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THE MEASUREMENT OF THE AIR-WAY OF THE NOSE AND NOSE-OPENING RAYS

BY LEONARD HILL

(*From the Laboratory of the St John Clinic and Institute of Physical Medicine, London*)

(With 13 Figures in the Text)

DISHOECK (1935) confirmed the claim for the discovery of nose "opening" rays made by L. Hill (1932), a discovery denied by Dufton and Bedford (1933) and Winslow, Greenburg and Herrington (1934). By means of a blower fan and a well-fitting tube Dishoeck sends a stream of air through one nasal orifice and out through the mouth while the subject holds his breath. The input pressure of the air, meanwhile, is measured by a water manometer which is connected with the air tube just before this enters the nasal orifice. A few seconds suffices to secure such a reading. He calibrates the instrument by measurements made with glass tubes, each about the length of the nasal passage, viz. 6 cm., and fitted with varying diaphragmatic holes.

He thus finds that a decrease of cross-sectional area from 50 to 40 mm.^{2} gives an insignificant increase of pressure, viz. about 3 mm. of water, from 40 to 30 mm.^{2} about 6 mm., from 30 to 20 mm.^{2} about 15 mm., and from 20 to 14 mm.^{2} about 42 mm.

The main reason for this is the fact that the pressure increases inversely as the square of the cross-section according to Poiseuille's law. The average pressure in cases of normal passability of the nose is, he says, 3–4 mm. of water, corresponding to a glass tube with cross-section of about 40 mm. A higher pressure is found corresponding to a smaller passage in cases of septum deflection, rhinitis, etc. A pressure smaller than 3–4 mm. is not found because the ostium internum (the fissure between the plica vestibuli and the septum) is the narrowest part of a normal nose, and the input pressure is mainly determined there.

Beyond the ostium the average cross-section of the nasal passage according to Dishoeck is 200 mm.^{2}, and that of the choana 450 mm.^{2} In normal quiet inspiration, then, the air sucked through the narrow ostium internum comes into a relatively large space, only about one-fifth of which is needed for the passage of the air. In order then to increase the resistance produced by the constriction at the ostium internum, the swelling of the mucous membrane of the nasal passage must fill up no less than four-fifths of the total lumen.

From the above considerations Dishoeck concludes that the study of intranasal changes of volume must be carried out on patients that have a nasal air-way smaller than the normal cross-section of the internal ostium. One must, he says, look for these cases among people with septum deviations. He, moreover, selected only those cases which showed a well marked constriction of the air-way after spraying it with 1/1000 histamine chloride solution, and dilatation on spraying with adrenaline 1:1000. On such selected cases Dishoeck confirmed the nose "shutting" effect of the longer, and the nose-opening effect of the shorter, infra-red rays, but finds the shutting effect had a latent period of about 6 min. and the opening one about 1–3 min. The latent time is that which is spent while the mucous membrane becomes sufficiently congested to have a significant obstructive effect on the passage of the air coming from the blower fan. If the fan were made more powerful so as to produce a greater pressure than 3–4 mm. of water at the normal nasal entrance, a significant increase might be obtained earlier, a smaller degree of constriction of the air-way then becoming effective. The blowing of air into the nose has a cooling effect, and this also must delay the onset of closing. Dishoeck agrees with L. Hill that cooling is the most potent antagonist of nose-closing rays.

By L. Hill's methods a trigger-like effect is obtained, the nasal air-way being obstructed to such a degree that the least change in congestion of the mucous membrane becomes at once manifest. As a result the latent period is reduced to a few seconds. The air-way can be obstructed either by a screw nose-clip which presses in the wing of the nose, and so narrows the ostium internum or by insertion, in the nostril, of a very short length of glass tubing with a suitably narrowed orifice.

Dr W. A. R. Thomson (1934) (Patterson Research Scholar, London Hospital), used the nose-clip method, and investigating a random sample of 100 young sailors who knew nothing of the object of the enquiry, found in ninety-four breathing was made more difficult on exposure of their faces to a bowl-shaped electric heater; in forty-five of these the breathing was eased by switching on an incandescent lamp. L. Hill has pointed out that there is a balance between the antagonistic action of the nose-closing and nose-opening rays, and the respective distance of the sources has to be so arranged in order that the nose-opening rays may be effective. His critics do not appear to have attended to this matter.

In recent observations L. Hill uses as sources a small electric heating coil about 4 by $1\frac{1}{2}$ in. in size, and a small naked tungsten arc. These are placed side by side and at a distance of 2–3 ft. from the subject's face. The energy of the coil was found to be from seven to eighteen times that of the arc, the variation depending upon the size of the flame of the arc. The rays of the tungsten arc at the above distance have a nose-opening effect, while at a shorter distance, *e.g.* $1\frac{1}{2}$ to 1 ft., the nose-closing effect of the longer infra-red rays given off by the hot tungsten rods overcomes the nose-opening effect of the rays coming from the flame of the arc. When, then, the nose-closing rays reach a certain intensity the nose-opening rays of the arc fail to be effective, although also increased in intensity. The trials are made in a cool room. Into one nostril a nipple-shaped tube is inserted so as to fit the nasal opening. This tube is connected with a water-manometer and this in its turn with a recording tambour. Breathing takes place through the other nostril, and into this one or other of a set of tubes can be inserted, each about ½ in. long, and with varying sizes of orifice. In this way there can be found the size of orifice which causes an increase in excursion of the meniscus of the water-manometer when the subject is sitting at rest and quietly breathing.

The excursion of the meniscus of the manometer produced by breathing through a normal side of the nose, when the subject is sitting at rest, can be made equal to that larger one given on breathing through a partially obstructed side of the nose, by insertion into the normal side of a tube with a suitably narrow orifice; the tubes were graded thus:

Diameter in mm.	Approximate surface area of orifice in sq. mm.
2·6	5½
3·5	9½
4·2	14
4·9	19
5·2	21
5·6	24½
6·0	28½
7·0	38½

It must be kept in mind that when the recording tube is inserted the wing of the nostril is pushed out. This relieves any obstruction at the ostium; and makes possible the taking of a record from a nasal passage which happens to be partially obstructed there.

Figs. I and II show on two resting subjects the effect of introducing tubes into a normal breathing passage. Insertion of a tube with orifice 19 mm.^{2} makes the breathing easier in both subjects, one with orifice 14 mm.^{2} keeps it equal in one subject, and one with orifice 9½ mm.^{2} in the other.

The conclusion reached from a number of observations is that an orifice of 9½–14 mm.^{2} suffices for normal quiet respiration, a tube 5½ mm.^{2} makes the breathing exaggerated, but respiration is possible for a time through this without undue discomfort while the subject is at rest.

In order to find the size of the normal ostium internum the subject is made to take hard exercise, lifting his body weight up on to, and down from, a box 6 in. high, each lift being in time with every other beat of a metronome. The subject is told to inspire with each uplift, and expire with each descent. When stepping thirty-three times a minute the insertion of a tube with orifice 24½ mm.^{2} made the breathing easier, one of 21 mm.^{2} about equal, one of 19 mm.^{2} more difficult, and one of 14 mm.^{2} so difficult that distress occurred, *e.g.* sweating and headache which result from excess of carbon dioxide, and the breathing through this tube had shortly to be given up. When the frequency of stepping was raised even to fifty-two times a minute, the tube

$24\frac{1}{2}$ mm.^{2} still eased the respiration, and that of 21 mm.^{2} kept it about equal (Fig. III).

Figs. IV and V show other examples of the stepping experiment. The table shows measurements on either nasal passage made on ten subjects by the frequent stepping method:

		Approximate area of tube orifice in mm.^{2}				Conclusion
Subject		38	28	19	14	R.N. = 19 mm.^{2}
L.	R.N.	−	−	Equal	+	
	L.N.	−	−	−	− slightly	L.N. smaller than 14
S.	R.N.	−	Equal	+		R.N. = 28
	L.N.	−	−	−	Equal	L.N. = 14
C.	R.N.	−	−	Equal	+	R.N. = 19
R.	R.N.	−	Equal	+		R.N. = 28
M.	R.N.	−	Equal	+		R.N. = 28
R.	R.N.	−	− slightly	+		R.N. almost 28
	L.N.	−	−	Equal	+	L.N. = 19
T.	R.N.	−	− slightly			R.N. about 28
	L.N.	−	−	−	Equal	L.N. = 14
Ra.	R.N.	Cannot naturally breathe through it				R.N. = 0
	L.N.	−	−	−	Equal	L.N. = 14
L.H.	R.N.	−	−	+ slightly		R.N. about 20
	L.N.	−	−	−	+ slightly	L.N. less than 14
Re.	R.N.	Equal	+			R.N. = 38

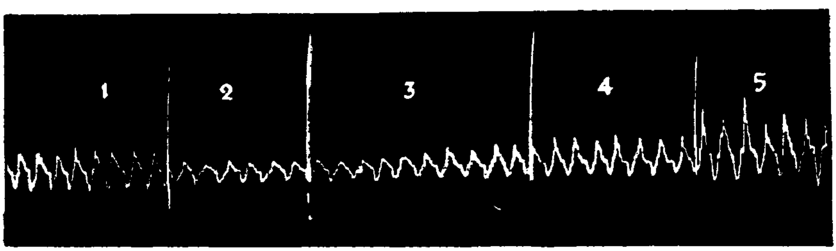


Fig. I.

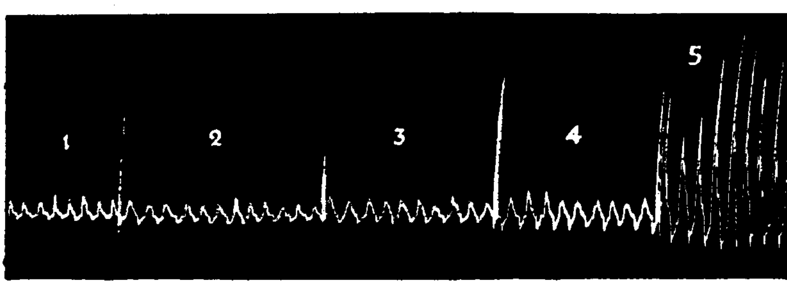


Fig. II.

Figs. I and II. Subjects A and B. Normal side of nose. 1, quiet respiration; 2, respiration with tube 19 mm.^{2} inserted; 3, respiration with tube 14 mm.^{2} inserted; 4, respiration with tube $9\frac{1}{2}$ mm.^{2} inserted; 5, respiration with tube $5\frac{1}{2}$ mm.^{2} inserted.

Dishoeck in wide noses found the size of the ostium internum to be 36 mm.^{2}, while in cases used for observation the average size was about 20 mm.^{2} The agreement between the two methods is, then, good.

Fig. VI shows (1) a record of breathing, while stepping fourteen times a minute, through the normal side of the nose in the case of an asthmatic patient, (2) through the partially obstructed side, (4) the normal side with tube 19 mm.^{2}, (5) with tube 14 mm.^{2} and (6) with tube $9\frac{1}{2}$ mm.^{2} As the excursion at (6) is about equal to that at (2) it is concluded that the partially obstructed side equalled an orifice of about $9\frac{1}{2}$ mm.^{2}

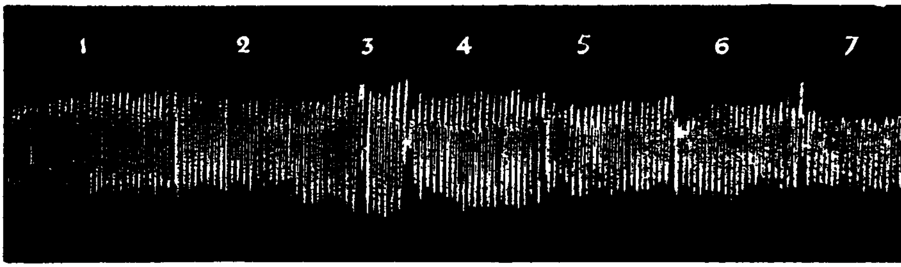
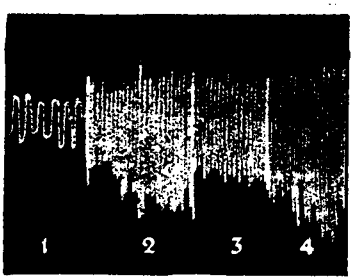
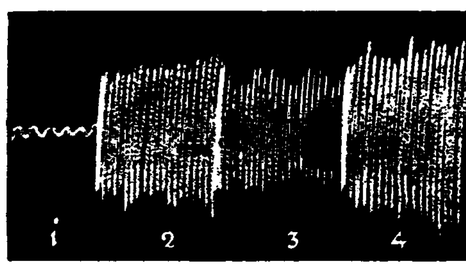


Fig. III. Subject L.H. Stepping 37 times a minute. 1, respiration through normal side of nose; 2, with tube 21 mm.^{2} inserted, respiration about the same as 1; 3, with tube 14 mm.^{2} respiration became too difficult to continue; 4, with tube 19 mm.^{2} respiration made somewhat difficult; 5, with no tube; 6, with tube 21 mm.^{2} respiration about the same as with no tube; 7, with tube $24\frac{1}{2}$ mm.^{2} respiration made easier. Conclusion: the ostium internum is about 21 mm.^{2}





Figs. IV and V. Subject T. Normal side of nose. 1, quiet respiration; 2, stepping 52 times a minute; 3, stepping 52 times a minute with 28 mm.^{2} tube inserted, breathing made easier; 4, stepping 52 times a minute with 19 mm.^{2} tube inserted, breathing more difficult. Conclusion ostium internum is between 19 and 28 mm.^{2} in size.

Subject L. Normal side of nose. 1, quiet respiration; 2, stepping 37 times a minute; 3, stepping 37 times a minute with 28 mm.^{2} tube inserted; 4, stepping 37 times a minute with 19 mm.^{2} tube inserted. Conclusion: size of ostium internum is between 19 and 28 mm.^{2}

Fig. VII shows similar measurements made with subject L. whose nose is partially obstructed on one side. These showed that his normal side has an orifice of about 19 and his obstructed side one less than 14 mm.^{2}

It is clear from the above measurements and from those of Dishoeck that a large reduction may be made in the normal nasal passage without affecting quiet respiration. The critics of L. Hill inserted in normal subjects at rest a tube in one nostril and connected this with a recording manometer, leaving open the other nostril for breathing. Obviously it is only in those with the breathing side of the nose considerably obstructed who will so show the effect of irradiation.

The increased excursion brought about by stepping exercise or in the resting subject by insertion of a tube with narrow orifice, *e.g.* 5½ mm.² enables one to test the effect of dull and bright rays.

Fig. VIII shows the effect on the normal nose of L. H. when stepping 40 times a minute, (1) with the arc on, (2) with the arc off. The arc made the b reathing easier; (3) and (4) show the effect of stepping only 16 times a minute

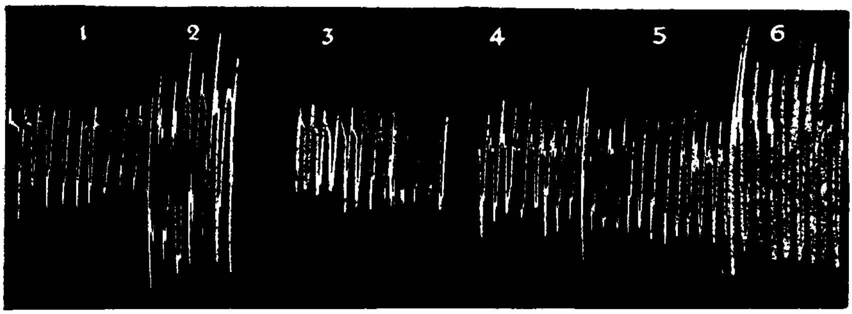


Fig. VI. Subject R. Asthmatic. Stepping 14 times a minute. 1, normal side of nose; 2, partially obstructed side of nose; 3, normal side; 4, with tube 19 mm.² inserted; 5, with tube 14 mm.² inserted; 6, with tube 9½ mm.² inserted. Conclusion: partially obstructed ostium internum is equal to 9½ mm.²

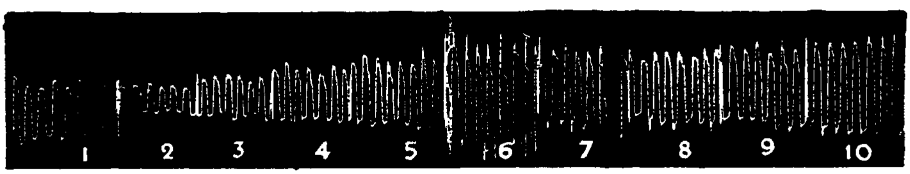


Fig. VII. Subject L. 15 steps a minute. R.N. 1, normal; 2, with tube inserted, orifice 38 mm.²; 3, with tube inserted, orifice 28 mm.²; 4, with tube inserted, orifice 19 mm.²; 5, with tube inserted, orifice 14 mm.²

L.N. 6 normal, partially obstructed side. 7, with tube 28 mm.²; 8, with tube 38 mm.²; 9, with tube 19 mm.²; 10, with tube 14 mm.²

Conclusion: R.N. ostium internum is equal to about 19; L.N. is a little smaller than 14.

with and without the arc on; the ventilation in this case was insufficient to show any effect of the arc on the nasal passage; (5) shows the significant effect of the arc being off, and (6) on, when a tube with orifice 5½ mm.² was inserted so as to obstruct considerably the breathing way of the subject who was now at rest.

Fig. IX shows the contrast with heater on between the (naturally) partially obstructed nasal passage of L. H. (1) arc on, (2) arc off, (3) arc on; and the normal passage (4) (putting the arc on or off in this case made no difference); the normal side (5) with tube with orifice 5½ mm.² inserted and arc on, (6) ditto arc off.

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Fig. X shows, with heater on, respiration through the partially obstructed side (1) with arc on, (2) with arc screened by a glass water cell, (3) with arc on, (4) with arc screened by glass, (5) with arc screened by glass wet with a film of water. In this subject screens of glass and a glass water cell take away the easement afforded by the arc, while glass wet with a water film allows this easement.

In another subject L. Fig. XI the respiration with heater on (1) was eased by the arc (2) and this easement continued when the arc was screened with the glass water cell (3) or with glass (4).

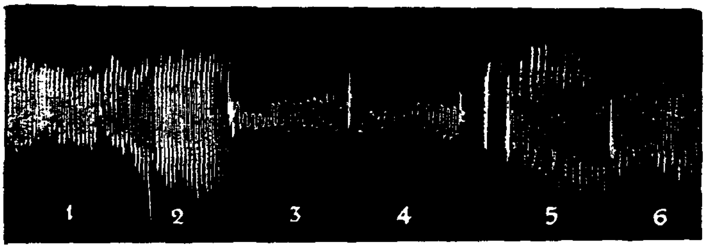

Fig. VIII. Subject L.H. 1, 40 steps a minute with arc on; 2, 40 steps a minute with arc off, nose-opening effect of arc is evident; 3, 16 steps a minute with arc on; 4, 16 steps a minute with arc off, nose-opening effect not shown; 5, resting with tube orifice $5\frac{1}{2}$ mm.^{2} inserted, arc off; 6, resting with tube orifice $5\frac{1}{2}$ mm.^{2} inserted, arc on, nose-opening effect evident.

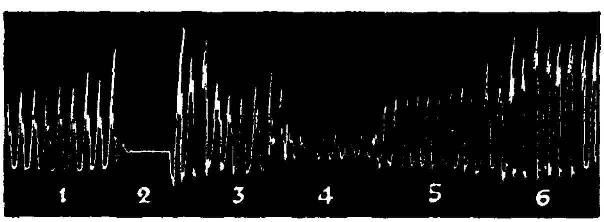

Fig. IX. Subject L.H. 1, L.N. partially obstructed, with arc on; 2, arc off, breathing obstructed; 3, arc on; 4, R.N. normal side; 5, with $5\frac{1}{2}$ mm.^{2} tube inserted and arc on; 6, arc off, breathing much more difficult, but not stopped as in case of L.N. 2.

Subjects may vary then, not only in their sensitivity to the arc but also in the effect of glass, and glass and water screens. The second subject said the screens took away the heat of the arc and made his breathing easier; in other subjects a glass screen converts an arc or the sun from a nose-opening into a nose-closing source. The varying sensitivity of individuals to rays may be compared with the sensitivity of certain people to pollen, or other dust.

Fig. XII shows that (1) exposure to the bright red heater (2) interposition of a glass water cell screen, this made the breathing of the subject L. H. more difficult, while on exposure to the dull red heater (3) the same screen made the breathing easier (4). Either glass, or glass and water, or vapour rising from a bowl of water protects this subject from the nose-closing effects of a dull red or dark heater.

The sodium flame (Fig. XI) acts as a nose "opener" no less well than the tungsten arc; and in the case of the same subject a glass or glass water cell screen does not stop its action. The coloured flames produced in the Bunsen flame by holding copper and calcium in it also act as nose openers.

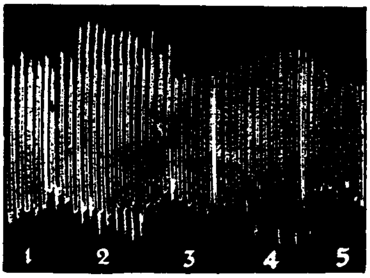

Fig. X. Subject L.H. Stepping 33 times a minute. 1, with arc on; 2, arc on and glass water cell screen; 3, arc on; 4, arc on and glass screen; 5, arc on and glass wet with film of water. Glass water cell and glass screens interfere with nose-opening rays in the case of this subject.

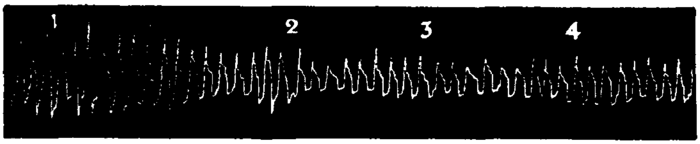

Fig. XI. Subject L. Quiet breathing. 1, heater on; 2, heater on and arc on; 3, heater on, and arc on, and glass water cell screen; 4, heater on, and arc on, and glass screen. The screens do not stop the action of the arc in this subject.

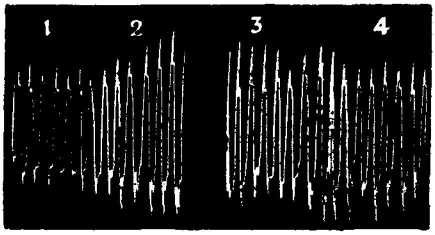

Fig. XII. Subject L.H. Stepping 16 times a minute. 1, bright electric heater on; 2, glass water cell screens off nose-opening rays and makes breathing more difficult; 3, dull red electric heater; 4, glass water cell screens off nose-closing rays and makes breathing easier.

Dishoeck attributes the action of the nose-opening rays to their power of penetrating the epidermis and exciting an increased circulation in the derma which cools the over-heated Malpighian layer. The long-wave infra-red radiation causes a capillary dilatation and stagnation, the penetrating short infra-red an arteriolar dilatation and increased circulating volume. He lays stress upon the long latent period recorded in his observations. But L. Hill's "trigger" method of observation shows that the latent period may be short, *e.g.*

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3–4 sec. The effect would appear then to be a direct reflex one, and not by way of a cooling of the nerve endings in the Malpighian layer brought about by greater blood flow in the derma.

CONCLUSION

A simple method of measuring the nasal air-way is described, and the size of nasal orifice given which is required for quiet respiration, and for stepping exercise. Further proof of nose-opening rays is set forth. The sodium flame is found to give off such rays. The action of a glass screen on the rays is shown to vary with different subjects. The latent period for the action of the rays is in some cases about 3–4 sec.; the shortness of this is considered to be against the view that the rays act indirectly by provoking hyper-hyperaemia in, and so cooling of, the skin.

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ADDENDUM

Further research has shown that in the susceptible subject the air-tubes of the lung, no less than the nasal passage, are narrowed reflexly by irradiation of the skin with dark or dull red heat rays, and widened by rays of the arc. To show this the recording tube is inserted in a cork, which closes one end of a mouth-piece, together with a short tube of $5\frac{1}{2}$, 9 or 14 mm.^{2} orifice. The other end of the mouth-piece is clasped tightly by the lips and breathed through.

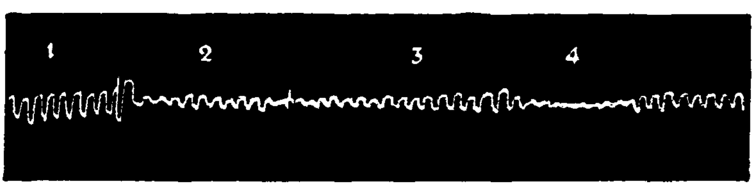

Fig. XIII. Subject sitting at rest. 1, nasal breathing by tube 14 mm.; 2, mouth breathing by tube 14 mm.; 3, mouth breathing by tube 14 mm. with heater on; 4, mouth breathing by tube 14 mm. with heater on and arc on also.

The record shows that the resistance to air flow by way of mouth is less than by the nasal passage. The switching on of the heater now makes the breathing more laboured, and of the arc much easier. In some the breathing becomes rapid, shallow and irregular when obstructed, slower and deeper when relieved.

How far some cases of Asthma are sensitive to such irradiation remains to be explored.

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