A Transducer for Motion Study by Radio Telemetry. (30816)

ARTHUR STATTELMAN AND HERBERT COOK (Introduced by R. W. Dougherty)
Electronic Development and Physiopathological Investigations Sections, National Animal Disease Laboratory, Animal Disease and Parasite Research Division, ARS, USDA, Ames, Iowa

The availability of devices for quantitatively measuring activity and motion in the experimental animal appears to be inadequate (1,2,3). This study was conducted to develop a miniature transducer, adaptable to radio telemetry, for detection of body motion in the unrestrained animal. Following development of the motion transducer it was assembled with a transmitter as the motion transducer transmitter (MTT).

To ascertain the versatility of the MTT, several species were subjected to simultaneous observation and recording of various activities. Direct-wire recordings with a pneumatic system were employed simultaneously with radio telemetry as a standard for comparison in several experiments. The sheep, pigeon, cow, and infant were selected as experimental subjects to show various applications of the MTT to motion studies.

Materials and methods. Motion transducer transmitter. The motion transducer (MT) was a variable capacitor which consisted of half circle brass plates attached to each side of a sealed plastic cylinder partially filled with oil* (Fig. 1). The MT was attached to the transmitter by pin receptacles to provide ease of adjustment and replacement. The capacitance of the MT was dependent on the ratio of oil to air between the brass plates (X_1). This ratio being a function of the cylinder position (angle θ) varied directly with the rotation of the cylinder about its axis (Fig. 1).

TABLE I. Components and Specifications of the Motion Transducer Transmitter.

MOTION TRANSDUCER	
Plastic cylinder: 3/32 in. thick, ¾ in. diameter oil/air ratio: 50-50.	
TRANSMITTER	
RESISTORS	CAPACITORS
R1 470 Ω 1/10 watt	C1 .5-8 pf miniature piston trim type
R2 5.6 K Ω 1/10 watt	C2 5 pf silvered mica
R3 22 K Ω 1/10 watt	C3 .01 uf miniature disc
RADIO FREQUENCY CHOKE	
RFC1 15 uh miniature molded	C4 .01 uf miniature disc
RADIO FREQUENCY COIL	TRANSISTOR
L1 .2 uh 8 turns No. 16 wire—¼ inch diameter ID ⅝ inch length center tapped	Q1 Motorola No. 2N 741
	BATTERIES
	B1 (2) No. N22 nickel-cadmium, 1.25V, Eveready
Total wt of MTT 38 g	

The information from the MT was emitted as a frequency modulated signal from the transmitter. Resonant frequency of the transmitter was determined by the capacitance of the MT and capacitor C1 while modulation of the transmitter frequency was dependent only on changes in the capacitance of the MT (Fig. 2). Therefore, the modulated frequency of the transmitter was the information from the MT.

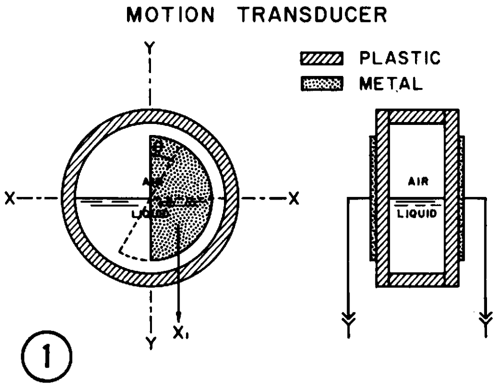
The transmitter consisted of a single transistor in a grounded base configuration (Fig. 2). Two important features of the transmitter include (1) sustained oscillation achieved by a feedback through capacitor C2 and (2) optimal frequency changes with transducer motion obtained by center tapping of coil L1. Following complete assembly, the MTT was placed in a plastic housing for experimental use. The base of the plastic housing was coated with copper print† to prevent proximity artifact from the subject during motion studies. During these studies the telemetry range was less than 100 feet, consequently the transmitter did not require an external antenna. The signal from the MTT was received using a standard F-M receiver‡ and recorded with a polychannel direct-writing recorder.§

* Centrifuge Oil, Cat. No. 1710, International Equipment Co., Boston, Mass.

† G. C. Electronics Co., Rockford, Ill.

‡ Fisher Model 100-FM tuner, Allied Radio Corp., Chicago, Ill.

§ Sanborn Model 350 Direct-Writing Recorder, Sanborn Co., Waltham, Mass.



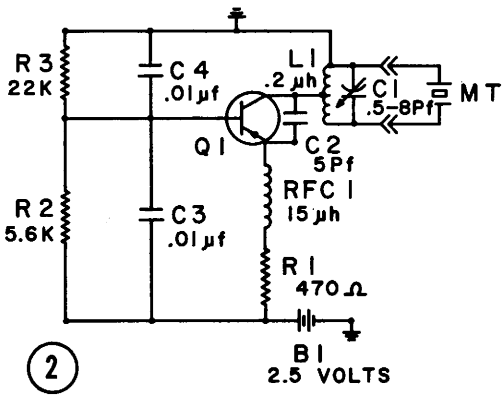


FIG. 1. Cross sectional view of motion transducer.
FIG. 2. Circuit diagram of motion transducer-transmitter.

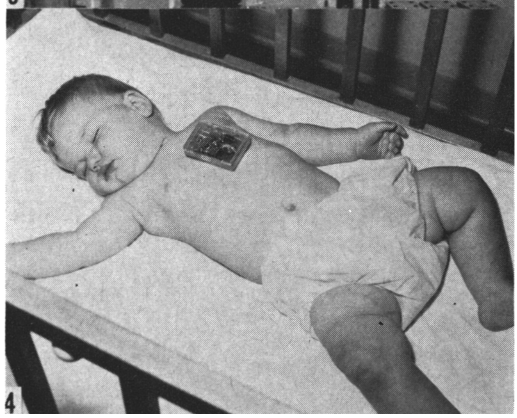


FIG. 3. A pigeon in flight with motion transducer-transmitter attached.
FIG. 4. An infant with motion transducer-transmitter placed on mid-sternal part of thorax.

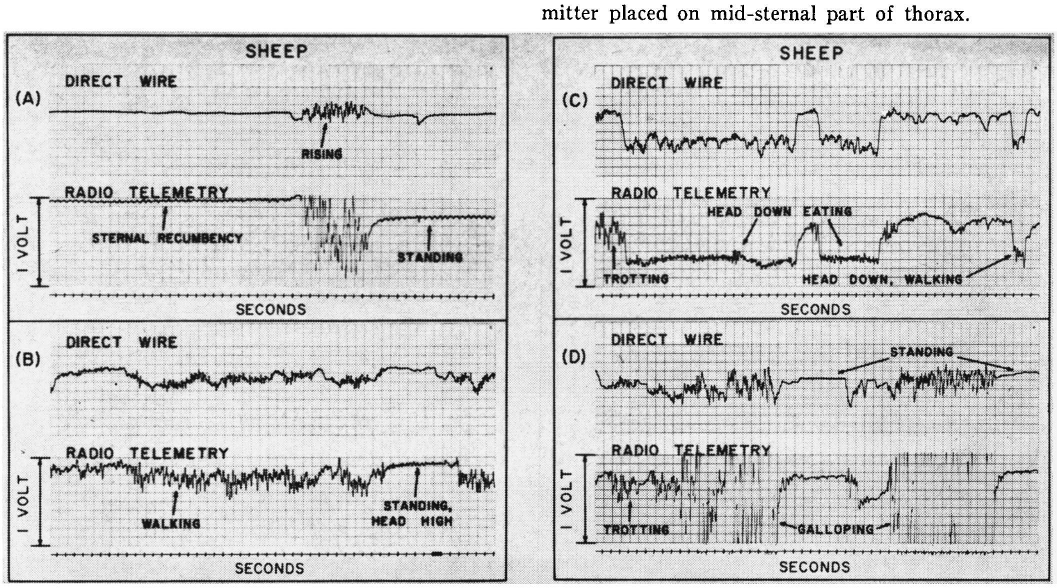
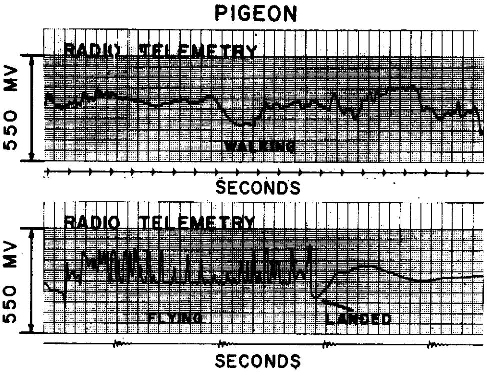
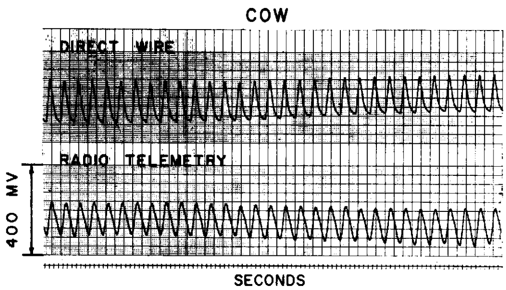


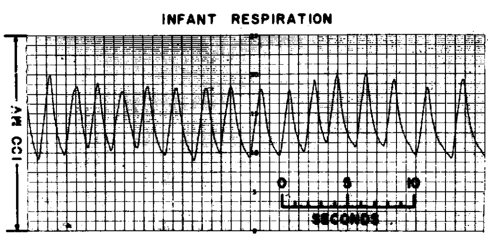
FIG. 5. Direct-wire and radio telemetry recordings from sheep during different types of activity, A through D.



6



7



8

FIG. 6. Radio telemetry recordings of motion from the pigeon while walking and in flight.

FIG. 7. Direct-wire and radio telemetry recordings of respiration activity from the cow.

FIG. 8. Radio telemetry recording or respiration activity from the infant.

MTT attachment methods. During motion studies of the sheep, the MTT was placed in a small wooden box and attached to a 0.5-inch wire mesh saddle. The saddle with the MTT was located immediately caudal to the withers of the sheep. This location provided adequate detection of body motion and posture. The homing pigeon carried the MTT on its back in a cloth harness attached by a loop around the base of each wing (Fig. 3). This provided a convenient method of attachment and permitted freedom of movement.

Placement of the MTT was selected to detect maximum thoracic movement of the cow and infant during respiration studies. Respiration was recorded from the cow during experimental surgery. The cow was in lateral recumbency on the operating table with the MTT positioned, caudal to the last rib, in the left paralumbar fossa. Infant respiration recordings were obtained with the MTT placed on the mid sternal part of the thorax (Fig. 4).

Direct-wire methods. The direct-wire recording device for these studies consisted of a pneumatic system. A pneumograph usually used for respiration recordings was placed around the neck of the sheep. The pneumograph was connected to a 10-foot length of polyvinyl tubing and then to a pressure transducer.‖ The polyvinyl tubing was suspended from overhead, thus the sheep could move about in a small pen without becoming entangled in the apparatus. A similar arrangement was used on the cow except that the pneumograph was placed around the thorax for respiration recording.

Results and discusssion. Recordings of the sheep's activity depict motion and posture (Fig. 5). The recumbent position and standing are characterized by a steady baseline in each position. Rising, walking, trotting, and galloping, in general, had characteristic amplitude and frequency responses. Eating with the head down was evidenced by a downward baseline shift and low amplitude activity.

Recordings of the pigeon walking and in flight, again, are indicated by characteristic baseline shift, amplitude, and frequency pattern (Fig. 6). The pigeon quickly adapted to the MTT attached to its back and was able to fly without difficulty.

Respiration of the cow was monitored and recorded during experimental surgery. Records obtained by the pneumatic system (direct-wire) and radio telemetry are nearly identical (Fig. 7). Changes in respiration were graphically depicted during surgery.

‖ Model 267B, Sanborn Co., Waltham, Mass.

Infant respiration was monitored and recorded during sleep (Fig. 8). Frequency and amplitude of respiration are clearly defined. During the recording period the infant changed from a supine position to sternal recumbency and the record of respiration was momentarily interrupted. Thereafter, a clear record of respiration was obtained with decreased amplitude.

It was necessary to correlate visual assessment of the animal's activity with the recordings obtained by the MTT method for accurate record interpretation. After acquiring proficiency in record analysis one can monitor subject activity without the necessity of constant observation. The authors believe that the MTT can be successfully employed in many other types of activity studies. Perhaps the MTT could be successfully used for patient monitoring, *e.g.*, surgical recovery or the newborn infant. A warning device coupled into the MTT patient monitoring system to alert hospital staff of critical events in the patient's progress would serve a crucial need.

Summary. A motion transducer adaptable to radio telemetry has been designed and described. The transducer was evaluated by studying activity of the infant, sheep, cow and pigeon. Evidence of the motion transducer's versatility is presented by typical recordings from 4 subjects. Activity recorded included walking, trotting, eating, flying and respiration. Observation of the subject and record during initial recording periods permitted interpretation of records from unobserved subjects. Thus, the device was adaptable to monitoring subject activity over prolonged periods without constant observation.

1. Canaway, R. J., Raymond, W. F., Taylor, J. C., Electronic Engineering, March, 1955.

2. Johnstone-Wallace, D. B., J. Royal Agric. Soc. Eng., 1953, v114, 11.

3. Reid, C. S. W., Titchen, D. A., J. Physiol., 1959, v149, 14.

Received October 4, 1965. P.S.E.B.M., 1966, v121.

Separation of $7S\gamma_1$-Globulin, $7S\gamma_2$-Globulin and Macroglobulin Guinea Pig Antibodies. (30817)

RALPH A. REISFELD AND NEWTON E. HYSLOP* (Introduced by M. Landy)
Laboratory of Immunology, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Md.

Guinea pig immunoglobulins consist of at least 3 distinct types, as indicated by the work of Benacerraf, Block, Ovary and Franklin(1) and Uhr, Finkelstein, and Baumann (2). Two distinct functional types of 7S gamma globulins can be distinguished by their differing electrophoretic mobility in starch block, as shown by Benacerraf and coworkers (1): γ_1 or passive cutaneous anaphylactic type, and γ_2, or cytotoxic type. A third species of immunoglobulin was detected by Uhr and colleagues(2,3) in a fraction rich in macroglobulin and essentially free of 7S gamma globulins obtained by sucrose density gradient ultracentrifugation. This fraction contained the antibody activity against bacteriophage ϕ X 174 during the initial phase of the primary immune response.

These methods are in general quite satisfactory for preparation of small amounts of biologically active materials; however, neither method is capable of readily processing large amounts of serum.

In view of the possibility of separating γ_1 and γ_2 antibodies on the basis of electrical charge, it was of interest to reexamine a variety of well-known immunological phenomena, such as Arthus reactions and the hemorrhagic reaction(4) by passive transfer of large amounts of the fractionated gamma globulins into normal animals. To study the biological activity of macroglobulin antibody

* Present address: Peter Bent Brigham Hospital, Boston, Mass.