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Robert Hare M.D.

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of this species was shot near Crosby-upon-Eden, on the 11th of April. The lowest part of the white patch on each side of the neck was only clearly defined: above this were a few irregular longitudinal white streaks, more numerous and distinct on the left than on the right side.

The Brent Goose is one of our rarest visitants here; whilst on the contrary the Bernacle (*A. Bernicla*) is a regular winter visitant, and occasionally seen in great numbers.

Black-throated Diver (*Colymbus arcticus*). — A speckled Diver was killed in the river Eden about the 7th of February, which from its weight and size* was in all probability an immature bird of this species. I could not ascertain its sex: in the stomach were three small chubs or skellys (*Leuciscus cephalus*) recently swallowed. An old Red-throated Diver (*C. septentrionalis*) was killed on the same river on the 17th of April, 1823. Both are of rare occurrence here. Dr. Fleming, in his History of British Animals, appears to think that these two species may eventually prove to be the same; the latter being the female of the former.

Carlisle, April 27, 1829.

XIX. On the Construction and Applications of the improved Sliding-Rod Eudiometer and of the Volumescopé. By ROBERT HARE, M.D. of Philadelphia†.

Description of an improved Mercurial Sliding-Rod Eudiometer.

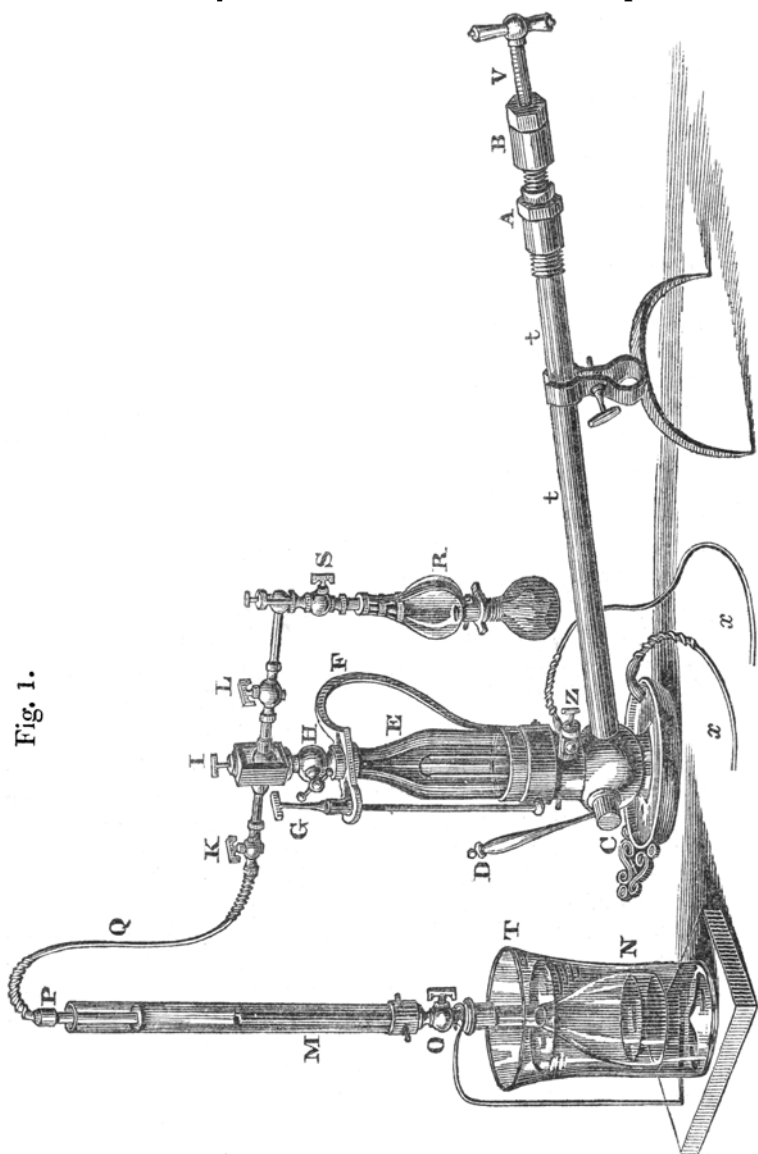
THE aqueous sliding-rod hydro-oxygen eudiometer, (see Phil. Mag. vol. lxxvii. p. 21.) although perfectly well qualified for experiments in which water is employed, does not answer well when used over mercury. The great weight of this liquid causes the indications to vary during manipulation, in consequence of changes of position too slight to be avoided.

The instrument represented in fig. 1. is furnished with a water-gauge O M, which, being appealed to, enables us to cause the pressure of any contained gas to be *in equilibrio* with that of the external air, and consequently to measure it with accuracy. Excepting the gauge, the mechanism by which the measurement is effected is the same as that of the sliding-rod eudiometers for water above alluded to. However, in addition to the stuffing-box at A, there is in the mercurial eudiometers a collar of cotton wick soaked in oil, and packed by a screw B, which includes the cotton and compresses it about the rod. The object of this addition is to supply oil to the rod where it enters the collar of leather; otherwise, they would soon become so dry as to allow air or mercury to pass.

* Weight, 4 pounds 1 ounce; Length, 28 inches.

† Communicated by the Author.

Let us suppose that this eudiometer has been thoroughly filled with mercury, and that it is firmly fixed in the position



in which it is represented in the figure, so that the lower part
 may descend about an inch below the surface of some mercury
 Q 2 contained

contained in an iron cup. At C is a cock, the key of which, in addition to the perforation usual in cocks, has another at right angles to, and terminating in the ordinary perforation. When the lever D, attached to the key, is situated as it appears in the figure, the tube containing the sliding-rod communicates with the receiver, but not with the mercury in the cup. Supposing the lever moved through a quarter of a circle to the other side of the glass, the tube in which the rod slides will communicate at the same time with the receiver E and the mercury. F is a steel spring, which has a disk of oiled leather let into it, so as to correspond with the surface of the apex of the receiver E, which is ground as true as possible. Hence, a slight pressure from the screw G renders the joint made between the apex of the receiver and the spring airtight; while at the same time the bore of the cock H communicates with the cavity of the receiver by means of a perforation through the leather and spring. On the other hand the relaxation of the screw permitting the spring to rise, opens a communication between the cavity of the receiver and the external air. The cock H, supported by the spring, carries a gallows with a screw I, which serves to fasten a small brass casting, so perforated and fitted as to produce a communication between the cock H, and two others K L, with which the ends of the casting are severally furnished. The cock K serves to open or close the communication with the gauge M, and bell-glass within the jar N. The bell-glass is furnished with a cock, upon which the socket O of the gauge screws.

Description of the Water-Gauge.

The gauge consists of three tubes, the interstices between which are partially supplied with water. In the first place a larger and outer glass tube O M, open at the upper end, is at the lower end cemented into a socket attached to the cock O of the bell-glass. Secondly, a small tube of varnished copper, the axis of which is made to coincide with that of the larger tube, is inserted into the bore of the cock. Lastly, a glass tube, in size and situation intermediate between the tubes just mentioned, and open at the lower end, at the upper end enters the pipe Q, which communicates with the bore of the cock K, and of course, when this is open, with the cavity of the receiver. When water is poured into the tube M, if the pressure within and without be *in equilibrio*, it rises in the interstices between the three tubes to the same height; but whenever there is any diversity of pressure between the air of the inner and outer glass tubes, it is indicated by a consequent difference in the height of the liquid columns included.

Descrip-

Description of the Contrivance for the removal of Carbonic Acid from the Gas left after exploding Gaseous Mixtures, partly consisting of the Compounds of Carbon.

The glass receptacle R fastens by means of a gallows screw to a knob at the end of a perforated cylindrical projection from the cock L, so as, with the aid of interposed leather, to make an air-tight juncture. Between the gallows screw and the receptacle, another cock S is interposed, the bore of which communicates by means of corresponding perforations with that of the cock L.

Below the receptacle a caoutchouc bag is fastened, which, as well as the receptacle, must be filled with lime-water.

Means of causing the Explosion of Gaseous Mixtures within the Receiver of the Sliding-Rod Eudiometer.

A gaseous mixture, when contained in the sliding-rod eudiometer, may be inflamed by galvanic ignition excited in a platina wire, in a mode analogous to that already described in the case of the barometer-gauge eudiometer. See Phil. Mag. and Annals, vol. iv. p. 130.

The circuit is established by means of the leaden rods x x , one of which communicates with the mercury of the cistern; while the other is fastened to the insulated wire by means of the gallows z . To the rod which communicates with the mercury, a piece of iron should be soldered so that the lead need not be immersed, and consequently corroded. The insulated wire, where it enters the cavity of the eudiometer, is made air-tight by means of a small stuffing-box. It is protected from the mercury within the receiver by a covering of twine, well soaked in and coated with shell lac varnish.

Determination of the Quantity of Carbonic Oxide in a Gaseous Mixture, by the improved Mercurial Sliding-Rod Eudiometer.

In the first place the mixture must be well washed with lime-water, or a caustic alkaline solution, in order to remove carbonic acid, if present. In the next place let us imagine the bell-glass O N, after being adequately supplied over the pneumatic cistern with equal measures of the purified mixture and oxygen gas, has been transferred to the jar I, containing a sufficiency of water to displace the gaseous mixture as required.

In order to fill the receiver with gas, through the gauge-tube and the pipe Q, by which it communicates with the gaseous mixture in the bell-glass, the eudiometer must be filled with mercury to the total exclusion of air, and the sliding-rod wholly within its tube. Under these circumstances the spring being pressed upon

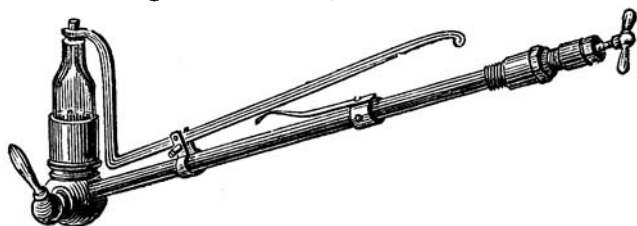
upon the apex of the receiver by the screw G, and the three cocks H K O being open ; on drawing out the rod the receiver will be proportionally supplied from the bell-glass with the gaseous mixture. The receiver being thus supplied, the cock O of the bell closed, and K and H being open, on pushing the rod home, the gaseous mixture, driving the air before it through the interstices between the gauge-tubes, will in part effect its escape, in part supply in the tubes the place of the air which it has expelled. This process may be repeated two or three times. After the atmospheric air has in this way been removed from the apparatus, the cocks between the bell and receiver being open, if the rod be drawn out 200 degrees, 200 measures of the mixture, consisting of 100 of each gas, will enter the eudiometer. This being effected, the cock of the bell must be closed. In consequence of the hydrostatic pressure to which the gas will have been subjected in the bell, its density within the receiver will be unduly great. Hence the pressure of the screw on the spring must be relaxed until the gauge indicate that the gas within the receiver has, by the escape of a portion of it, become, with respect to pressure, *in equilibrio* with the atmosphere. The cock communicating with the gauge is then to be closed, the pressure on the spring restored, and an explosion effected. The communication with the gauge is now to be opened. The indicated deficit must be compensated and measured by pushing in the rod, until the columns of water in the interstices of the gauge are on a level. In the next place, close the cock K communicating with the gauge, and open the cocks H L S, which are between the receiver and the receptacle R. Into this receptacle, by forcing the rod home, the gas is to be transferred. Being agitated with the lime-water, it is drawn back into the eudiometer, brought into *equilibrium* with the atmosphere, by appealing again to the gauge, and then measured by noticing the number of graduations which the sliding-rod must enter, in order to effect its expulsion. This residual air, and the deficit produced by the explosion being deducted from 200, the remainder will be the quantity of the carbonic acid, and of course of carbonic oxide originally in the mixture; since carbonic oxide, in passing to the state of carbonic acid, absorbs half of its bulk of oxygen without any enlargement of volume.

Analysis of Olefiant Gas.

As a volume of this gas has been ascertained to be equivalent to two volumes of carbon and two volumes of hydrogen, it must require three volumes of pure oxygen for its complete combustion, and must leave, after the union, two volumes of carbonic

carbonic acid. In order to insure a competent supply of oxygen, four volumes of it may be mixed with one of the olefiant gas in the bell-glass, and the same manipulation resorted to as in the case of carbonic oxide, excepting that before the explosion, the rod V must be drawn out to the greatest extent; and that as soon as the explosion has taken place, the rod must be returned into the tube, so as nearly to compensate the condensation before resorting to the gauge.

Fig. 2.—*Subsidiary Eudiometer.*



Of the Use of the Subsidiary Eudiometer.

It may sometimes happen that the quantity of gas to be examined may be too small to be measured into the bell-glass by a volumeter, as above described. In that case, a subsidiary eudiometer is employed. Excepting that it is shorter, the rod in this instrument has precisely the same dimensions as in that described in the preceding article; and the graduation in both is exactly the same. The use of the spring and lever, also the method of manipulation, has been described in Phil. Mag. vol. lxvii. page 21.

Analysis of Cyanogen.

Let us suppose it were an object to ascertain the products which result from the combustion of a volume of cyanogen.

A quantity of oxygen gas amply sufficient for the intended experiments must be introduced into the bell-glass N, (fig. 1.) and two hundred measures drawn into the receiver of the principal eudiometer, the manipulation being the same as above described in the case of the mixture. In the next place the subsidiary eudiometer must be supplied with 100 measures of cyanogen, by introducing the apex into a bell-glass containing the gas over mercury, and duly drawing out the rod, the orifice of the receiver being kept open by pressing on the lever, only while above the surface of the mercury, and inside of the bell. The gas thus taken into the subsidiary instrument is next to be transferred to the principal one, *which must in this case be placed over the mercurial reservoir*, and be filled with mercury, the rod V being half withdrawn from its tube.

By

By moving the lever D, a communication must also be opened between the receiver E and the reservoir, and the apex of the subsidiary eudiometer must be introduced into a funnel-shaped cavity, with which the cock C is furnished. The rod of the subsidiary instrument being, under these circumstances, pushed home, the gas must pass from it into the funnel-shaped cavity, and thence rise into the receiver above it. When this object has been effected, close the communication with the reservoir, and open that with the iron tube *tt*; also open the cock H. Then appealing to the gauge, adjust the rod so that the pressure of the included gas may be *in equilibrio* with that of the atmosphere. An explosion is now to be effected; after which on opening the gauge, if the cyanogen be pure, there will be no condensation*. The residual gas, by transfer to the receptacle, may be deprived of carbonic acid; and the deficit thus arising may be measured by transferring what remains to the receiver, and ascertaining how many measures the rod must enter, in order to eject it into the air, or to return it into the receptacle.

Modifications of the Eudiometer, described in the preceding Article.

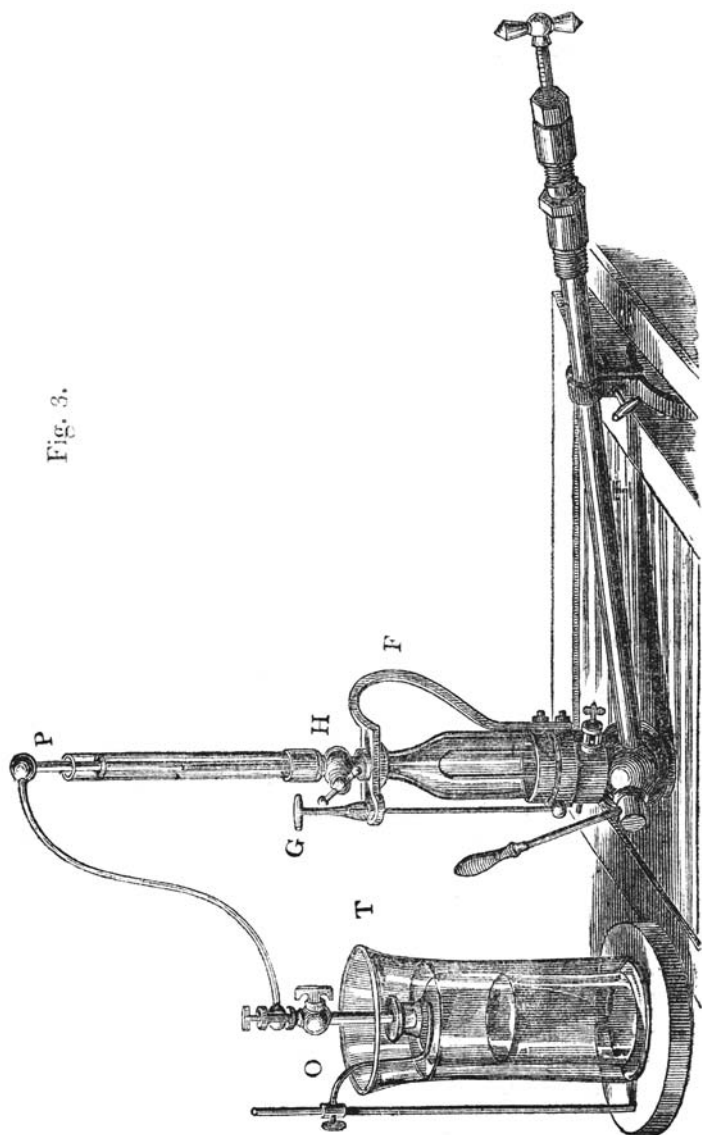
The opposite figure represents another form of the sliding-rod eudiometer, in which the apparatus for the removal of carbonic acid is omitted. The gauge in this eudiometer is attached to the cock of the receiver, instead of surmounting the bell-glass. It answers equally well in either situation.

If, instead of the bell and jar, a self-regulating reservoir of hydrogen were attached to the flexible pipe, a convenient arrangement would be obtained for ascertaining the proportion of oxygen in the atmosphere. In that case the mode of operating would be as follows. The pipe and tubes of the gauge being filled with hydrogen, and the receiver with mercury, also the cocks H and O being open, draw out the sliding-rod 50 degrees. A quantity of hydrogen, in bulk equivalent to the part of the rod withdrawn, will pass from the reservoir through the flexible pipe into the cavity of the receiver. The cock O being shut, on appealing to the gauge it will be found that the hydrogen, in consequence of the hydrostatic pressure of the reservoir, will be a little denser than if *in equilibrio* with the atmosphere. By relaxing the pressure of the screw G upon the spring, as much hydrogen will escape as may be necessary to

* Before the explosion, two volumes of oxygen and one of cyanogen are present; the latter comprising two volumes of carbon, and one of nitrogen. During the inflammation, the carbon is transferred to the oxygen without altering it in bulk, while the nitrogen is set at liberty, uncondensed, so as to occupy as much space as the cyanogen did previously.

produce

Fig. 3.



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ter. The pressure of the screw G upon the spring F being restored, and an explosion effected, agreeably to the directions already given, by returning the rod into its tube, more or less, and appealing to the gauge, the deficit may be ascertained. If no error shall have taken place, expelling the residual gas will just return the rod to the situation which it occupied when the experiment commenced. Of the deficit, of course one-third is due to oxygen. It may be proper to mention that some delay is necessary, in order to permit the residual gas to part with the heat acquired from the combustion of the hydrogen and oxygen.

As for the analysis just described, the eudiometer may, as represented in the preceding figure, be seated in a cup of mercury, instead of being placed over a mercurial reservoir; and since the apparatus, when once put into operation, enables us to multiply experiments with great facility, it will be found peculiarly well calculated for a series of observations under circumstances in which access to a pneumatic cistern cannot be had.

Eudiometrical Apparatus analogous to the preceding, excepting that it is constructed of Brass, used with Water, and that Explosions are caused in it by an Electric Spark.

In the analysis of atmospheric air, agreeably to the process last described, no gaseous product being generated which is absorbable by water, it is not necessary to employ mercury, and, consequently, to have the metallic part of the eudiometer of iron and steel. It is in fact preferable to have it of brass, as in that case it will not rust, and may be kept in operation for many months without requiring much adjustment. I have an apparatus thus made, and so contrived as to be ignited by an electric spark. Excepting the substitution of brass for iron, there is no material difference between that apparatus and the one represented by the figure, excepting that the receiver E is exchanged for one of which there is a representation in *Phil. Mag.* vol. lxvii. p. 22, fig. B.

In the brass eudiometer last described, the cock C is omitted; while, at right angles to the receiver, a small cock is inserted, which supports a glass vessel holding water. By these means, any excess or deficiency of this liquid is easily remedied, and the employment of the cup beneath the eudiometer rendered unnecessary.

[To be continued.]