AN APPARATUS FOR RECORDING MILK-FLOW CURVES OF COWS MILKED BY MACHINES

BY A. J. W. MURRAY*

SUMMARY

The apparatus records the speed of milking graphically through low voltage electrical impulses. Each 0·2 lb milk entering the vacuum milk bucket is registered as an increment on the graph. All necessary data for the assessment and comparison of milking rates can be obtained from the milk-flow curves.

The apparatus is portable, may be used in any bail, and may be fitted to any commercial milking plant, thus enabling recordings to be made of the milking rates of cows in commercial herds.

I. INTRODUCTION

Research workers in several countries have carried out experiments to obtain information about the mechanical milking of cows. In many of these experiments concerning milking rate, the data were obtained by suspending a bucket from a balance and, using a stop-watch, noting the amount of milk registered by the scales at intervals of 10, 20 or 30 seconds (Smith and Petersen 1946; Baxter, Clarke, Dodd, and Foot 1950; Dodd 1953; and Stewart, Schultz, and Coker 1957). This method would appear to be very laborious, and easily subject to human error. To achieve an accurate assessment of rates of milking, any means used should be capable of measuring small variations in the milking speed. It is desirable to have a complete record of milk ejection and this can be obtained only by having some recording device which gives a graph of the milk flow.

Several reports have been made of apparatus designed to give a graphic record of the milking process. Whittlestone (1945) described apparatus for the measurement of milking rate, and this equipment was later modified to make it completely automatic (Whittlestone and Phillips 1953). This apparatus was relatively complex and designed for use attached to special milking equipment in a research institute. Beck, Pryer, and Roark (1951) also used mechanical apparatus for recording rate of milk flow. In this case a copper wire was attached to the end of a suspension-coil spring, on which was hung the milking bucket, and to a pen assembly mounted on a continuous-feed kymograph. The complete apparatus was set up in the bails. A somewhat similar piece of apparatus was used by Ace, Theole, Kesler, and Cloniger (1959).

* Senior Adviser, Division of Dairying, Queensland Department of Agriculture and Stock.

A description is given here of a recording device which has been used in Queensland in measuring the milking rate of dairy cows. This apparatus is portable and designed for operation in conjunction with any type of commercial milking equipment.

II. DESCRIPTION OF THE APPARATUS

The two sections of the milk flow recording apparatus can be described as (1) the weighing and signalling system, and (2) the graphing unit. The former is set up in the bails beside the cow, and the graphing device may be placed in any convenient position within the milking shed, so the operator can be positioned away from the bails with no danger of causing unaccustomed disturbance to the cows.

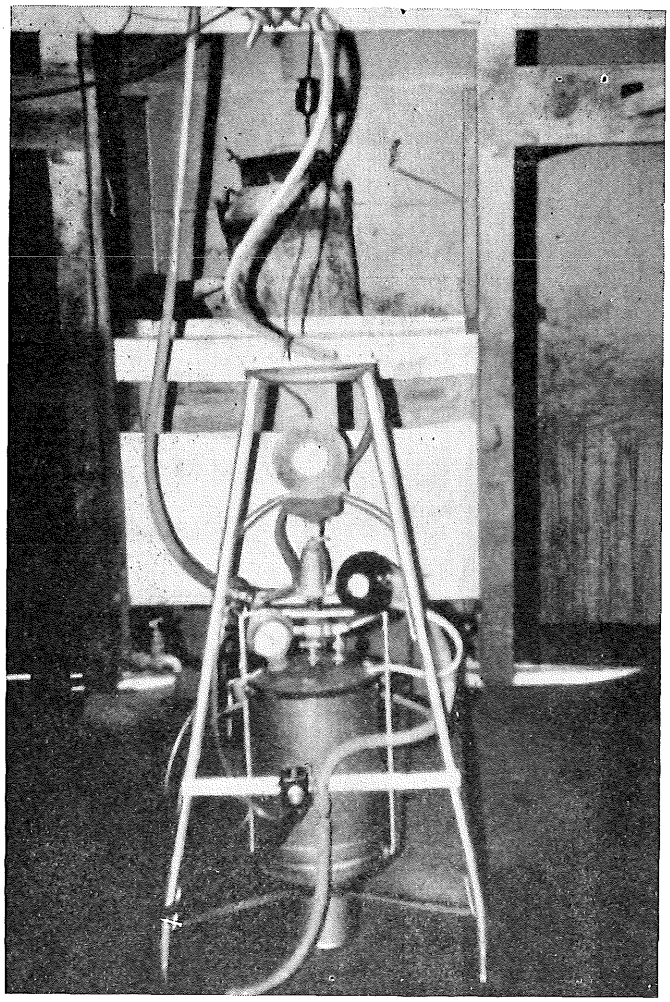

Fig. 1.—The weighing and signalling section of the recorder set up in the bails.

(a) Weighing and Signalling System

This section of the recorder is shown in Figure 1. A vacuum bucket suspended from spring-type weighing scales is set up within a metal tripod stand. This stand has screw adjustments on each leg which enable the weighing bucket and frame to be positioned in a vertical plane irrespective of the slope of the bail floor. Rods, operating through ball-bearing guides at the top and bottom of the frame, prevent sideways movements of the bucket, which would affect the accuracy of the recording.

The lid is fitted with two taps and two $\frac{5}{8}$ in. metal tubes, so arranged internally as to enable milk to be completely emptied from the bucket into the main milk-line of the milking plant after each recording. The milk intake line is designed to minimize vibration of the bucket and frothing of the milk during filling by directing the flow of milk down the sides of the bucket. Any remaining vertical vibrations, which would cause undue oscillation of the arm of the signalling device, are dampened by a saucer-shaped, adjustable disc attached to the base of the bucket frame and operating in oil. Premium multi-grade oil, which maintains approximately constant viscosity at different air temperatures, is used. Flexible plastic tubes connect the metal tubes on the lid of the bucket to the main air-line and milk-line of the milking machine.

Milk from the teat assembly of the machine passes through a milk-flow indicator before entering the bucket. When the rate of milk flow is greater than 1 lb per min the sight-glass is full, but when the milk flow becomes less than this rate the level of milk in the sight glass falls. Machine stripping of cows was carried out when the milk in the sight-glass of the milk-flow indicator showed it to be half-full.

A special vacuum control valve enables any lower milking vacuum to be maintained in the test unit during controlled milking experiments without affecting the vacuum level of the remaining milking units of the machine. Vacuum is registered on a gauge fitted in the lid of the milk weighing bucket. A commercial pneumatic pulsator, operating directly from the control valve, and plain synthetic inflations with cluster-type milking claw are used. Another vacuum gauge mounted on the tripod stand can be connected by a plastic tube and metal T-piece to a milk claw rubber, to enable vacuum levels in the claw rubbers to be noted during the milking process.

The signalling device is attached to the face of the weighing scales and has a moving contact arm actuated directly by movement of the centre spindle of the scales. A series of 100 equidistant contact points are arranged in the form of a circle so that the contact arm moves from one point to the next around the circle as the weight of milk in the bucket increases. Each increment of 0·2 lb milk causes the arm to make contact with the next point. Alternate points are connected by electrical wiring, giving two distinct circuits in the signalling unit, such that each point is in a different circuit to the point on each

side of it. The electrical circuits are completed by attaching the positive terminal of a 6 v. battery to the centre movable contact arm, and connecting the lead wires from the two circuits in the signalling unit to negative through the recording unit. A standard 3-wire electrical lead is used to complete the circuit between the signalling unit and the graphing unit.

(b) Graphing Unit

This unit is illustrated in Figure 2. It is contained in a cabinet 15 in. x 15 in. x 8 in. and includes a drum which is operated by clockwork and which carries the graph paper around its circumference. The drum rotates at a constant speed of approximately one revolution per hour. Stopping and starting the clockwork is carried out by a manually operated lever. The upward movement of the recording arm and nib in contact with the paper rotating with the drum results in a milk-flow curve being drawn.

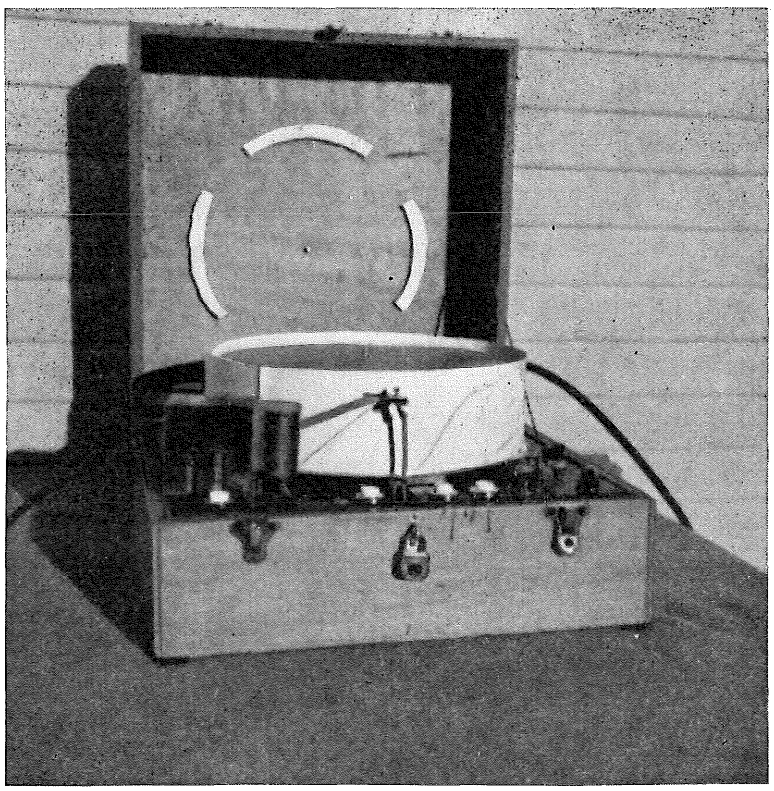

Fig. 2.—The graphing unit of the recorder.

Electrical impulses from the signalling unit, as the contact arm completes the circuit associated with each alternate set of points, momentarily energize relays in the graphing unit. The relays in turn cause an electromagnet to operate a catch-and-release trip which directly controls the constant upward movement of the recording arm through a train of spring-loaded cogs.

An electrically operated circuit breaker is used to break the flow of electricity automatically immediately the circuit is closed by the contact of the moveable contact arm with any contact point. This immediate breaking of the circuit prevents pitting or burning of the points in the signalling unit. The flow of electricity required to operate the automatic circuit breaker is sufficient to energize the electromagnet which controls the movement of the recording arm.

Indicator lights on both the weighing and the recording sections of the apparatus ensure that the weighing unit is at zero before the commencement of each cow's recording. Provision is made for manually controlled, electrically operated notations to be made on the milk-flow curves to indicate when the teat assembly is placed on the cow, the commencement of machine stripping and the time the cups are removed from the cow.

III. INTERPRETATION OF MILK-FLOW GRAPHS

Typical examples of the graphs obtained are shown in Figure 3. Curve A is a recording of a cow which milked out quickly and Curve B is that of a slower milker under the same conditions. The small arrows indicate the time of machine stripping.

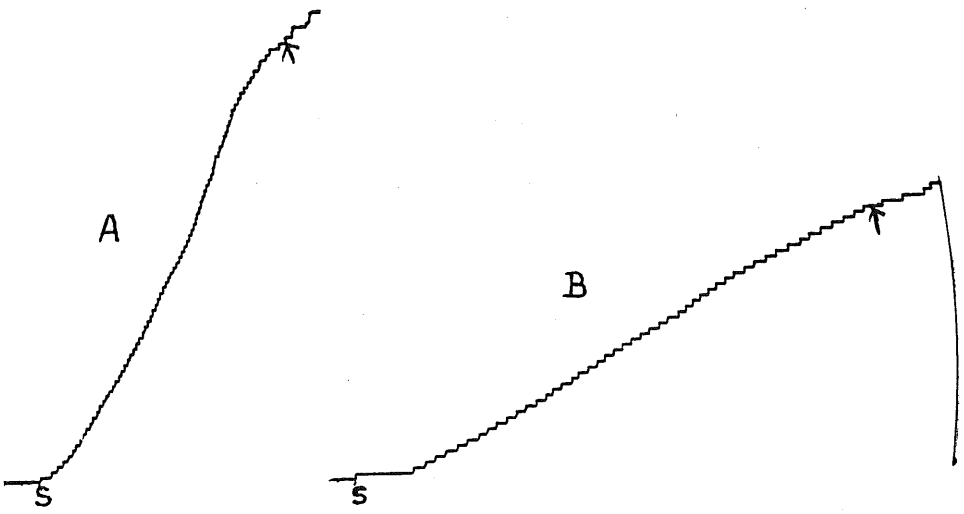

Fig. 3.—Typical milk-flow curves of a fast cow (A) and a slower cow (B) under the same milking conditions. S indicates the start of milking and the arrow machine stripping.

A plastic guide, calibrated with a time base in half-minute graduations along its horizontal axis and pounds of milk along its vertical axis, is used to obtain relevant data from the milk-flow curves. By this means, values for (*a*) total yield of milk, (*b*) total milking time, (*c*) milking time to the start of the machine stripping, (*d*) yield before machine stripping, (*e*) duration of

machine stripping, (*f*) amount of machine strippings, (*g*) time before the first 0·2 lb milk was recorded, and (*h*) maximum milking rate in lb per min during any half-minute can be obtained directly. By the use of the data and other calculated information, the milking characteristics of individual experimental cows can be compared.

IV. DISCUSSION

The apparatus described is similar to that of Whittlestone (1953) in that increases in the weight of milk as milking proceeds are conveyed to a recording unit by electrical impulses. However, the details of the methods used in the two recorders are quite different. The apparatus as described here is simple to operate and robust. It has been designed as simply as possible so that it is easily portable and can be attached to any type of commercial milking plant. It is not completely automatic but requires an operator other than the milker to tend the recording device.

The inclusion of the special vacuum control valve permits the test unit to be used at a lower vacuum than that of the main plant, without the need for a special vacuum pump. Pulsation rate is also set in the test unit quite independently of conditions in the other units. Test cows can therefore be milked as desired without upsetting the normal milking procedure for the rest of the herd.

The design of the bucket and connections is such that emptying of milk into the main line is very rapid and easily controlled by the milker. Cleaning and sterilizing operations at the end of milking are also simple. On machines fitted with in-line cleaning, the bucket, teat-cups and lines can be joined to the main system and cleaned without dismantling.

REFERENCES

ACE, D. L., THEOLE, H. W., KESLER, E. M., and CLONIGER, W. H. (1959).—Device for measuring rate of milk flow. *J. Dairy Sci.* 42:876-7.

BAXTER, E. S., CLARKE, P. M., DODD, F. H., and FOOT, A. S. (1950).—Factors affecting the rate of machine milking. *J. Dairy Res.* 17:117-27.

BECK, G. H., FRYER, H. C., and ROARK, D. B. (1951).—Use and interpretation of milk flow curves in measuring variations in the response of cows to machine milking. *J. Dairy Sci.* 34: 58-67.

DODD, F. H. (1953).—Normal variations in the rate of machine milking. *J. Dairy Res.* 20:301-18.

SMITH, V. R., and PETERSEN, W. E. (1946).—The effect of increasing the negative pressure and widening the vacuum release ratio on the rate of removal of milk from the udder. *J. Dairy Sci.* 29:45-53.

STEWART, W. R., SCHULTZ, L. H., and COKER, S. P. (1957).—Studies on the rate of machine milking of dairy cows. 1. Normal variations. *J. Dairy. Sci.* 40: 258-63.

WHITTLESTONE, W. G. (1945).—Apparatus for the measurement of the rate of milk ejection in the dairy cow. *N.Z. J. Sci. Tech.* A 26: 252-7.

WHITTLESTONE, W. G., and PHILLIPS, D. S. M. (1953).—Automatic apparatus for drawing milk ejection curves of cows under controlled milking conditions. *J. Dairy Res.* 20: 319-26.

(Received for publication March 14, 1960)