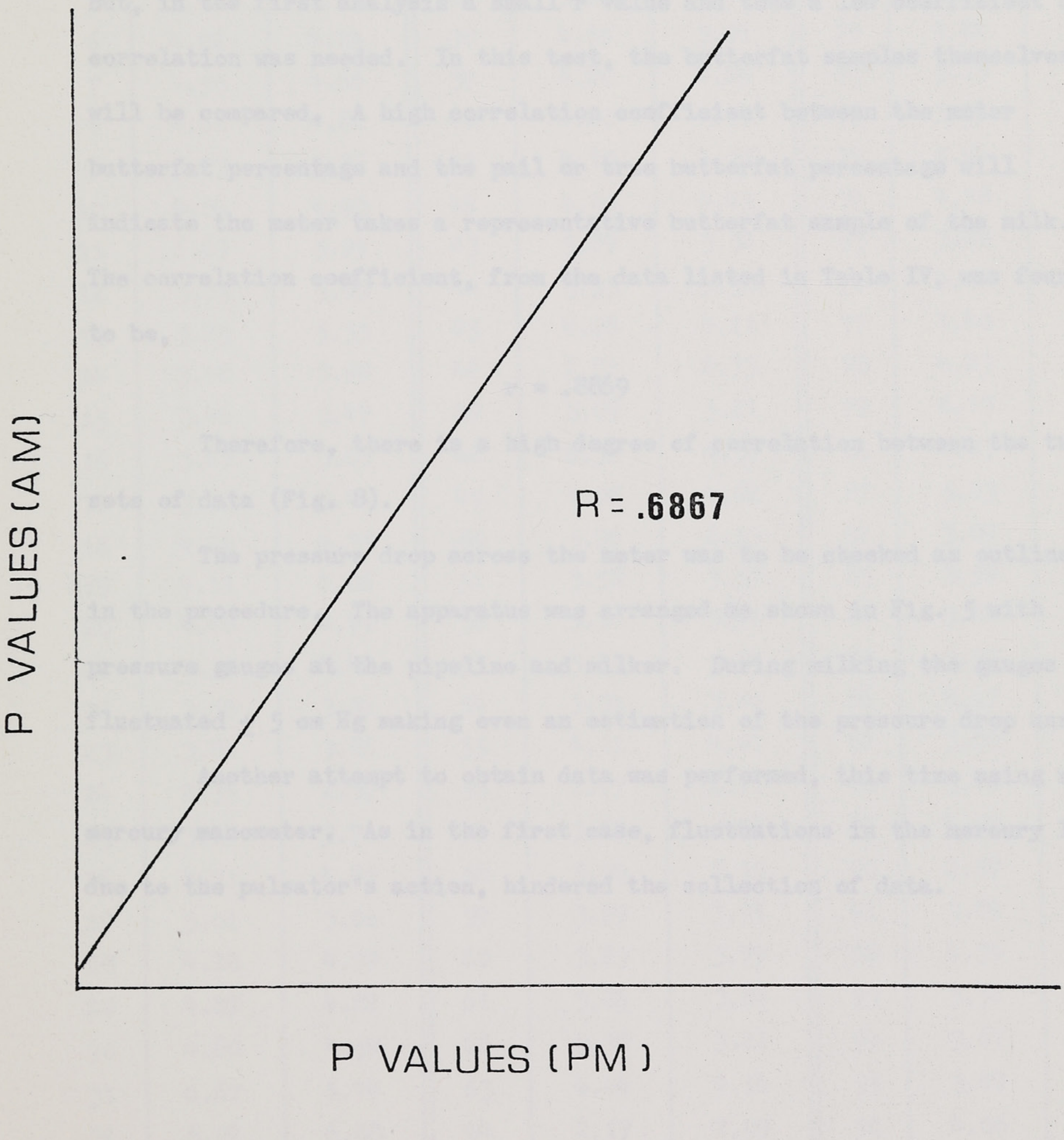


Table II shows that the meter reading consistently falls below the true milk weight. This explains the relatively low p values but the high degree of bias (Fig. 7).

The statistical analysis for the butterfat samples will use the same general procedure as that followed for the milk weights analysis. But, in the first analysis a small r value and thus a low coefficient of correlation was needed. In this test, the butterfat samples themselves will be compared. A high correlation coefficient between the meter butterfat percentage and the pail or true butterfat percentage will indicate the meter takes a representative butterfat sample of the milk. The correlation coefficient, from the data listed in Table IV, was found to be,

$$r = .8869$$

Therefore, there is a high degree of correlation between the two sets of data (Fig. 8).

The pressure drop across the meter was to be checked as outlined in the procedure. The apparatus was arranged as shown in Fig. 5 with pressure gauges at the pipeline and milker. During milking the gauges fluctuated $\pm$ 5 cm Hg making even an estimation of the pressure drop unreliable.

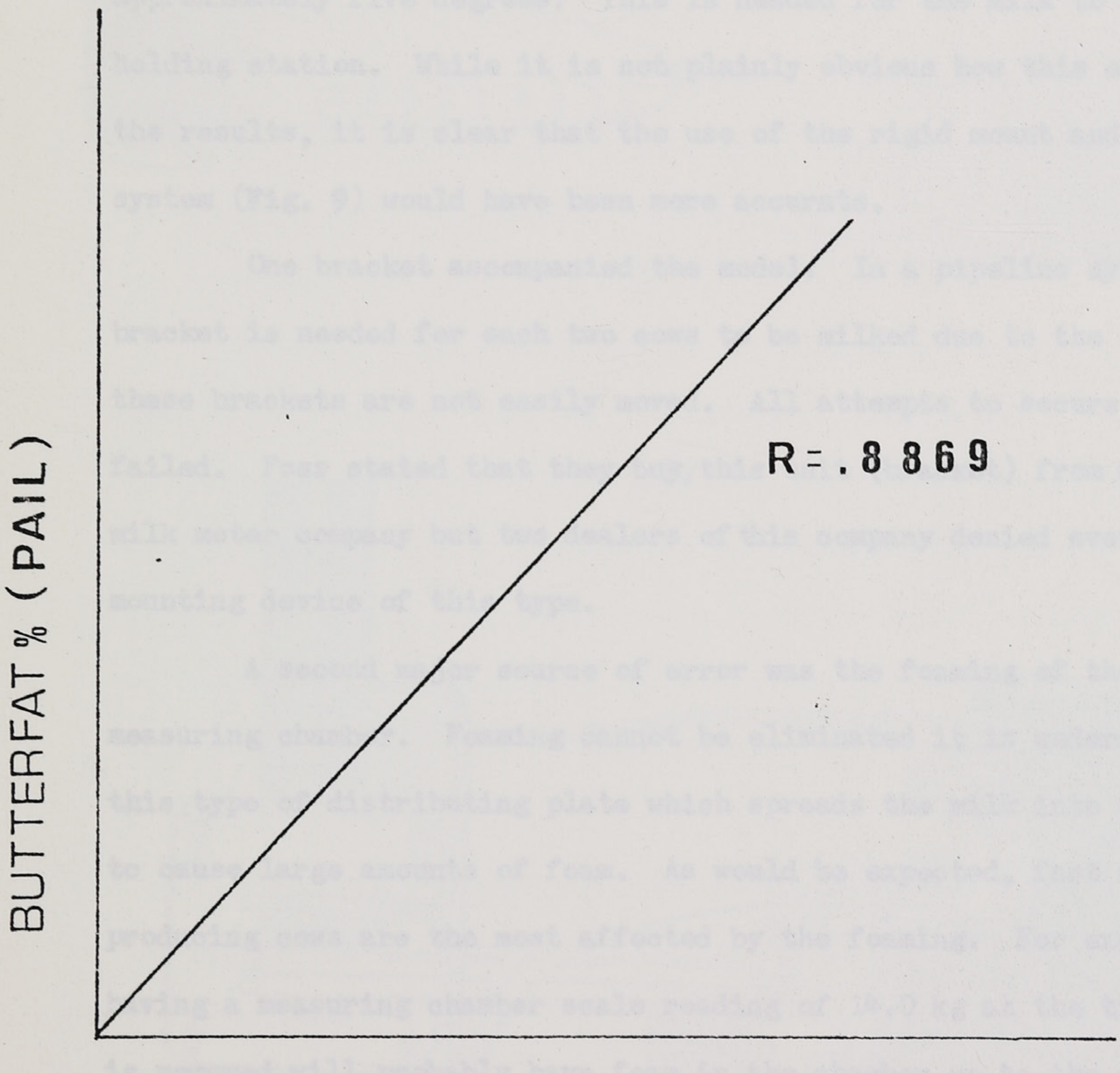
Another attempt to obtain data was performed, this time using a mercury manometer. As in the first case, fluctuations in the mercury level, due to the pulsator's action, hindered the collection of data.

TABLE IV Butterfat Samples

No.	Meter Sample	Pail Sample	No.	Meter Sample	Pail Sample	No.	Meter Sample	Pail Sample
1	3.31	3.42	33	5.22	5.24	65	3.69	3.71
2	3.66	3.64	34	5.16	5.28	66	3.41	3.32
3	3.37	3.38	35	4.73	4.68	67	3.29	3.30
4	3.41	3.36	36	4.71	4.81	68	3.71	3.85
5	3.42	3.35	37	3.66	3.80	69	3.76	3.68
6	4.02	4.04	38	4.00	3.91	70	3.82	3.68
7	4.55	4.66	39	4.20	4.29	71	3.15	3.26
8	4.68	4.84	40	4.20	4.19	72	3.08	3.12
9	5.73	5.88	41	4.10	4.19	73	5.94	6.01
10	4.84	4.90	42	4.50	4.43	74	4.78	4.83
11	6.09	5.99	43	3.89	3.52	75	3.28	3.16
12	5.05	5.09	44	5.35	5.36	76	4.07	4.03
13	5.23	5.33	45	4.28	4.21	77	4.40	4.44
14	3.98	3.98	46	2.81	2.73	78	4.23	4.19
15	3.46	3.47	47	5.09	5.21	79	6.17	6.27
16	3.67	3.68	48	4.56	4.56	80	4.73	4.82
17	3.50	3.44	49	4.08	4.02	81	5.03	4.87
18	4.28	4.35	50	5.96	6.13	82	3.09	2.94
19	4.11	4.06	51	3.58	3.57	83	3.59	3.69
20	4.48	4.71	52	5.36	5.41	84	3.06	3.12
21	4.37	4.42	53	5.23	5.14	85	3.90	3.85
22	3.50	3.51	54	3.34	3.24	86	2.17	2.20
23	3.84	3.86	55	4.11	4.01	87	3.00	2.92
24	2.38	2.37	56	2.77	2.71	88	3.48	3.42
25	3.74	3.71	57	3.83	3.73	89	4.59	4.42
26	4.71	4.81	58	3.00	3.10	90	2.87	2.83
27	3.01	3.01	59	3.89	3.91	91	3.89	3.85
28	4.28	4.37	60	3.83	3.79	92	4.34	4.18
29	4.87	4.82	61	3.86	3.89	93	3.52	3.62
30	4.60	4.59	62	3.39	3.21	94	3.67	3.59
31	6.67	6.74	63	4.04	4.14	95	3.49	3.47
32	6.02	6.08	64	2.17	2.09	96	4.06	4.06

Figure 8.

CORRELATION OF BUTTERFAT %



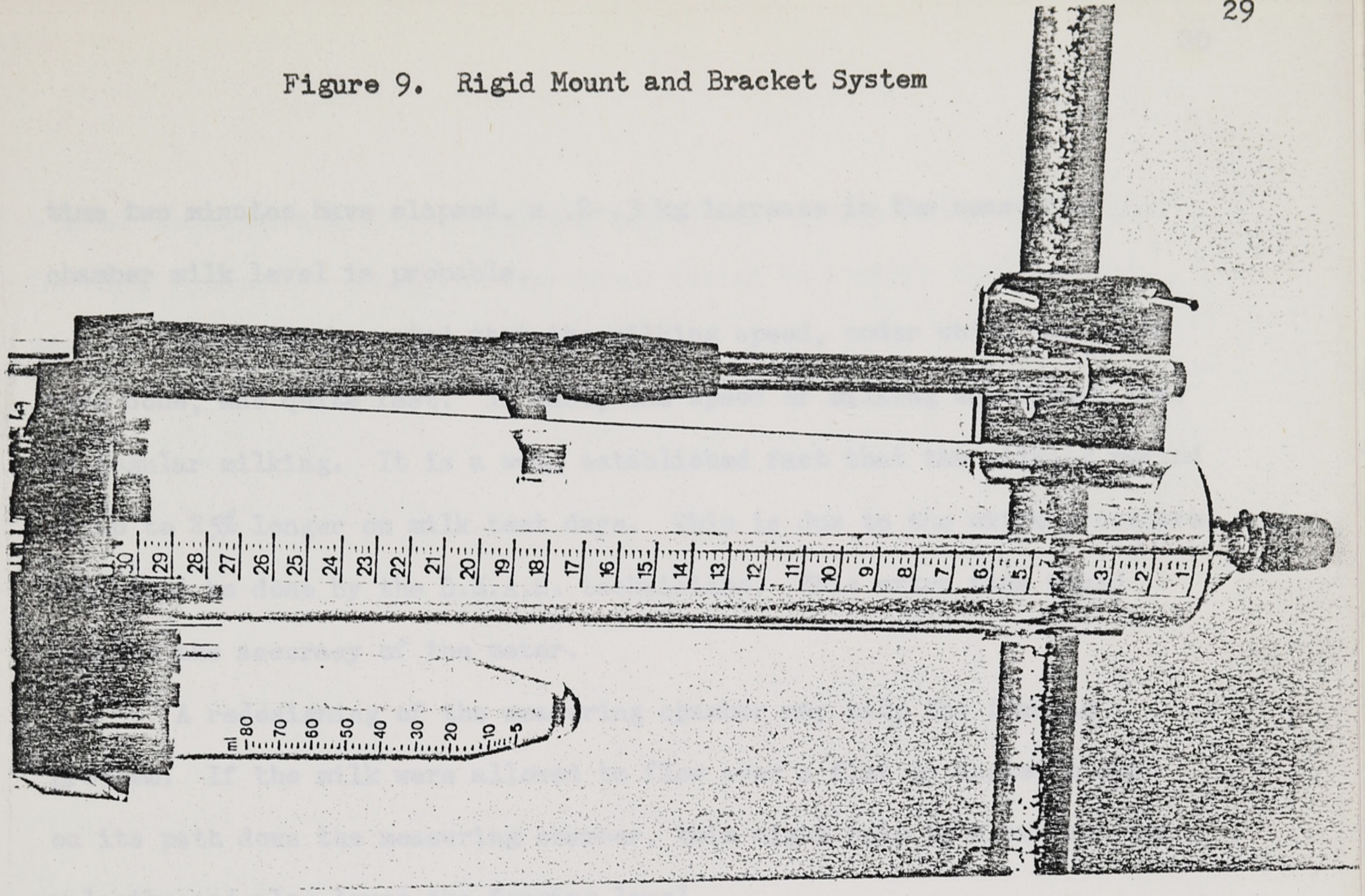
Discussion

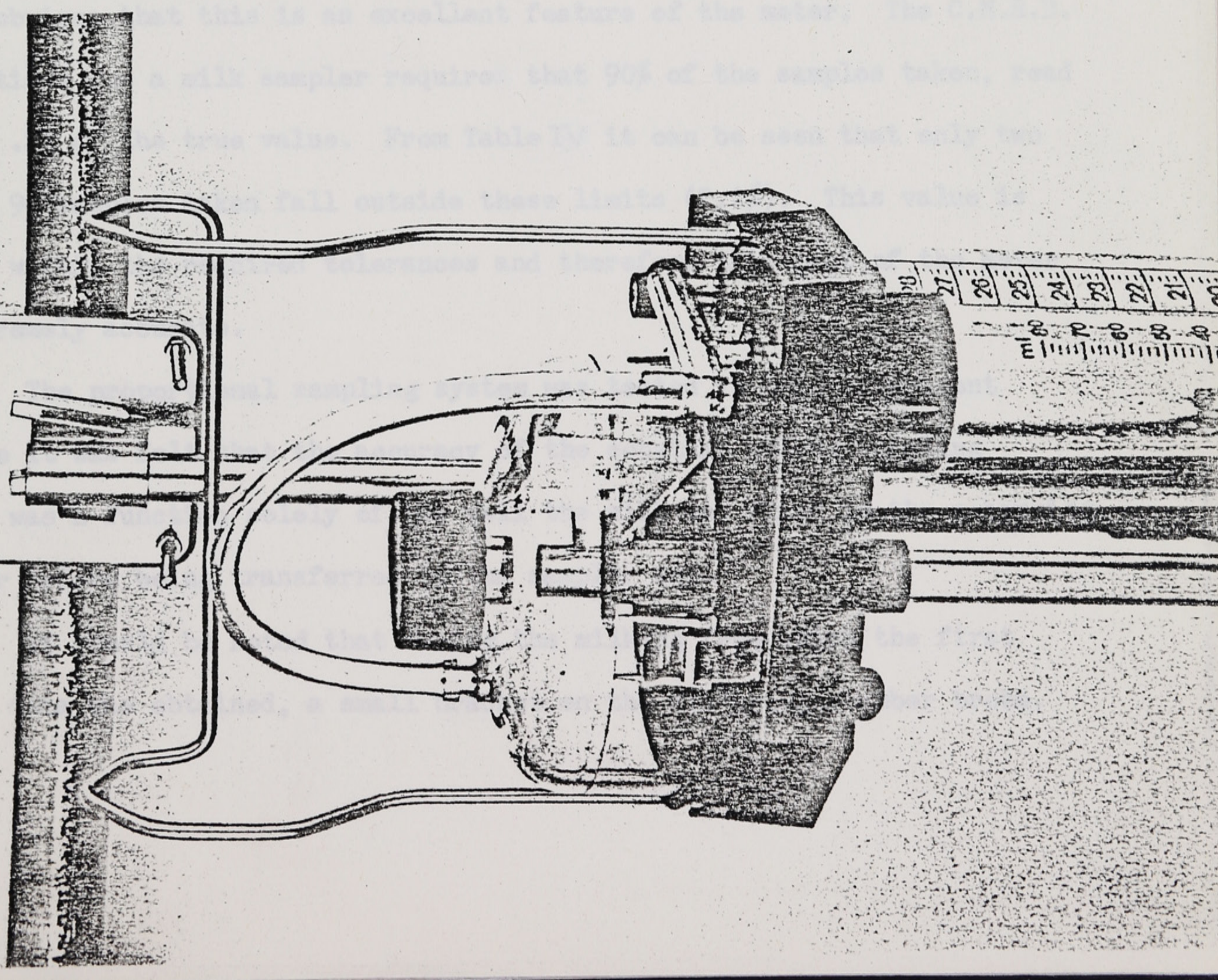
A first reaction to the bias error calculated for the meter would be that this meter is highly inaccurate and warrants no further inspection. A partial explanation for these errors may be found in the testing procedure. First of all, the meter was mounted on the pipeline by means of a hanger. Pipelines are on a grade of up to 1:10 so that the angle is approximately five degrees. This is needed for the milk to flow to the holding station. While it is not plainly obvious how this error affected the results, it is clear that the use of the rigid mount and bracket system (Fig. 9) would have been more accurate.

One bracket accompanied the model. In a pipeline system one bracket is needed for each two cows to be milked due to the fact that these brackets are not easily moved. All attempts to secure more brackets failed. Foss stated that they buy this unit (bracket) from a competitive milk meter company but two dealers of this company denied ever seeing a mounting device of this type.

A second major source of error was the foaming of the milk in the measuring chamber. Foaming cannot be eliminated it is understood, but this type of distributing plate which spreads the milk into a dome seems to cause large amounts of foam. As would be expected, fast milking, high producing cows are the most affected by the foaming. For example, a cow having a measuring chamber scale reading of 14.0 kg at the time the milker is removed will probably have foam in the chamber up to the 15 kg scale reading. If this reading is not taken immediately, a slow decrease in the foam and a very small increase in the milk line can be seen. By the

Figure 9. Rigid Mount and Bracket System





time two minutes have elapsed, a .2-.3 kg increase in the measuring chamber milk level is probable.

It should be noted that the milking speed, under which the tests were done, was quite fast. In fact, the speed of milking was almost that of regular milking. It is a well established fact that the milking period is up to 25% longer on milk test days. This is due to the extra procedures that must be done by the D.H.A.S. technicians. This extra time would improve the accuracy of the meter.

A redesigning of the measuring chamber may help the foaming problem. If the milk were allowed to flow over a flat or angled plate on its path down the measuring chamber, this might help to slow down its velocity and also lower the foaming level.

From the data collected for the comparison of the butterfat sample taken by the meter and the butterfat sample taken from the pail it is obvious that this is an excellent feature of the meter. The C.M.R.B. regulations for a milk sampler require that 90% of the samples taken, read with ± .2% of the true value. From Table IV it can be seen that only two of the 96 samples taken fall outside these limits (2.1%). This value is easily within the required tolerances and therefore this part of the meter is extremely accurate.

The proportional sampling system was tested in this experiment because it was felt that the accuracy of the constant volume sampling system was a function solely of how well the milk was mixed in the measuring chamber before being transferred to the sampler cup.

It should be noted that during the milking from which the first set of data was obtained, a small bracket on the measuring chamber broke.

A later discussion with Foss indicated that many meters had been recalled for this reason and changes in the meter design to rectify this problem were already on the drawing board.

Conclusion

The decision of the C.M.R.B. on whether to continue with further testing on this meter, is based solely on the accuracy of the data contained in this experiment. While the results indicate the bias error of the meter exceeds government standards, it is the firm recommendation of this author that the second phase of tests be initiated.

This conclusion is based on the observation of errors discussed in the previous section. The obvious high quality of engineering to produce this product is displayed in its crash-proof plastic frame, the choice of two types of butterfat sampling, the permanently mounted measuring chamber and its change of calibration mechanism.

The small p values indicate that the meter is consistent and if the foaming problem is overcome, or at least not as prominent when the unit is used inline with other milking systems, then this meter will prove to be one of the best on the market today.

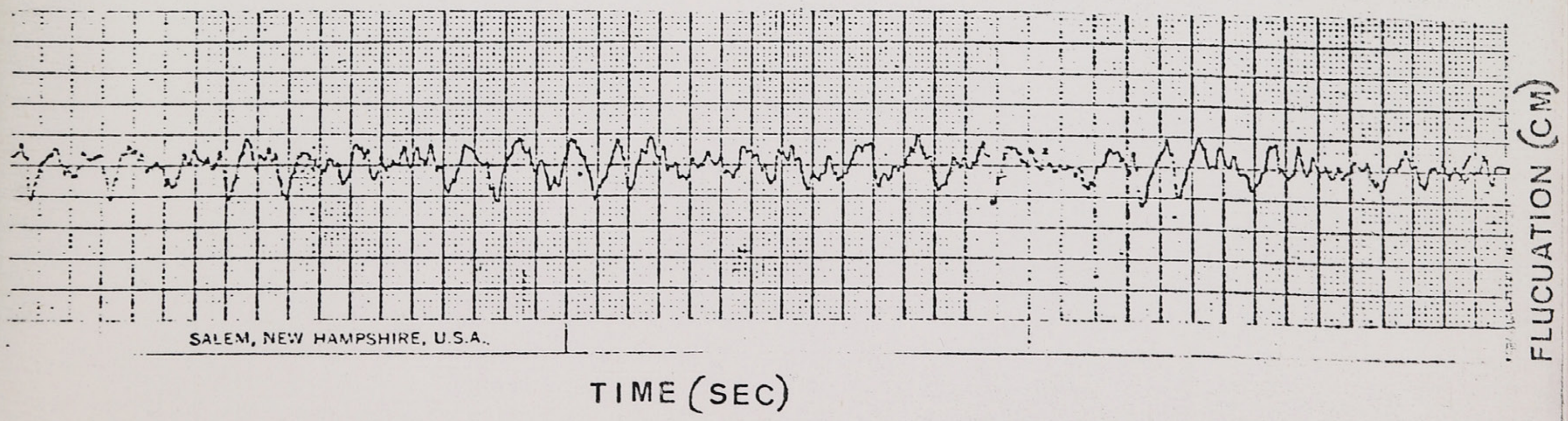
Further Research Required

The approval of a milk meter cannot be based on one single set of test data. For an unbiased view of the accuracy of a meter, many groups of cows and several different milking systems must be used. There are too many variables due to milking systems and cows for decisions to be made on small sample sizes.

The accuracy of any meter will vary when the hang angle of unit is changed. Accuracy at different angles should be inspected to ensure that an error is not introduced into readings when the meter is hung on the pipeline by means of a wire clamp.

The need to verify the manufacturer's pressure drop claim is one of the most important factors needed to be tested on this meter. As previously described, the pressure gauges and mercury manometer proved to be inadequate in measuring the pressure differential. It is the opinion of this author, that an automatic electronic mini-volt manometer, which can either monitor the pressure continuously or intermittently (Fig. 10), would prove to be the best solution to this problem. This machine would also give a much more accurate pressure reading.

Figure 10. Vacuum Fluctuations in Milk Lines



Bibliography

1. Ashton, E. D. 1956. Milk and Butterfat Recording - A World Survey. Commonwealth Bureau of Dairy Science and Technology. Bradley and Son Ltd., Reading, England.

2. Burnside, E. B., Hacker, R. R. and Shoraley, M. A. 1971. The Use of Milking Meters and Instrumented Milk Analysis in dairy herd recording. J. Dairy Technology. 30(2): 67-70.

3. Farrall, A. N. 1963. Engineering for Dairy and Food Products. John Wiley and Sons, Inc., New York.

4. Lapin, L. 1975. Statistics - Meaning and Method. Harcourt Brace Jovanovich, Inc., New York.

5. Smith, J. W. and Plowman, R. D. 1968. Accuracy and Precision Required in Measuring Devices Used in Dairy Herd Improvement Association Recording. J. of Dairy Science. 51(2): 162-168.

6. Smith, J. W., Plowman, R. D. and Spencer, S. B. 1969. Current Status of Weighing, Sampling, and Testing Devices for Use in the National Dairy Herd Improvement Program. J. of Dairy Science. 52(2): 128-137.