IV. *Some* Obſervations *upon Mr.* Sutton's *Invention to extract the* foul *and* ſtinking Air *from the* Well *and other Parts of* Ships, *with* Critical Remarks *upon the Uſe of* Windſails, *by* William Watſon, F. R. S.

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AS nothing is more conducive to the Health of the human Body, than taking a ſufficient Quantity of wholſome Air into the Lungs, ſo the contrary is attended with pernicious and often with deſtructive Conſequences.

One of the great Uſes of Air in Inſpiration is, to cool the Blood paſſing through the Lungs, where Nature has provided, according to the excellent *Malpighius*, that the Blood ſhould be diſtributed through a vaſt Number of exceedingly fine Arteries, which are applied all round the thin Veſicles of the Lungs; and by this means the Blood is expoſed to the Air under a prodigious large Surface, whereby the Putrefaction is prevented, which, from the alcaleſcent Quality of that Fluid, would otherwiſe be ſpeedily deſtructive.

Obſervations inform us, that contagious Diſtempers are more frequent in hot Climates than cold; and in cloſely built Cities fully inhabited, than in Towns: The former may, in ſome meaſure, proceed from the too great Heat of the Air, not fully anſwering the above-mentioned Purpoſes; and the latter from too many People breathing in the ſame Atmoſphere, thereby rendering it unfit for Reſpiration.

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It has been frequently tried, that if a Gallon of Air be contained in a Bladder, and by means of a Blow-pipe inſpired and expired into the Lungs of a Man, without having any Communication with the external Air; in the Space of a Minute, or little more, it becomes heated, and unfit for Reſpiration; and without the Addition of freſh Air, the Perſon would ſpeedily be ſuffocated. The Diving-bell is another Inſtance of the ſame kind, where a conſtant Supply of freſh Air muſt be had, to keep out the Water, and refreſh the People included.

Although Air is abſolutely neceſſary to our Exiſtence, and Neceſſity conſtrains us inevitably to breathe therein, it may be made a Vehicle of moſt malignant Poiſons, as the famous *Grotto del Cani* in *Italy*; poiſoning Air by Charcoal, Air impregnated with the Fumes of fermenting vegetable Liquors, ſtagnant Air, either alone or mixed with Water, ſoon becomes pernicious, and very offenſive; as in Wells dug for Supply of Water, and diſuſed for ſome time; alſo in the Wells and in the Holds of Ships, where what is uſually called the Bulge-water, if the Ship is tight, and the Water not pumped out often, it ſoon becomes ſo extremely poiſonous, as frequently to ſuffocate thoſe Seamen, who, as the Pumps are ſubject to be clogged with Filth, venture down to cleanſe them; and alſo to affect Perſons at a Diſtance with violent Head-achs, cold Sweats, and frequent Vomitings, which continue more or leſs, in Proportion to the Diſtance from the Well of the Ship when the Injury was received, and the Degree of Putrefaction in the Water and Air.

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The Air, in Ships particularly, is very liable to be vitiated; not only from the Bulge-water, but from too many People breathing in the ſame Atmoſphere; eſpecially in Ships of War, Hoſpital-ſhips, and thoſe uſed in the *Guinea* Trade for *Negroes*, where a Number of uncleanly People, being ſtowed too cloſe together, heat the Air, make it replete with noxious *Effluvia*, deſtroy the Particles therein adapted to cool the Lungs, particularly the acid nitrous *Gas*, which is ſo abundant in cool Air, and manifeſts itſelf not only from the Quantity of nitrous Cryſtallizations, which may be collected from Caverns of the Earth, eſpecially thoſe open to a Northerly Aſpect, but from expoſing Pieces of the Fleſh of Animals freſh cut, or their Blood, whereby the Colours of their Surfaces are ſoon changed from a dark deep Red to a more lively and florid one. Air robbed of this valuable Property, and replete with hurtful ones, not only from the People, but from the ſtinking Water in the Well and lower Parts of the Ship, muſt produce the moſt putrid, if not peſtilential Fevers.

Although the *Æquilibrium* within Places confined is maintained by the external Air, yet unleſs, by Openings properly adapted, the Air is ſuffered to paſs freely through, the external Air proves as a Stopple to the internal, and only mixes with the next in Contact; as is evident from the common Occurrence in Privies, which are ſcarcely offenſive in clear Weather, but are much ſo in foul or windy, from a Diminution of the incumbent Preſſure, when the Vapours that have been pent up, expand themſelves to a conſiderable Diſtance.

To prevent the above-mentioned Inconveniencies, and preſerve the Healths and Lives of that valuable Part of the Nation, the Seafaring People, many Schemes have been thought of; particularly the Machines of thoſe two very worthy ingenious and induſtrious Members of this SOCIETY, the Rev. Dr. *Hales*, and the Rev. Dr. *Deſaguliers*; the firſt by an Inſtrument which he calls *the Ship's Lungs* *, and the latter by a Machine †, which is an Improvement of the *Heſſian* Bellows: But as theſe have been laid before the SOCIETY by the Gentlemen themſelves, I ſhall paſs them over, and proceed to mention the Contrivance commonly made uſe of, I mean the Wind-ſails. They are made of the common Sail-cloth, and are uſually between 25 and 30 Foot long, according to the Size of the Ship, and are of the Form of a Cone ending obtuſely: When they are made uſe of, they are hoiſted by Ropes to about Two thirds or more of their Height, with their Baſis diſtended circularly by Hoops, and their Apex hanging downwards in the Hatch-ways of the Ship; above each of theſe, one of the common Sails is ſo diſpoſed, that the greateſt Part of the Air, ruſhing againſt it, is directed into the Wind-ſail, and conveyed, as through a Funnel, into the upper Parts of the Body of the Ship. Theſe muſt be hung up and taken down every time they are uſed, and the Supply by this Method is not conſtant. Though Cuſtom has given a Sanction to this Device, it is ſubject to many Inconveniencies: 1*ſt*, Each Ship having com-

* See Dr. *Hales's* Treatiſe of Ventilators.

† See theſe *Tranſactions*, N° 437

monly three of theſe, (one to each Maſt) the Seamen are a conſiderable time in getting their Apparatus ready, and hoiſting them up, to make uſe of. *2dly*, They can only be uſed in mild Weather. *3dly*, Near the Equator, where freſh Air is moſt wanted, there ſometimes happen ſuch ſtark Calms, that they are uſeleſs by not having Air enough to diſtend them. *4thly*, The Air hereby admitted paſſes only into the upper and more open Parts of the Ship, ſo that the Well, *&c.* receive no Change therefrom; and it is obſerved, that ſometimes, upon uſing them after ſome Diſcontinuance, they drive offenſive Air into the Cabin, and more airy Parts of the Ship; like as the pouring ſome freſh into ſtinking Water makes more Water ſtink, though in a leſs Degree. *5thly*, They are improper to be uſed in the Night-time, when the People are ſleeping between Decks. And, *Laſtly*, admitting they had none of the former Inconveniencies, their Uſe muſt be deſtructive in Hoſpital ſhips; where, though freſh Air imperceptibly received is abſolutely neceſſary to preſerve the Crew as free as poſſible from the infectious Breath and Exhalations of the diſeaſed and wounded Seamen, yet Blaſts of Wind, pouring impetuouſly into the very Places where the Sick lie, muſt be attended with ſuch Conſequences as are too obvious to mention.

To remedy theſe Inconveniencies, to prevent Air proving foul even in the Wells and Holds of Ships, and to cauſe imperceptibly a large Circulation of freſh Air into every Part of the Ship at all times, Mr. *Sutton* has invented the following Scheme *, which is

* See theſe *Tranſactions*, N° 462. *p.* 42.

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uſeful not only in theſe Caſes, but, by altering ſome Parts, as particular Places require, may be applied to Houſes, cloſe Parts of Priſons, Wells at Land, Privies, Hoſpitals, *&c.*

Nothing rarefies Air ſo conſiderably as Heat, and whenever it cauſes a Diminution of the Denſity of the Air, that Part next in Contact will ruſh in, and be ſucceeded by a conſtant Supply, till the Air becomes of an equal Degree of Elaſticity. Therefore, if a Tube be laid in the Well, Hold, or any other Part of the Ship, and the upper Part of this Tube be ſufficiently heated to rarefy the impending Column of Air, the *Æquilibrium* will be maintained by the putrid Air from the Bottom, which being drawn out this way, a Supply of freſh Air from the other Parts of the Ship will ſucceed in its Place; which Operation, being continued, will intirely change the Air in all the Parts of the Ship. This Principle, exactly conformable to the Doctrine of Pneumatics, is the Baſis of Mr. *Sutton's* Machine, which being put in Execution on board the *Hulk* at *Deptford*, before the Lords of the Admiralty, Commiſſioners of the Navy, our very learned and ingenious Preſident *M. Folkes*, Eſq; Dr. *Mead*, &c. performed to their Satisfaction, in bringing Air from the Bread-room, Horlop and Well of the Ship at the ſame time, in ſuch Quantity, that large lighted Candles being put to the End of Tubes, the Flame was immediately ſucked out as faſt as applied, though the End of one of the Tubes was above Twenty Yards diſtant from the Fire. The Method is as follows:

To boil the Proviſions of the Ship's Company, they muſt have a Copper which is bigger or leſs, in pro-

portion to the Size of the Ship, and Number of the Crew: This Copper is fixed in Ships in the Manner as on Land, having under it Two Holes divided by an iron Grate. The firſt Hole, having an iron Door, is for the Fire; the Aſhes from the Grate drop through into the Bottom of the other; the Smoke paſſes through a Chimney, and is diſcharged as uſual. After the Fire is lighted, it is ſupported by the Air from the Parts next the Aſh-pit; but having, contrary to the uſual Cuſtom, adapted an iron Door, like the former, made very tight, to prevent the Ingreſs of Air, the Fire would ſoon be extinguiſhed, if not ſupplied by ſome other Aperture; in order to which, one or more Holes are made through the Brick-work in the Side of the Aſh-pit; and Tubes of Lead or Copper, fitted cloſely in the Holes, and made faſt, are laid from thence into the Well, and other Parts of the Ship; by which means the Air next the Bottom of the Tubes ruſhes through them, and the foul and ſtinking Air ſucceeding is tranſmitted through the Fire, and paſſes off, without offending, by means of the Chimney; and a Supply of freſh Air from the other Parts of the Ship continually fills the Place of the former, the Fire requiring a conſtant Support, which Support will be wanting, not only during the Continuance of the Fire, but while any Warmth remains in the Fire-place, Copper, or Brick-work, as was obſerved on board the *Hulk* at *Deptford*, where the Draught of Air through the Tube laſted above Twelve Hours after the Fire was taken away. This being conſidered, as the dreſſing the Proviſions for a Number of People will take up ſome Hours every Day, the Warmth of the Brick-work and Flues will con-

continue a Draught of Air from one Day to the next. Mr. *Sutton* propoſes thus to circulate the Air by the ſame and no greater Expence of Fire than is cuſtomarily uſed for the Neceſſities of the Ship. The Operation of the Machine will be equally uſeful in large as ſmall Ships; for the greater the Number of People they have on board, the larger Quantity, and longer Continuance, of the Fire will be neceſſary to dreſs the Proviſion; and therefore there will be required a greater Quantity of Air to ſupport that Fire. The Size and Number of the Tubes need not be ſpecified, becauſe as the Conſumption of Air is in proportion to the Quantity of Fire, the wider the Tube, and greater the Number, the leſs the Velocity of the Air, and *vice verſa*.

I ſeveral times obſerved in this Machine, when for the ſake of Obſervation, after the Fire was well lighted, and the loweſt iron Door left open, that the Flame did not aſcend ſo high, or burn ſo fierce; but immediately upon ſhutting thereof, when the Draught of Air was only through the Tubes, the Flame ſoon recovered its former Vigour.

There is likewiſe, eſpecially in large Ships, not only a Copper, but alſo a Fire-grate like thoſe uſed in Kitchens: That the Heat and Smoke of this alſo may not be uſeleſs, an iron Tube may be fixed behind the Grate, and inſerted quite through the Brick-work, and through the Deck, ſo that one End thereof will ſtand about a Foot, or little more, in the Chimney above the Brick-work, and the other will enter into the Hold, or any other Part of the Ship; ſo that the upper End being heated, the Draught of Air will be ſupplied from below, as in the other Caſe. This

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likewiſe was tried on board the *Hulk*, with an iron Tube about Two Inches and an half in Diameter, and the lighted Candles held at the Bottom of this Tube were extinguiſhed as faſt as by any of the other.

It may be objected, that a Number of Tubes take up too much Room, eſpecially in Merchants Ships, and are ſubject to be broken or injured by loading or unloading: To remedy which, it is adviſeable, that only one Tube of a convenient Size be made faſt unto the Side of the Aſh-pit, and, as ſoon as it comes through the main Deck, to compreſs it (a circular or any other Form being equally uſeful) not too cloſe; and it may be divided into as many Ramifications as may be thought neceſſary, (eſpecially as the Bread-room, Store-room, *&c.* cannot be kept too ſweet, a Branch for each of theſe) and theſe Branches be carried between the Beams which ſupport the Deck, till they come to the Side of the Ship, and there let down likewiſe between the Beams into the Places intended; by which Contrivance their Operation will not in the leaſt be obſtructed, and the Tubes be ſecured from any Accident.

The Simplicity of this Machine, it being ſo little cumberſome, its Operation without any Labour to the Seamen, the ſmall Expence to put it in Execution, and maintain it, beſides the before-mentioned Conſiderations, are other Arguments for its general Uſe.