CLINICAL NOTE

A CLINICAL OTOMANOMETER

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THIS clinical otomanometer has been designed as an air pressure gauge to measure the degree of negative pressure in the Siegle pneumatic circuit (and by inference in the middle-ear cleft) in patients suffering from partial eustachian obstruction.

The need for it became evident in the course of research into hearing defects in children at the Children's Hospital, Birmingham, which has been undertaken with the aid of a grant from the Medical Research Council, and the Endowment Fund of the United Birmingham Hospitals, in order to test the value of irradiation (using radium applicators in the nasopharynx) in the treatment of deafness of eustachian origin, with a planned follow-up of the cases under treatment over a five-year period.

The selection of cases for which this method of treatment was appropriate has involved the examination and assessment of the hearing capacity of large numbers of children suffering from various types and degrees of deafness, and it was essential to the enquiry that in those selected for radiation treatment the presence of eustachian dysfunction should be established.

The estimation of its presence and extent has been made by visual observation of the mobility of the membrana tympanum using the Siegle pneumatic speculum, and when the intact M.T. has been immobile or a diminution in its freedom of movement has been present, eustachian dysfunction has been inferred, while the presence of a freely mobile membrana tympanum was regarded as diagnostic of a patent and functioning eustachian tube.

In a large proportion, however, of the cases investigated, there was some degree of mobility of the membrane, but less than free mobility, and as our investigation proceeded it was felt that a greater degree of precision in the measurement of the negative pressure in the circuit (and by inference in the middle ear) in those with a poorly mobile membrana tympanum was necessary.

There were two reasons for this. The first was diagnostic, for if deafness was present we had to decide how much of this was due to the eustachian dysfunction on the one hand, and how much on the other hand to other causes of auditory loss. The second reason was to enable us to measure the changes in the degree of negative pressure which took place during treatment.

The requirements for the manometer were:

1. One which could be used on the usual examination table.
2. One which could be introduced into the Siegle circuit.

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3. An instrument to give reasonably accurate readings of changes in pressure in the circuit in the lower ranges.

The Theoretical Considerations

The maximum theoretical negative pressure in the middle-ear cleft, on the gas diffusion absorption hypothesis, resulting from eustachian tube closure (the lesions of barotrauma excepted) lies in the region of −40 mm. Hg and −40 mm. Hg (−50 cm. Aq.) was found by Van Dishoeck experimentally in his investigations published in 1941 (*Acta Otolaryng., Stockh.*, **29**, 303).

The normal laboratory technique for making these measurements is by a water manometer, but this is an inconveniently large piece of fixed equipment and unsuitable for use on the examination table. It was therefore decided to adapt a portable air manometer to the usual Siegle circuit, as for our purpose it was more important to obtain a fair measure of accuracy in the lower ranges of pressures than to record the pressures present when the membrana tympanum was "immobile".

The maximum negative air pressure which can be obtained from the standard Siegle bulb is about −160 mm. Hg but the rigidity of the bulb makes it difficult to record small changes in negative air pressure near to atmospheric pressure. We have therefore chosen a bulb of slightly larger capacity and lesser rigidity which produces a maximum negative pressure of −60 mm. Hg.

The accurate measurement of these pressure changes in the lower range required a large instrument dial, and considerable magnification of the chamber movement by the indicating pointer. After trial a suitable expansion chamber was found, and with a dead beat 4½ in. balsa lever this recorder gives a sweep of 4 in. over a 45° arc for a positive pressure change of 30 mm. Hg and of 2 in. over a 20° arc for a negative pressure of −20 mm. Hg.

On subsequent test by Messrs. Short & Mason, this chamber had a spring rate of 5·5 lb./in., and this specification has been adopted for the chambers used in the construction of further instruments.

Technically: "This figure is derived from a measurement of the deflection with a change of pressure of −20 to +40 mm. Hg, and the effective area of the bellows, i.e.

Change of pressure:	−20 to +40 mm. Hg (1·17 lb./sq. in. approx.)
Deflection:	0·5 in.
Effective area:	2·4 sq. in.
∴	Spring rate−5·5 lb./in."

The Instrument

The prototype was designed and constructed by Messrs. Webb and Harding in the Department of Physiology in the University of Birmingham by the courtesy of Professor Gilding. It consists of a metal expansion chamber of Barograph type which is introduced into the rubber tubing circuit of the Siegle system. The lever, which is moved by the free surface of the chamber, travels in both directions from a mean position across a calibrated dial which indicates

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the air pressure in millimetres of Hg up to a maximum of 30 mm. Hg positive and 20 mm. Hg negative pressure.

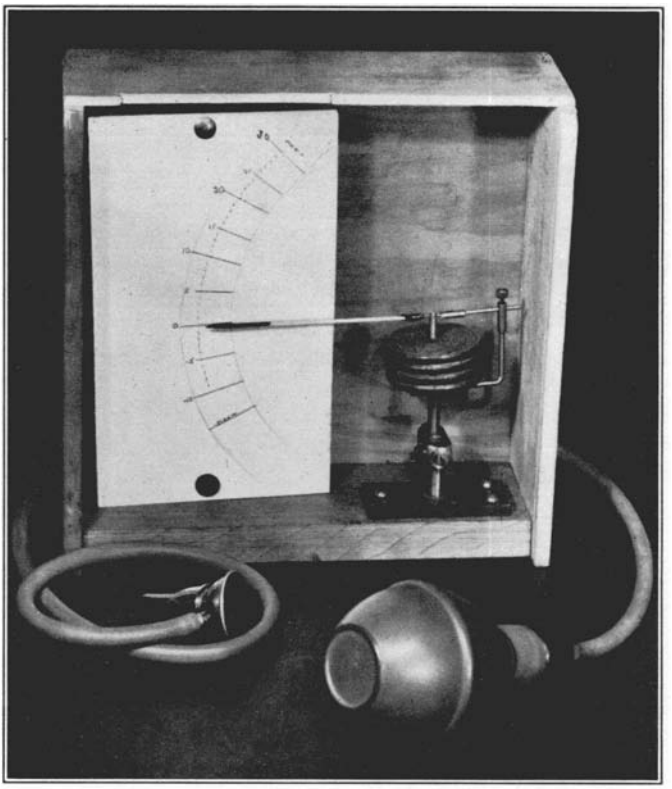


Photo of Otomanometer by the Photographic Department, the Children's Hospital, Birmingham, in its case 10″ × 10″. At the back of the case the rubber tubing of the Siegle is connected by a "T" piece to the hollow pillar on which the expansion chamber is mounted.

Method of Use

It is used to obtain a reading of the minimal pressure change in the Siegle system which produces the slightest movement of any part of the drum head. With the aural speculum inserted into the external auditory canal the observer views the membrana tympanum through the Siegle lens by reflected light in the usual manner, and by rapid compression and release of the bulb the air pressure in the external auditory canal is alternately raised and lowered. At the point at which the first movement of any part of the membrana tympanum is seen, a second observer notes the pressure which has been reached on the instrument dial. With practice it is also possible for the operator to make this observation himself.

When the pressure change required to produce membrana tympanum movement is minimal, of 1-2 mm. Hg the whole of the lower membrana tympanum

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and the umbo move as one, and it is immaterial whether positive or negative pressure readings are taken. When there is no movement at these pressures, two methods are available for obtaining a reading. The first is by applying direct negative pressure from bulb suction; but a reading can also be obtained by raising the pressure in the circuit to some level below the maximum of 30 mm. Hg and then rapidly releasing this positive pressure by sudden expansion of the compressed bulb. This method has been the one adopted in clinical use.

Conclusions

With a normal freely mobile membrana tympanum a very free movement of the membrane and also of the umbo occurs with the lightest touch on the air bulb (with a pressure change of 1-2 mm. Hg) and establishes the diagnosis of a patent eustachian tube. If deafness is present in such a case, its cause is not due to eustachian dysfunction.

When the reading is higher, in the range of 3-12 mm. Hg by the release from positive pressure method, the membrana tympanum does not always move as a whole and movement of the umbo is seldom seen. Movement usually appears first in the postero-inferior quadrant, less often in the light reflex area, and occasionally in the postero-superior marginal membrana tympanum only.

It has been frequently observed that the pressure required for movement of some part of the lower membrana tympanum and of Shrapnell's membrane are not equal in the same ear, and usually the membrana flaccida moves at a lesser pressure than the membrana tensa.

Up to 12 mm. Hg by the release from positive method, there is little if any loss of auditory acuity, either by audiogram or whisper test, and in these lesser degrees of eustachian dysfunction the manometer gives the earliest indication of physiological disturbance of middle-ear pressure; loss of hearing acuity only appears when this disturbance becomes much greater.

If there is deafness in an ear within this range of negative pressure a tubal dysfunction is unlikely to be entirely responsible, and if the deafness is of conduction type, some degree of additional window impedance is probable. When the reading by the positive release method is over 12 mm. Hg some hearing loss is almost invariably present.

Supply

The instrument is being developed and produced by Messrs. Short & Mason Ltd. of Walthamstow, and should be available later this year, when details will be given in the advertisement pages of the *Journal*.

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