

GENERAL NOTES

A Portable Device for Non-destructive Determination of Avian Embryonic Viability.—Thick-shelled or heavily pigmented avian eggs cannot easily be “candled” or “trans-illuminated” (e.g., Enemar and Arheimer 1980, Hanson 1954). It is difficult therefore to determine in the field if the embryo is alive unless the egg is opened. There are ways of estimating the developmental stage of an egg by floating it (Westerskov 1950) or by measuring its specific gravity (Hoyt 1979). However, even if the exact date of laying is known, these methods are not adequate to determine whether the egg is alive at the time of inspection.

The technology to detect life in an unopened avian egg exists, although to our knowledge it has not been applied to field use. We describe a portable detector with which we are able to assess embryonic viability in a non-destructive fashion at approximately half-way into incubation.

Cain et al. (1967) employed an ultra-sensitive piezoelectric transducer (termed ballistocardiograph—developed by NASA) to measure the acceleration of the eggshell induced by embryonic movements. They claim that the heartbeat was picked up as a distinctive signature as early as day 4 in the chicken. Evans (1972) picked up the heartbeat in the chicken on day 13 by placing an egg between copper disk electrodes and passing the output through a polygraph. Petry and Wittmann (1978) affixed a small magnet on the surface of the shell and measured the magnetic induction generated by the egg when placed in a wire coil. Finally, Kugler et al. (1982) devised a small piezoelectric transducer with which they were able to record embryonic body movements just prior to hatching. After considering these options and others (e.g., ultra-sound equipment used in obstetrics was tried without success) we decided to adapt the ballistocardiograph for field use.

The “heart” of the instrument is a Gulon R203 rectangular bender transducer, a piezoelectric beam (Lion 1959) having a very high length to cross-sectional movement-of-inertia ratio. This beam is supported at both ends with the egg placed at the center (Fig. 1). A cantilevered beam which would be more sensitive, was considered but rejected because it would have been exposed to stresses that could have fractured it. Any strain on the beam, originating from an acceleration of the egg is translated into a high output electrical signal. This signal is converted to a lower source impedance, amplified and passed through an active, two-pole, high-pass filter (cutoff: 5 Hz) to reduce the low frequency noise originating from the dampening mechanism (see below). The filtered signals drive a voltage-to-frequency converter and some audio enhancement circuits to produce a new signal, the frequency of which varies with the strain in the transducer. With earphones, the operator can hear the variable frequency tone and detect characteristic signals related to motions of the egg.

To reduce electrical noise, the beam is placed close to the circuitry and this unit is mounted on a steel plate to which are clamped two large 12 V lantern dry cells (National Electrical Distributors Association Number 926). An elastic suspension (4 sets of rubber bands) provides good mechanical noise insulation between the egg/transducer/electronics and the carrying case which is in contact with the ground and hence subject to environmental noise. By achieving an optimum spring-constant to suspended-mass ratio, the motion of the suspended steel plate with beam, egg, battery pack and electronics is reduced to a pure, damped, low frequency oscillation that is below the frequency band resulting from egg motion. Shocks and vibrations from outside the carrying case are also minimized. Our carrying case, including the suspension, measured $34 \times 24 \times 30$ cm with a mass of 9 kg. The full circuit diagram is reproduced in Figure 2.

Typically, all oscillations cease within one minute after the suspension is disturbed by placing an egg on the beam. However, the operator only has to wait 5–10 s before egg-generated signals can be differentiated from the regular oscillations. Because of the relatively crude damping mechanism of this field model, heartbeat cannot readily be picked up. One relies on body movements of the embryo which must be of certain size before it produces a movement that can be detected above ambient noise.

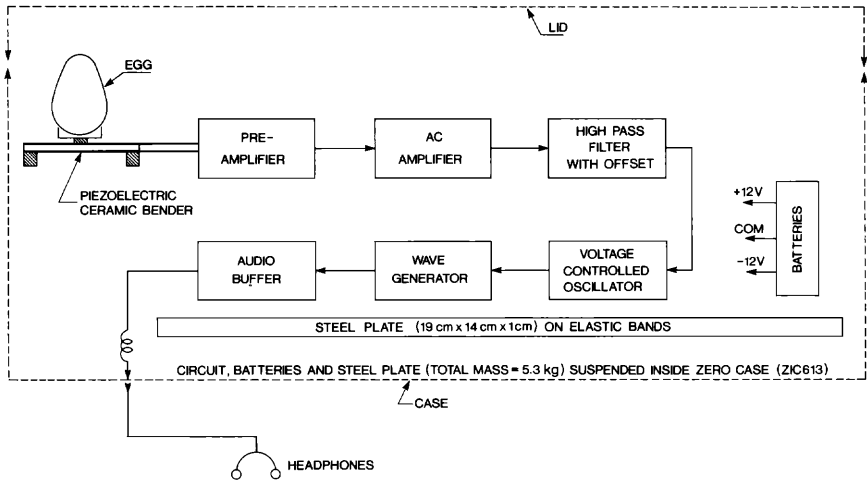


FIGURE 1. Block diagram for an embryonic viability sensing system.

The instrument was built in order to respond to our specific need of testing Herring Gull (*Larus argentatus*) eggs from the Great Lakes in order to correlate embryonic viability with organochlorine contamination (Mineau et al. 1984). The initial testing of the instrument was carried out with domestic turkey (*Meleagris gallopavo*) eggs since these have approximately the same weight (70–100 g) and incubation period (28 d) as Herring Gull eggs. Unincubated turkey eggs were used as “controls.” We were able to clearly hear the signals produced by embryonic motion as early as day 11 of incubation. On day 12, movements of the embryos in all turkey eggs tested (24) were discernable.

Subsequent field trials at Herring Gull colonies indicated that a number of factors have to be considered to ensure proper functioning of the equipment in the field. The instrument must be positioned on stable ground, the lid must be closed and footfalls must be eliminated from the immediate vicinity of the testing site. Rain, or wind in excess of 20 km/h should be avoided. Eggs to be tested should be warm to the touch since chilled eggs do not score as reliably as warm ones, embryonic motion being greatly reduced. To minimize errors in often less than optimal field conditions, we tested eggs that had been incubated at least 16 d. Herring Gulls have a modal clutch size of 3, and eggs are generally laid every second day. By marking nests containing 1 or 2 eggs early in the season and testing the eggs 20 d later in those nests which received a new egg in the intervening period, embryonic age fell between 16 and 23 d (day 1 being defined as the day the egg was laid). A key element of this procedure is that it allowed for a measure of pre-hatch egg viability while avoiding the disturbance associated with the presence of an observer at hatch.

Table 1 gives the results obtained in 1982. Testing was performed in 10 colonies from the Great Lakes and one from the Maritimes under a variety of conditions and by different observers. Although further testing is required to better define the operating range of the instrument, the method already shows great potential for field research. In toxicological research, opening all eggs which score “dead” partway through incubation can yield valuable information on the cause of death since it is possible to separate infertility from embryonic failure (see Kosin 1944).

Although the instrument has not been tested on eggs of other wild species, there is little doubt that it would work as well on eggs of approximately the same size as those we tested. With very small eggs, it remains to be seen whether the embryo’s movements could be adequately picked up by the transducer and, if so, at what developmental stage.

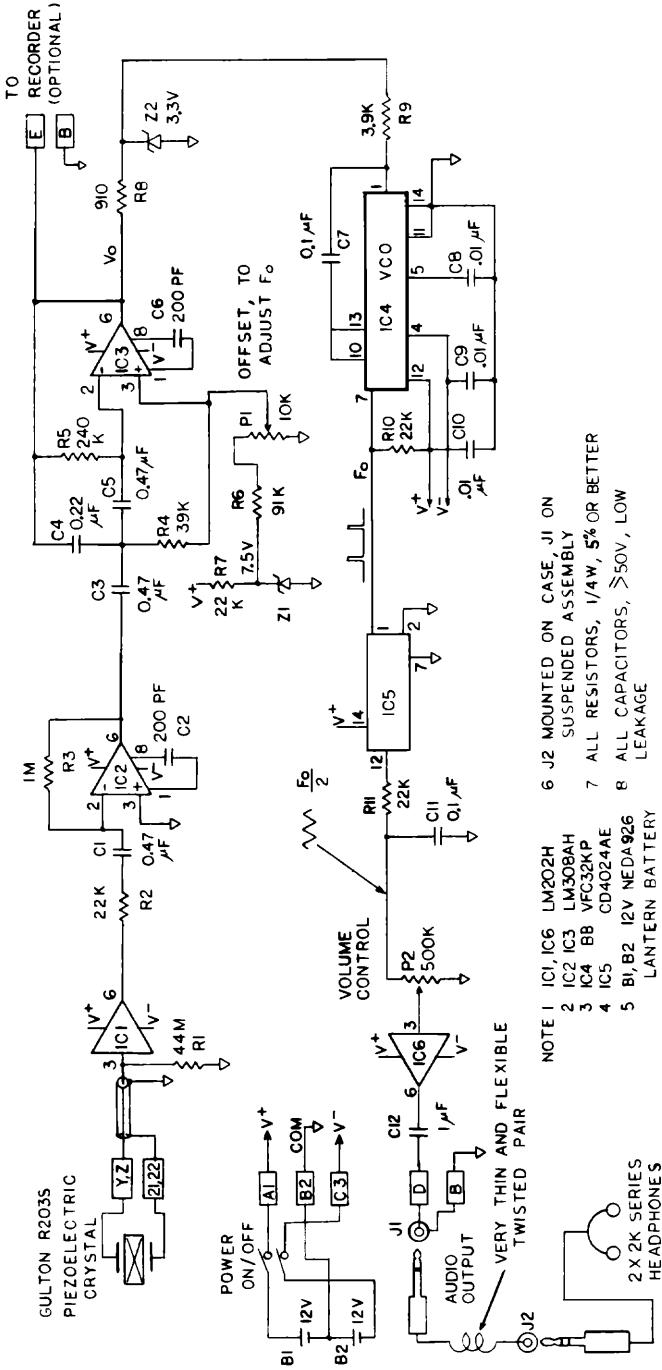


FIGURE 2. Circuit diagram for an embryonic viability sensing system.

TABLE 1. Comparison of embryonic viability as determined by the electronic sensing device and by visual inspection (data from 11 colonies).

Electronic diagnosis	Number of eggs tested	Number opened	Number confirmed alive	Number confirmed dead	Number unknown	% Accuracy
Dead	105	95	2	90	3*	95-98%
Alive	905	48 ^b	48	0	0	100%

* These eggs were severely underdeveloped but otherwise in good condition. We could not distinguish whether they had been alive at testing since they were not opened until some time later.

^b Only one egg was opened per clutch. All clutches were from the same colony.

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