

## AN ELECTRONIC NEONATAL RESPIRATORY MONITOR\*

W. E. B. EDGE, M.B., B.Ch., M.R.C.P., D.C.H., D.(OBST.)R.C.O.G. and W. L. EATON, Associate S.A.I.E.E., Durban

To all who are concerned with the care of the newborn, and particularly of the premature baby, cyanotic and apnoeic attacks are familiar, alarming and depressing events. How often has one entered a nursery to find a 'prem', who was apparently quite well when last seen only a few minutes previously, now limp and blue, and whom one revives with considerable difficulty, only to learn of its subsequent demise in another apnoeic attack! How often is the 'cerebral' baby, whom the sister left for a few minutes to attend to another emergency, found dead on her return! How often, too, does one hesitate before demanding a special nurse for such cases, knowing that in private practice the financial strain placed upon young parents may be considerable, and that in State hospitals such staff can often not be spared! Yet there is no doubt that babies liable to apnoeic attacks should be under continuous and uninterrupted observation if avoidable fatalities are to be prevented. Such babies, if treated early in the attack, can frequently be revived by any form of simple stimulation. Timely aspiration of obstructing mucus in the nasopharynx will frequently save such a baby's life. Further measures such as oxygen administration, intramuscular, intravenous or intracardiac stimulants, or some form of artificial respiration, may become necessary if the attack is prolonged and anoxia has depressed the respiratory centre. But the basic essential in the management of such babies is the early detection of apnoeic episodes and the immediate availability of an

\*Paper presented at the Fourth Congress of the South African Paediatric Association (M.A.S.A.), Cape Town, 4-6 April 1960.

attendant to deal with them.

### *Which Babies are particularly Liable to Cyanotic Attacks?*

Small premature babies are especially prone, and Illingworth<sup>1</sup> in his study of 170 babies who had cyanotic attacks found that 60% were premature. Miller,<sup>2</sup> observing the respiratory behaviour of several hundred neonates, including 229 premature babies, found that all the deaths occurred among those showing a significant rise in respiratory rate after the first hour (his group III, which contained the vast majority of small premature babies). It is generally recognized that in the management of the premature baby 'maintenance of respiration' is one of the cardinal aims.

Apart from prematurity, cyanotic attacks were found by Illingworth<sup>1</sup> to be associated with certain maternal antenatal conditions — toxæmia, hypertension and antepartum haemorrhage — with intrapartum foetal asphyxia (24% of the babies had initial grade-2 or grade-3 asphyxia in Flagg's classification); and in those who died the commonest findings were atelectasis (with or without hyaline membrane), cerebral haemorrhage, and cerebral oedema. Less frequent findings were infections, pulmonary haemorrhage, oesophageal anomalies, and congenital heart disease.

Cyanotic attacks should therefore be anticipated in (1) premature babies, (2) babies showing initial moderate or severe asphyxia, (3) any ill baby, particularly if atelectasis, cerebral haemorrhage or cerebral oedema is suspected, and (4) any baby showing a significant rise in respiratory rate after the first hour of life.

### *When are Cyanotic Attacks most likely to Occur?*

Although the first 3 days are commonly stated to be

the most dangerous period from this point of view, and although it is true that the majority of attacks do occur on these days (72% in Illingworth's study<sup>1</sup>), nevertheless a significant number (28%) occur in the succeeding days; Miller<sup>2</sup> found a tendency for apnoeic attacks to occur throughout the first week. It follows that a baby in which such episodes might be anticipated should ideally have its respirations watched continuously for at least the first week of life.

#### The Problem

It is obviously impracticable to have every baby with a liability to cyanotic attacks 'specialled' for the first week, or even the first 3 days. If a device could be made which would alarm the attendants in the early stages of an apnoeic episode the same purpose would be fulfilled, with a great saving in personnel-hours. The apparatus should be simple, safe, reliable and inexpensive. It should be applicable to babies in incubators. It should not in any way hamper the respiration of the baby, nor should it interfere with access or observation. It should not introduce any potential danger such as infection or electrocution. Furthermore, it should be capable of distinguishing between true apnoeic attacks and the common pauses in respiration associated with periodic breathing, so frequently seen in the premature baby. These requirements seem to have been adequately met by the device here presented.

#### The Apparatus

The device consists of 3 units, viz.: (1) a respiratory-motion detector or transducer, (2) the respiratory-pulse

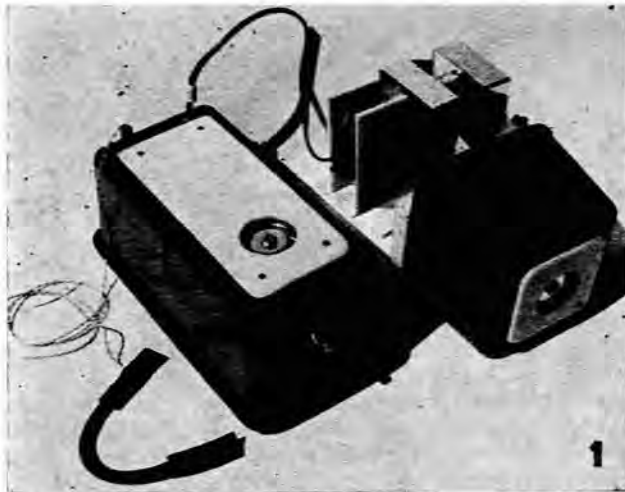


Fig. 1. The apparatus.

integrator and alarm control, and (3) an extension alarm. Briefly, the function of these various parts is as follows:

1. *The transducer.* This consists of a length of rubber tubing packed with carbon granules. When strapped over the baby's upper abdomen the longitudinal expansion and contraction of the tubing with the baby's respiratory movement causes a varying resistance, thereby converting

mechanical variation into electrical variation. This detector plugs into:

2. *The integrator and alarm control.* The varying electric pulse developed with the aid of the detector is amplified and caused to pass to an integrating circuit, the output of which is a function of respiratory amplitude and periodicity. This pulse is used to charge a reservoir capacitor. An electromechanical switch (relay) is held in the 'off' position so long as the integrated output exceeds a certain level. Should respiratory motion cease the capacitor slowly discharges, and at the critical level the relay reverts to the 'on' position, thereby completing an alarm circuit. The apparatus is so devised that the delay period is about 15 seconds. This is to exclude 'false alarms' resulting from periodic breathing. Battery or circuit faults producing a drop in integrated output will also cause the relay to revert to the 'on' position. An alarm hooter is incorporated in the casing of this part of the apparatus.

3. *The extension alarm.* This is simply an extra hooter to extend the range of the alarm. It plugs into the main component and can conveniently be hung over a door.

The whole apparatus is battery-powered, so that no extrinsic power-supply is necessary. It is furthermore extremely light and portable.

#### Experience with the Apparatus

A prototype has been in use for about 6 months. Towards the end of this period some trouble was experienced with the relay, but this has been remedied in the final model. Apart from this small defect the machine showed itself to be a reliable and efficient detector of apnoeic attacks. Not once did it alarm without just cause, and on more than one occasion it detected the attack of apnoea before a trained nurse did who was simultaneously 'specialling' the baby. We have, therefore, every confidence in the apparatus.

Wherever it has been in use the alarm has been welcomed most enthusiastically by the nursing staff, who, liberated from the necessity of watching the baby every few minutes, are able confidently to get on with their routine duties. To the paediatrician it gives the considerable reassurance of knowing that the baby will not die in an apnoeic attack without having received immediate attention. And, as for our small patients, we hope the apparatus will prove instrumental in saving some of their precarious lives.

#### SUMMARY

An electronic device is described which will monitor the respirations of the newborn and sound an alarm should the respiratory movements cease. By its use apnoeic attacks are reliably detected in their early stages and the need for 'special' nurses to maintain the respiration of premature or ill newborn infants is obviated.

#### REFERENCES

1. Illingworth, R. S. (1957): *Arch. Dis. Childb.*, 32, 164, 328.
2. Miller, H. C. (1957): *Pediat. Clin. N. Amer.*, February, p. 17.