

## AN ELECTRO-MAGNETIC MIXER FOR MANOMETRIC EXPERIMENTS

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(With Three Text-figures)

### INTRODUCTION

Manometric experiments often involve the addition of substances such as a substrate, an inhibitor, or acid, to the material under investigation. This is usually done in the following ways:

By running the substance into the main vessel from a turnable side bulb.

By tipping it in from a fixed side bulb.

By dislodging a dangling cup or 'Keilin tube' within the manometer vessel.

These methods have disadvantages in certain types of experiment. In all three the shaker has to be stopped when the substance is added, while in the last two, the vessel must be removed from the bath. Furthermore, in the first method, the substance cannot be added quantitatively and the turning of the side bulb may not always leave the manometer reading unaffected. These disadvantages are usually unimportant, as in ordinary experiments the gas change is of a fairly large order, and extrapolation can cover the first few minutes after the addition of the substances. The disadvantages involved in these methods are, however, accentuated if readings have to be made at short intervals after the addition of the substance (at intervals of less than 1 min. for example), and especially if the Warburg indirect method is used, when substances have to be added to both vessels at the same time.

These difficulties arose while investigating the fertilization reaction in the eggs of the sea urchin, *Psammechinus miliaris* (Laser & Rothschild, 1939), when the Warburg indirect method was used and very short interval readings were required after adding the spermatozoa to the egg suspension.

A method has therefore been developed for adding substances to the manometer vessels of a differential manometer without stopping the shaker or removing the vessels from the bath. The principle consists in holding a Keilin tube in the top of the manometer vessel by means of an electrically maintained magnetic field. The tube, which contains the substance to be added, in this case the sperm suspension, is allowed to drop into the egg suspension by interrupting the electric current. This device enables substances to be added simultaneously, or at known intervals, to any number of vessels. The method has the further advantage that small main vessels can be used, as the Keilin tube can be suspended in the hollow part of the manometer stopper. Consequently, the volume of the main vessel need not be enlarged

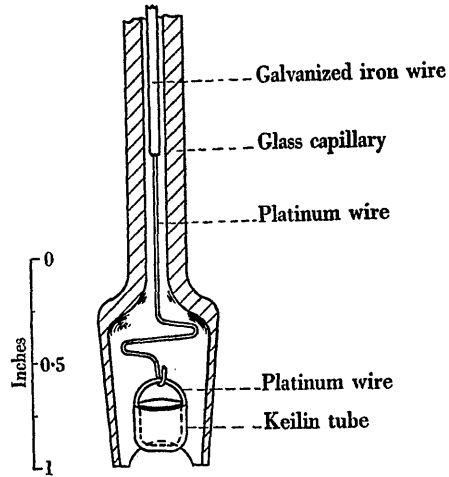


Fig. 1. Manometer stopper, with Keilin tube in position.

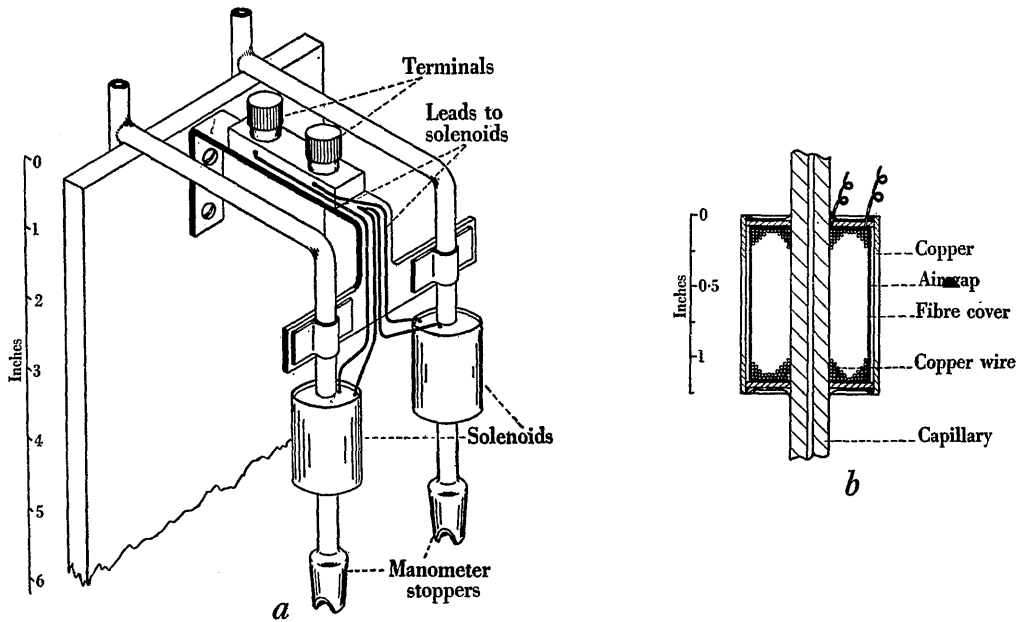


Fig. 2. *a*, rear view of manometer, showing solenoids on capillaries above manometer stoppers. *b*, section of solenoid.

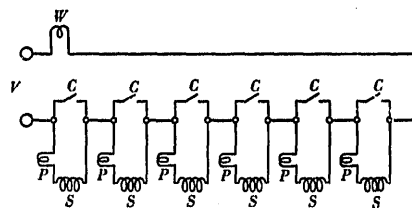


Fig. 3. Complete wiring diagram for six mixers. *V*, 110 V. d.c. supply; *W*, 60 W. bulb; *C*, switches; *P*, pilot lamps; *S*, solenoids.

by the volume of the side bulb, which would reduce the sensitivity of the apparatus. If two substances have to be added consecutively, two side bulbs are necessary (Dixon, 1943, p. 95) and this also is obviated by the electromagnetic mixer.

#### TECHNICAL DETAILS

The Keilin tube is hooked on to a piece of platinum wire in the hollow part of the manometer stopper (Fig. 1). At its distal end the platinum wire is connected to a length of galvanized iron wire, which is held by a magnetic field in the capillary tubing above the stopper. The manometer stoppers are cut away to provide a clear opening between the gas phase in the manometer and the capillary, as shown in Fig. 1. The Keilin tube is hooked into position and the magnetic field switched on before the vessel is put on to the manometer.

The magnetic field is produced by coils of wire or solenoids round the outside of the capillary tubing above *both* manometer vessels, and as the wattage is the same in each there is no asymmetrical heating effect. Each solenoid contains 1000 turns of silk covered no. 28 copper wire, and their total resistance is about 7 ohms. Constructional details of the solenoids are shown in Fig. 2*b*. Resin flux and not acid flux should be used to prevent corrosion of the copper wire.

The lengths of the iron and platinum wires holding the Keilin tube are adjusted so that when the magnetic field is switched off only the platinum wire comes into contact with the liquid in the manometer vessel.

The complete wiring diagram is shown in Fig. 3. It is convenient to have a pilot light associated with each coil in the circuit, and these should light up whenever a coil is energized. Neither the number of turns of wire in each solenoid, nor the gauge of the wire, nor the external voltage are critical.

We are much indebted to Mr M. J. Hubbard for making the electrical apparatus.

#### REFERENCES

- DIXON, M. (1943). *Manometric Methods*. Cambridge.  
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