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A TEMPERATURE CONTROLLED CAPACITANCE-TYPE ACTOGRAPH FOR CRYPTOZOAN ARTHROPODS

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During an investigation of the locomotor activity rhythms of intertidal beetles the need arose for an actograph especially suitable for these animals which spend a great deal of their time in crevices or under stones. The actograph also needed to be kept at a constant temperature without using an expensive and noisy growth chamber. A review of the literature on the many kinds of actographs used with insects indicated that the most suitable way to detect animal movement is through the use of electronic transducers. In the capacitance-type transducer a movement of the test animal causes a change in capacitance which is detected as a frequency change and amplified into a voltage output signal. Therefore, the electronic circuit of the sensing apparatus described by Schechter, Dutky and Sullivan (1963) and later modified by Grobbelaar et al. (1967) was, with minor modification, adapted for the actograph described here.

The sensors, however, differ from those used by the above authors. These formed a part of two parallel 5 mm x 11.5 cm x 11.5 cm plexiglass plates between which the insect is placed as shown in Figure 1. The thin wire forming the electrode on the bottom of the top plate is positioned to form a series of loops starting from one edge of a 10.5 cm circle and ending at the other edge and then going on to a ground terminal. In contrast, in order to obtain a maximum non-uniform electric field between the two plates, the other electrode wire consists of a 10.5 cm spiral starting from the center of the top surface of the bottom plate and eventually leading to the detector circuit. A change in capacitance due to a movement of the test insect is detected at the junction between the top electrode and the bottom one so that the insect need not touch either of the wires. The closer the wire spirals or the loops or the distance between the two electrodes the more sensitive is the actograph to small movements. The 31 gauge electrode wires were placed into grooves scored into the plates and held there by brushing over them a thin layer of plexiglass dissolved in ethyl acetate.

The thickness of the spacer is determined by the height of the insect so that ideally the insect is able to move freely about with the two parallel plates as close as possible to each other. A series of plexiglass spacers were made ranging in thickness from 0.25 to 3.5 mm and any of these, either alone or in combination, can be used for insects of varying heights. A test insect was first measured for height before placing in the actograph by viewing it in the bottom of a narrow glass vial with a micrometer hand lens.

Sometimes the test insect is kept in the actograph for periods of 10 to 14 days and in order to provide the high humidity and water necessary for hygrophilic insects two methods were employed, both involving some modification of the bottom plate. Where very high humidity was necessary, holes were drilled between the wire spirals of the bottom plate which was then tightly connected with screws to a plexiglass container of water. By using a graduated glass tube connected with flexible tubing to this water container the water level could be adjusted so that the holes in the bottom plate were almost filled with water. Loss of water through evaporation was measured by the graduated tube and water was added when necessary during a test. Where high humidity is not critical a cotton wick was inserted into a 2 cm x 0.25 cm inside diameter tube which was inserted into the center of the bottom plate and suspended over a container of water. The top of the wet wick just barely protruded above the top of the bottom plate. A few holes can be drilled between the wires in the top plate to maintain an air supply and a larger hole can be used for placing the insect into the space between the plates. This larger hole is then corked during the operation of the actograph.

The only modification of the electronic circuit described by Grobbelaar et al. (1967) consisted of the use of AC power with two regulated power supplies instead of a battery source. One power supply (± 10 volts) was used for the sensing part of the circuit while the other (± 15 volts) powered an amplifier and a comparator that switched a relay at selected output voltage peaks. In this way the activity record could consist of an analog tracing or a count of voltage peaks per unit time. A potentiometer allowed a range of voltage peaks from 0.1 volts to 10 volts to switch the relay thereby providing a means of sensitivity adjustment. The relay signals were counted and printed at hourly intervals on a Sodeco counter-printer.

Unless walk-in constant-temperature chambers are available, actographs are normally operated in constant-temperature cabinets such as plant growth chambers. Unfortunately with these cabinets the cooling compressor is often exceedingly noisy and the very noticeable on and off cycle of the compressor could influence an activity rhythm of a test animal. Figure 1 shows a non-cyclical constant-temperature container for holding the actograph. The container consists of a fiberglass-encased top and bottom of equal dimensions (34 cm x 34 cm x 14 cm) separated by two 13 mm thick foam rubber pads. A length of 6 mm outside diameter copper tubing, closely coiled in circles to form a 25 cm inside diameter cylinder, was placed in the top and bottom containers with inlet and outlet connections protruding from the sides. The spaces between the tubing and the walls of the containers were filled with poured-in foam insulation. Provided a styrofoam cover or base is used both top and bottom containers can be used alone or they can be used together as shown in Figure 1. In this case the cables from the temperature, humidity and capacitance sensors as well as the flexible tubing for the water supply fit between the two layers of foam rubber. The base of the bottom container is 2.5 cm thick foam insulation encased in fiberglass while the top of the top container which can be used for viewing the actograph consists of two sheets of 6 mm thick plexiglass separated by 1.5 cm of air space. The copper tubing is connected to a constant-temperature circulating bath and equilibrium is usually obtained after about 2 hours depending on the temperature required and ambient temperatures. I have been using two complete actographs in constant-temperature containers as shown in

Figure 1 connected to a Haake circulating water bath maintaining a temperature of 18.0° ± 0.25°.

An example of the kind of results that can be expected with this type of actograph is shown in Figure 2. Specimens of *Alphitobius piceus* (Tenebrionidae) were kept in the dark for two months (group A) while another group was exposed during this period to alternating 12 hours light and 12 hours darkness (group B). After this time five specimens of each group were placed in the actograph under dark conditions for 10 days. As is evident from Figure 2 the group kept in the dark for two months were arhythmic while the other group maintained a periodicity of 23.75 hours (periodogram analysis; *see* Enright, 1965), for the 10 days of activity measurements.

The actograph described here has proved to be very suitable for carabid beetles (a total of 18 species representing members of riparian, forest litter, marsh, intertidal and open-field habitats have been tested so far) and it probably can be used successfully with other cryptozoan animals such as chilopods, diplopods, mites, pseudoscorpions as well as beach-inhabiting isopods and amphipods.

ACKNOWLEDGEMENTS

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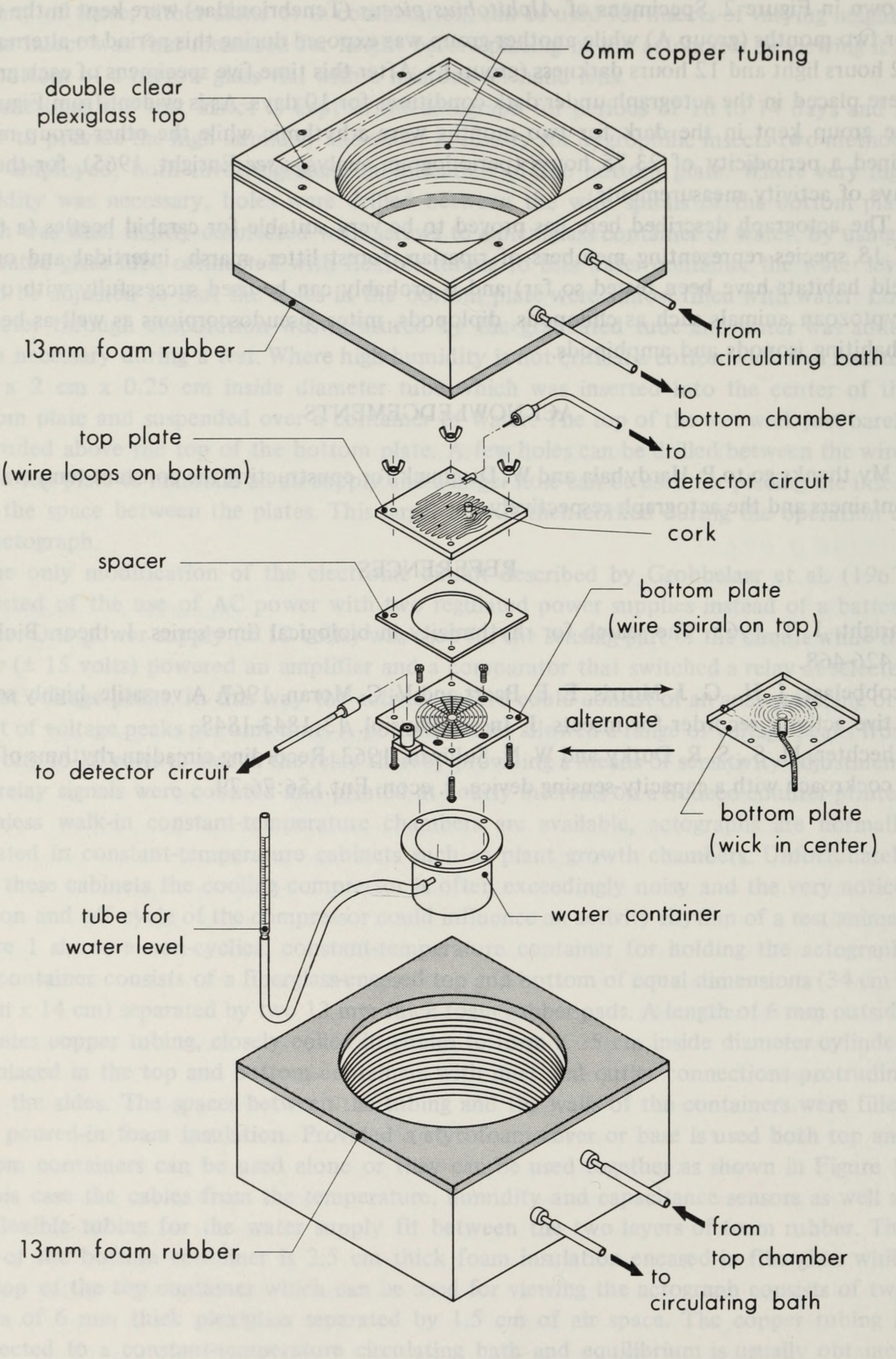

Figure 1. An exploded view of the sensors of the capacitance-type actograph and the constant temperature containers.

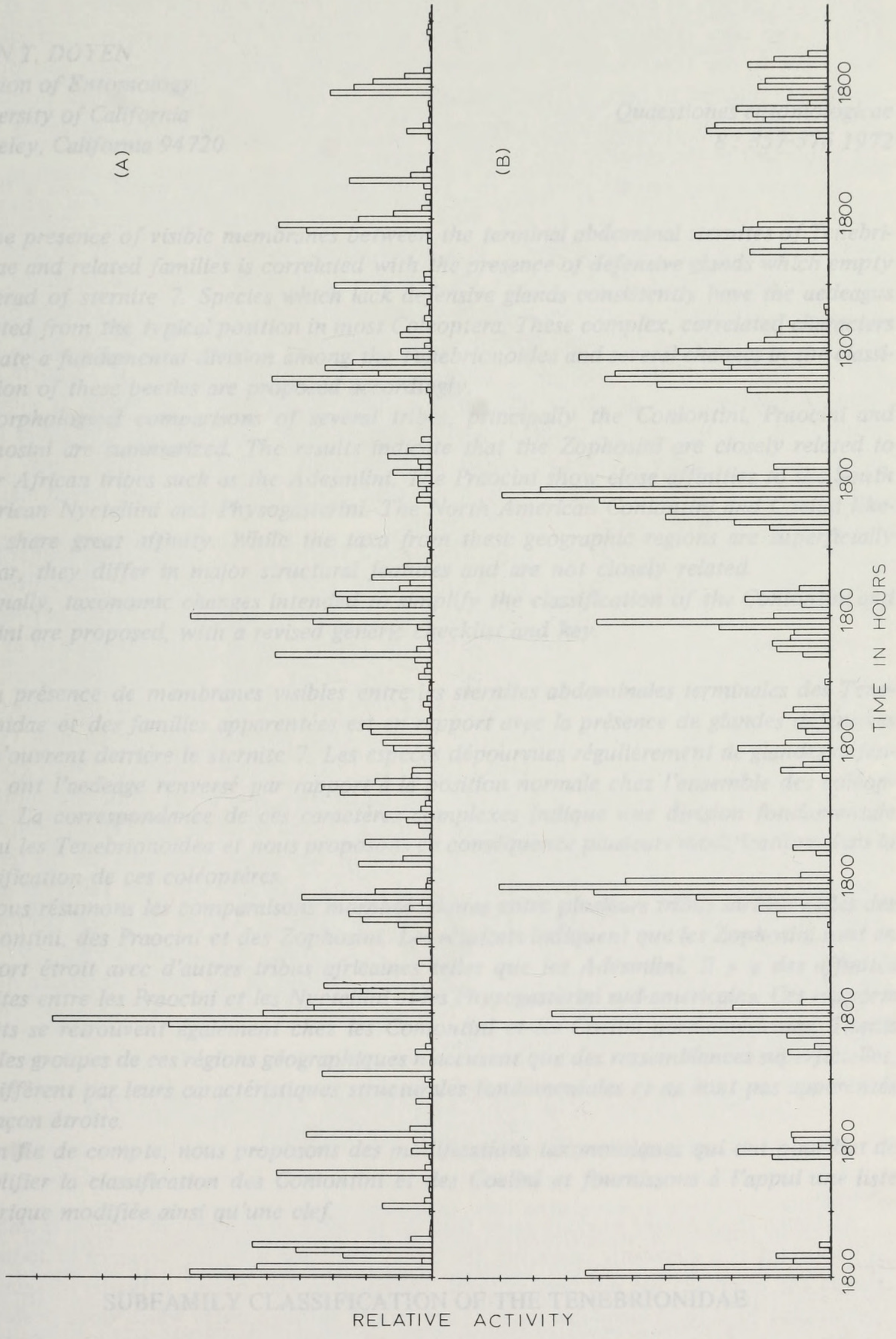

Figure 2. A 10-day activity record of two groups of five specimens of *Alphitobius piceus* obtained with the actograph in darkness. Group A were kept in the dark for two months prior to the test while group B were subjected to a DL 12:12 at the same time.

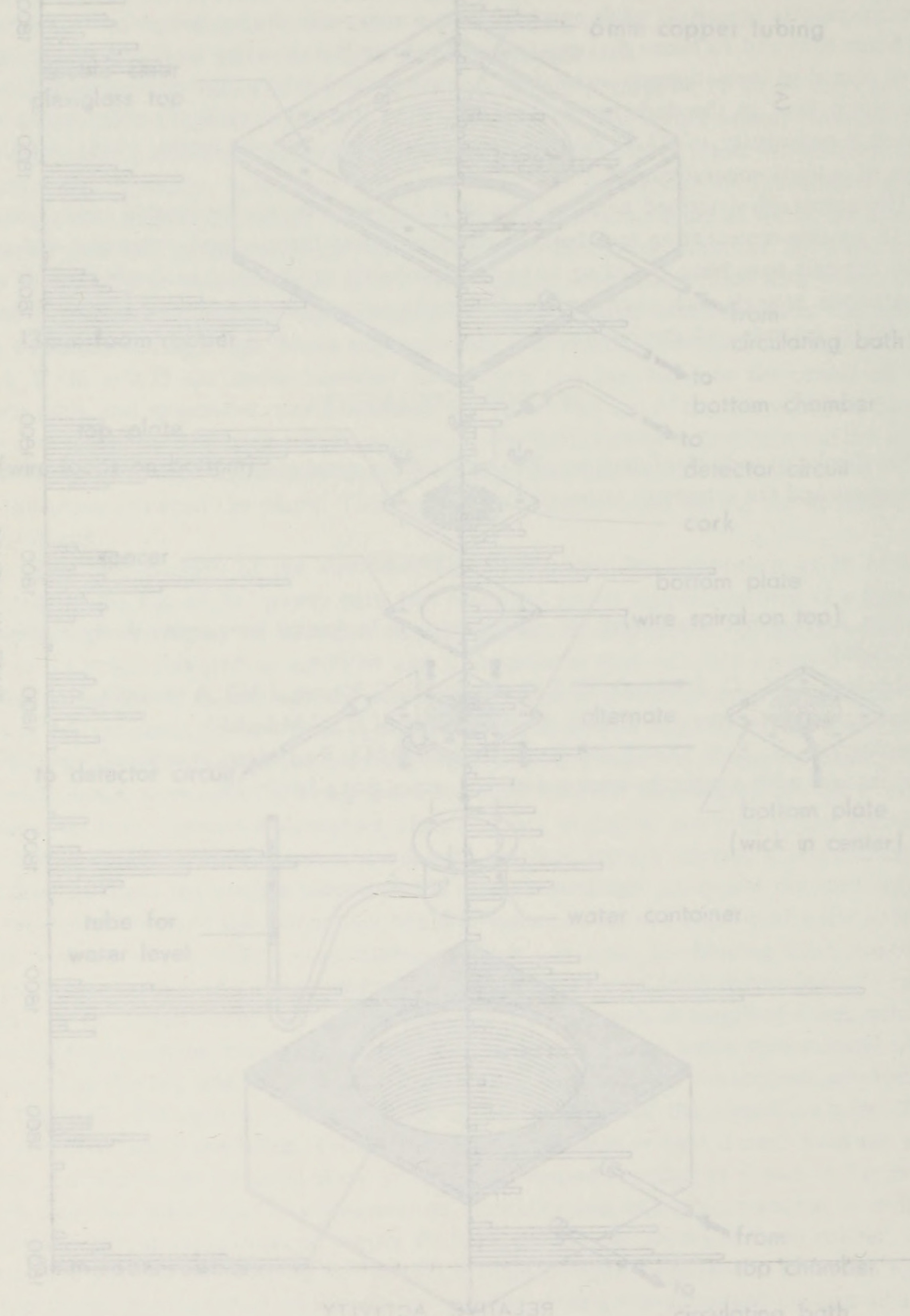

Figure 1. An exploded view of the sections of the capacitance-type actograph and the constant temperature [illegible]