A RADIOSONDE FOR MEASURING RUMINAL PRESSURE [1]

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INTRODUCTION

Classically, studies on rumen pressure and activity have been made by transmitting pressure from the rumen via a tube through the esophogous or left flank to conventional mannometric equipment. More recently ruminal pressure has been determined by the pressure necessary to flatten the bulge in the left flank (2). The limitations of these methods prompted investigation at South Dakota State College of the radiosonde as a device for measuring ruminal pressure.

APPARATUS

Three radiosondes were constructed, differing somewhat in construction but identical in circuitry. In operation, these were battery powered transistor oscillators frequency modulated by changes in pressure. The frequency modulation was achieved by mounting the tuning slug of the oscillator on the free end of a pair of evacuated bellows. Figure 1 shows diagrammatically the basic construction employed in these units. The transmitter is one described by Raytheon (1) less antenna and key and operating on 18 volts instead of nine. Figure 2 shows the relationship of frequency and pressure for one of these units.

The signal from the radiosonde is picked up and recorded by a system consisting of a Loopstick antenna, a communications receiver, a frequency meter, and a millivolt recorder, in that sequence. The receiver, set for cw reception, converts the signal to an audio frequency note. In effect, the receiver subtracts a given frequency (nominally the dial frequency reading, actually the difference in frequency between the local and beat frequency oscillators of the receiver) from the signal frequency. This conversion retains the sign and absolute magnitude of a change in signal frequency if the receiver is set below the signal frequency. The sign is reversed if the receiver is set above the signal frequency.

The audio signal is converted by a Heathkit frequency meter to a DC signal with voltage proportional to input frequency. A

[1]Approved by the director of the South Dakota Experiment Station as paper No. 432 of the Journal Series. This work was supported in part by Regional Research Fund NC-27.

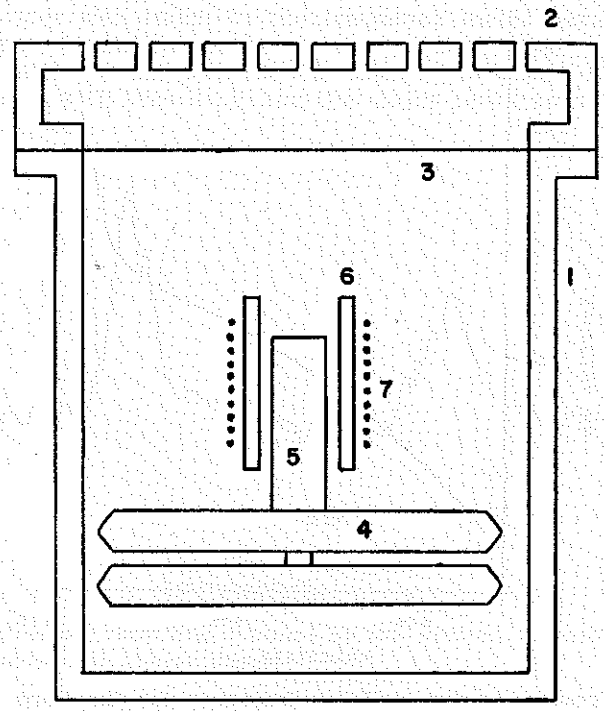

Figure 1

1. Plastic Case
2. Perforated Cap
3. Rubber Diaphram
4. Evacuated Bellows
5. Ferrite Slug
6. Tuning Coil
7. Feedback Coil

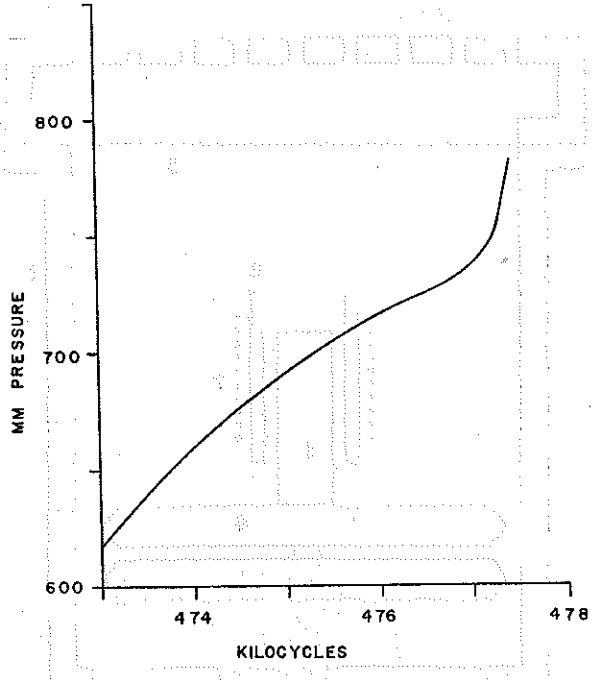

Figure 2. Pressure versus oscillator frequency for the third radiosonde. The break in the curve at 477.5 KC was caused by the rubber diaphram bearing down on the batteries.

voltage divider was added to the frequency meter parallel to the meter proper, furnishing output to the recorder. Figure 3 shows a sample recording obtained with this setup. The minor fluctuations are correlated with breathing, and the major peaks are due to ruminal contractions.

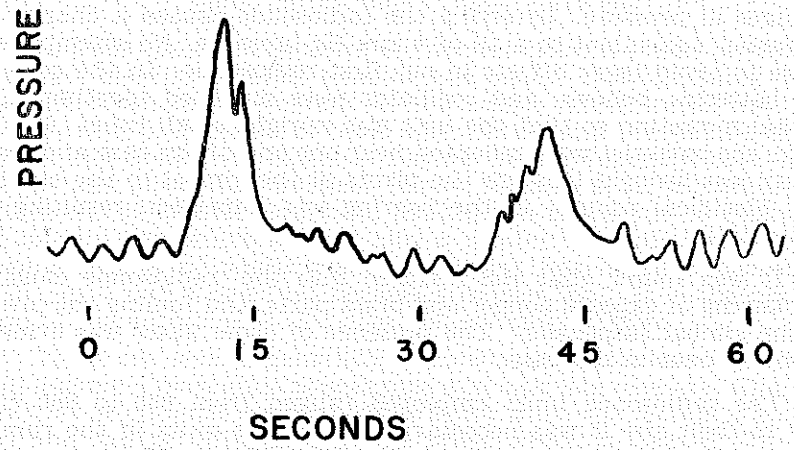

Figure 3. Pressure recording obtained by this system. Pressure scale (not shown) is almost linear.

DISCUSSION

This system permits convenient, precise and continuous monitoring of the pressure of the radiosonde unit and can easily be adapted to record pressure in several animals in rapid sequence. In this regard the system is a gratifying success. The radiosonde units, while they did operate successfully, are much in need of improvement.

The most obvious limitation of the radiosonde is battery life. The longest run was about 10 days at 18 milliwatts load using two mallory TR-146R mercury batteries. The energy yield of 2×10^{-3} watt days per gram is comparable to the published value for the Everready W-307 cell, 2.9×10^{-3} watt days per gram, and is about twice the yield expected from a D cell (3).

It is expected that more efficient power can be obtained by using a pair of electrodes attached to the radiosonde and using rumen juice as electrolyte. The theoretical energy yield is approximately 10^{-1} watt days per gram of anode, using magnesium as the anode. Even more promising as a power source is the atomic thermoelectric generator which is currently in the news.

Orientation of the radiosonde is a definite problem. First, the radiation pattern of the radiosonde has a conical shaped dead zone and its signal is not detectable when the pickup is in this zone. If orientation is not controlled, the received signal will occasionally drop to zero strength. The ferrite slug behaves as a weight attached to a spring so it responds to changes in orientation as well as changes in pressure. Inverting the radiosonde caused a change in frequency equivalent to a ΔP of 4 mm Hg pressure. No attempt was made to avoid these effects in our first radiosonde. In the second, the batteries, bellows, and oscillator were mounted together in a gimbal mounting so that the unit was upright at all times. In the third, the batteries were mounted near one end of the case and electricity was brought through the pivots of the gimbal to the oscillator. Electrical contact in the bearing was imperfect, resulting in some static.

It was found that H_2S diffused into the radiosonde causing blackening of exposed copper and brass parts, and fouling the pivots of the gimbal suspension. The presence of other gases was evident from the odor in the case.

The radiosonde units employed ranged from 650 to 950 cm^3. Due to their size it was necessary to place the units in the rumen surgically, going through the para lumbar fossa. Miniaturization to a size that will pass through the esophogus would add considerable convenience to this system.

For a static free signal, it was necessary to place the pickup immediately over the cow. If a loud speaker were substituted for the recording equipment, ruminal contractions could be detected by a change in pitch of the beat note when the cow was thirty feet from the pickup. An increase of power would extend this range but would shorten battery life. A passive device operating at VHF or UHF frequencies or atomic power is needed to circumvent these limitations.

REFERENCES

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