ELECTRONIC "END OF MILKING" DETECTOR AND TEAT CUP REMOVER

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ABSTRACT

A photo-transistor circuit has been developed to detect the milk-air interface in the "Ruakura" milk flow indicator. When the milk flow rate is between one-quarter and three-quarter lb per minute the teat cups are automatically removed. A time delay prevents the teat cups being removed before the start of milk flow.

INTRODUCTION

The recently introduced rotary milking systems have given the farmer the opportunity to milk 100--120 cows per hour with two milkers. One milker prepares the cows for milking and puts the teat cups on while the other removes the cups when the milk-flow rate has fallen below ½ lb of milk per minute. A system for automatic removal of the cups at the correct time would allow one man to milk 100--120 cows per hour. This paper describes the prototype of such a system.

TEAT CUP REMOVAL CIRCUIT

The detector consists of a lamp and photo-transistor in a sensing head which is attached to the milk-flow indicator, a transistor amplifier which drives a solenoid valve, and a time delay circuit.

The sensing head is shown in Fig. 1 and the assembly of milk flow indicator and sensing head in Fig. 2. A lens-end bulb focuses a bright spot of light on to the surface of the milk and the reflected light is picked up by photo-transistor type BPX25 which conducts heavily. When the level of milk in the milk flow

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"End of milking" detector

Fig. 2—Photo transistor sensing head and "Ruakura" milk flow indicator.

Fig. 3—Amplifier circuit.

Fig. 4—Time delay circuit.
indicator falls, the light spot impinges on the black inner surface of the indicator. Very little light is reflected and the photo-transistor current is greatly reduced. The 2.5V lens-end bulb is run at 2.0V to increase its life.

The amplifier circuit is shown in Fig. 3. The emitter of the BPX25 photo-transistor is connected directly into the base of the driver transistor BC109. The collector of the BC109 is directly connected to the base of the output transistor 40312. The collector load of the 40312 is a solenoid valve which controls the pneumatic rams of the teat cup removal unit.

When the photo-transistor BPX25 is illuminated by reflection from milk its resistance decreases to a very low value, a large current flows into base of amplifier BC109, and the transistor saturates. Collector of BC109 and base of 40312 fall to a very low voltage and 40312 switches off current flowing through the solenoid. The solenoid valve connects the rams to ambient air pressure which returns the teat cup assembly to position ready for milking.

When the milk level falls past the lamp very little light is reflected into the photo-transistor and its resistance increases to a very high value. Little current now flows into base of BC109 and it switches off. The collector of BC109 and base of 40312 are driven positive and a heavy current flows via 40312 collector through the solenoid. The solenoid valve switches to vacuum, operating the pneumatic rams of the teat cup removal unit.

The negative rail of this circuit is switched by a time delay.

TIME DELAY CIRCUIT

A time delay is necessary to prevent teat cup removal when the milk flow indicator is still empty at the start of milking. A delay of about 3 minutes is needed to allow a slow cow to start milking. If one or more teat cups leak air or fall off during milking, the milk flow indicator may empty suddenly and all teat cups will then be automatically removed. A further time delay of about 1 minute is needed to allow milk to fill the indicator again when teat cups have been replaced on the cow.

In certain circumstances the cups may have to be removed immediately and provision has been made for this in the circuit.

Fig. 4 shows the time delay circuit (Motorola Semiconductor Data Book 1969). The unijunction transistor 2N2646 is part of a relaxation oscillator circuit, the timing of which is controlled by a 16μF capacitor and constant current source field effect transistor MPF103. Oscillation commences when switch BP1 is pressed and released. This opens and then closes the 24V supply to the circuit. After approximately 3 minutes the 16μF capacitor is charged sufficiently to fire the unijunction transistor 2N2646 which now conducts heavily. The upper end of the 27 ohm resistor in the B1 lead of the unijunction is driven positive: this fires the silicon controlled rectifier MCR1906-2 which switches on the teat
cup removal circuit. The anode of the silicon controlled rectifier is now at a very low potential and the unjunction oscillator is locked off via the drain terminal of the MPF103. Oscillation ceases until switch PB1 is broken and made again.

For 1 minute time delay, switch PB1 is pressed and released. Next, the 16\(\mu\)F capacitor is partly charged from resistor chain 10K-10K by pressing and releasing switch PB2, thereby shortening the time to charge the capacitor fully.

For immediate cup removal switch PB1 is pressed and released. Switch PB3 is then pressed and released. This charges the 16\(\mu\)F capacitor via a 10K resistor and initiates almost instantaneous switching.

**DISCUSSION**

There are, of course, other methods by which one man can milk a herd on his own using the rotary shed. Phillips (1971) introduced the double rotation system using an odd number of bails which avoids the need for automatic teat cup removal. This system enables the man to inspect the cows' teats after milking.

In an alternative system, which does not require the automatic detection of end of milking, the teat cup removal is triggered at three different positions which are preset by the man at the "cups on" position. This assumes that he knows the milking time of each cow fairly accurately. No inspection of teats after milking is possible. The equipment is simple, robust, and unaffected by water, but does not avoid some over- or under-milking.

The electronic method described here provides a more accurate determination of the end of milking than these two methods, but the equipment is expensive and very difficult to keep water-proof against high-pressure hoses. Again, no inspection of teats after milking is possible. The prototype described was designed only to test the principles: in commercial production more economical components would be used.

**REFERENCES**
