THE APPLICATION OF THE PRINCIPLE OF PARTIAL PRESSURE OF GASES TO HALDANE'S METHOD OF STAGE DECOMPRESSION

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During the discussion following the late Sir Henry Japp's paper on 'Prevention of compressed air illness', read at a meeting of the Institute of Structural Engineers on 28 March 1935, I suggested an extension of Haldane's system of decompression which might prove of considerable practical value in tunnel and caisson work (Japp, 1935). Briefly the proposed extension consisted in making use of Dalton's theory of the partial pressure of gases in such a manner that denitrogenization of the blood might be brought about while the workers were still under full pressure, namely, by making them breathe before entering the decompressing chamber an artificial atmosphere containing no nitrogen.

Dalton's theory, first published in his *New System of Chemical Philosophy* (Dalton, 1808), stated that 'when any two or more mixed gases acquire an equilibrium the elastic energy of each against the surface of the vessel or of any liquid is precisely the same as if it were the only gas present occupying the whole space, and all the rest were withdrawn'. Dalton also stated that 'no one gas is capable of retaining another in water'.

Although experimental proof is lacking Dalton's theory may be, in my opinion, expressed as follows. The rate of evolution of a gas from a liquid is the same whether the evolution takes place into a vacuum or into a closed vessel containing another gas.

Haldane (1922) pointed out that during its passage through the lungs the blood is brought into such intimate contact with the inspired air that it loses all its excess pressure of nitrogen when the air pressure is lowered in the airlock. In his system the air pressure in the airlock is reduced quickly to half the absolute pressure on the worker entering it, and as the nitrogen is abstracted from the blood and body tissues further lowerings of the air pressure are made so as to maintain the nitrogen pressure in the blood at twice that of the partial pressure of nitrogen in the lungs.

Presumably, if a worker was, at the end of a shift, to put on a helmet and by that means breathe an artificial atmosphere, e.g. a mixture of 80 % helium and 20 % oxygen containing no nitrogen, he would denitrogenize his blood while still in the tunnel under the full working pressure and could then enter the airlock and pass quickly through to free air. As the partial pressure of nitrogen in the artificial atmosphere was zero the nitrogen in the blood would be wholly, instead of half, eliminated during each passage of the blood through the lungs. The denitrogenization of the blood would therefore be taking place at twice the standard rate and consequently the time required for denitrogenization would be halved. In some cases, however, the total time saved would not be exactly half the normal, because after long shifts at high pressure, the time the artificial atmosphere had been breathed might necessitate a short time in the airlock breathing ordinary air in order to eliminate any constituent of the artificial atmosphere of which a dangerous excess had been absorbed into the blood.

Table 1. *Showing times (in minutes) required, after a working shift of 4 hr., to pass from the working chamber to free air*

	Time for decompression				
			Using helmet for the denitrogenization and airlock for deheliumization		
Gauge pressure in the working chamber in lb. per sq. in.	Using the Institute of Civil Engineers' recommendations	Using partial pressure method in the ordinary steel airlock	At working pressure breathing helium mixture	In airlock breathing ordinary air	Columns 4 and 5 added together
30	35	18	18	Nil	18
40	84	42	42	15	57
50	136	68	68	34	102

Table 1 has been drawn up giving the suggested application of the proposed system.

The first column gives the gauge pressure in the working chamber.

The second column gives the times for decompression recommended by the Institution of Civil Engineers.

The third column gives the time when decompression takes place in the airlock in the usual way though an artificial atmosphere containing no nitrogen is breathed during the process, either by means of masks, or, which would, however, probably be too costly, by pumping an artificial atmosphere into the airlock.

The fourth column gives the time required to denitrogenize the blood when the artificial atmosphere is breathed from a mask at the full working pressure.

The fifth column gives the time required to eliminate

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any gas absorbed to a dangerous excess from the artificial atmosphere.

Column 6, obtained by adding together columns 4 and 5, gives the total times required.

As the suggestions I made in 1935 do not seem to have attracted attention I have taken this opportunity of stating them in greater detail in the hope that they may be investigated experimentally.

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