A proposal for destroying the fire and choak-damps of coal-mines : and their production explained on the principles of modern chemistry addressed to the owners and agents of coal-works, &c; / by Thomas Trotter.

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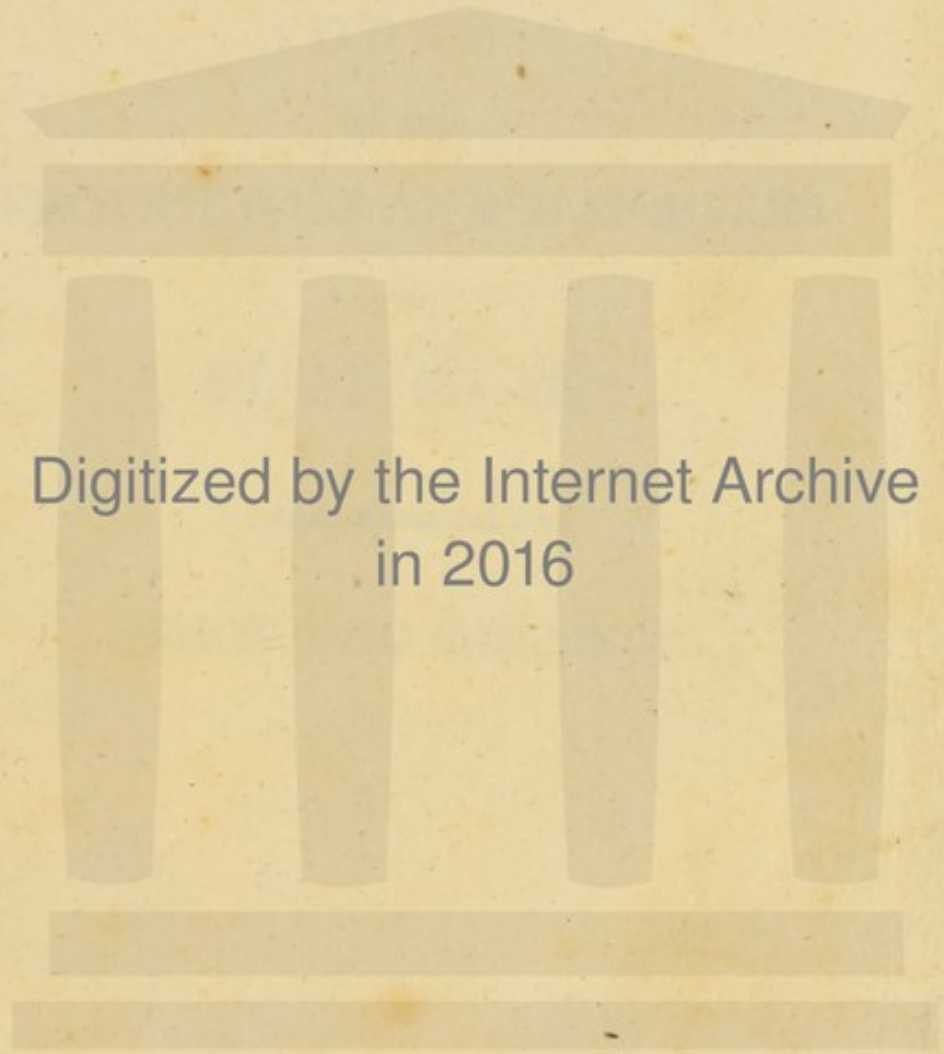

ERRATA.

Page 6, line 10, dele *is*.

Page 10, line 6 of the note, for *nitric gas* read *nitrous gas*.

Page 11, line last, for *hot* read *not*.

Page 19, line last but one, for *de Connoissances* read *des Connaissances*.

A

PROPOSAL

FOR

DESTROYING

THR

FIRE AND CHOAK-DAMPS

OF

Coal-Mines;

AND

THEIR PRODUCTION EXPLAINED

ON THE

PRINCIPLES OF MODERN CHEMISTRY:

ADDRESSED TO THE

OWNERS AND AGENTS OF COAL-WORKS, &c.

BY THOMAS TROTTER, M.D.
LATE PHYSICIAN TO HIS MAJESTY'S FLEET,
&c. &c. &c.

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1805.

TO THE

OWNERS AND AGENTS

OF

COAL MINES

IN THE

COUNTIES OF NORTHUMBERLAND, DURHAM,

&c. &c.

Gentlemen,

I have herewith the pleasure of presenting you with a proposal for destroying, by chemical agents, those noxious gases, "fire and choak damps," *that on numerous occasions have proved fatal to many of your workmen. The subject, I think, admits of demonstration, at least as far as human knowledge can depend on the faith of experiment. I have not attempted to puzzle a plain understanding by offering conjectures instead of truths, or to bewilder common sense by specious, but fanciful theories. Though a physician, my doctrine is intelligible, and my practice humble. No merit is claimed, where there is no invention; and no fame is expected*

for being industrious. If I appear obscure sometimes, it is from making brevity my aim. I only hold out a short explanation of well-known facts, in the hope of seeing them conducive to save human lives, whose labours are useful to the community.

Philosophy can little avail society, if confined to the study or the laboratory: it is valuable only as it makes mankind comfortable and happy. This little essay may be considered as the continuation of some former labours in the public service. To the cause which I have espoused you will not find me a cold advocate; but I shall be highly honored by receiving your approbation.

I am, with great respect,

Gentlemen,

Your faithful humble servant,

T. TROTTER.

Northumberland-Street,
Oct. 14th, 1805.

A

PROPOSAL

FOR

DESTROYING THE FIRE AND CHOAK DAMPS

OF

COAL-MINES.

SINCE my reſidence in this neighbourhood, a number of accidents have happened among pitmen, employed in coal-mines, by exploſions of what is called *fire-damp*, the hydrogenous gas of modern chemiſts, and very lately thirty-two men have been killed in Hebburn main. Suffocation from *choak-damp*, the carbonic acid gas of chemiſts, has alſo frequently happened. As far as my enquiries go, no certain means have yet been deviſed for preventing thoſe fatal accidents. The effect of ventilation from the ſhaft cannot be perfect, at ſo great a depth below ground as one hundred fathoms. This appears to me of vaſt importance in a *mining district;* and the preſervation of ſo many

valuable lives muſt at all times intereſt the humane owners of theſe extenſive works.

On conſidering this ſubject, I was immediately ſtruck with the great analogy it has to the ventilation and purification of ſhips. In the third volume of my work on the Diſeaſes of the Fleet, publiſhed ſince I fixed in Newcaſtle, a chapter is devoted to that branch of naval diſcipline, as connected with the preſervation of life, and the prevention of diſeaſe in his Majeſty's naval ſervice. With theſe preliminary ſtudies, I was in ſome meaſure prepared for this inveſtigation.

It has been one of the happy conſequences of the modern improvements in chemical ſcience, to explain numbers of facts, in the different arts, which, though familiar to us before in their general reſult, yet we knew nothing of them in principle. In nothing is this better exemplified than in *Pneumatology,* or the doctrine of airs. This, indeed, from the lately

acquired knowledge and rapid diſcoveries, may be juſtly called of itſelf a new ſcience. We can turn our eyes into no part of nature, without being edified and amuſed by pneumatic chemiſtry. The ſky, the lake, and the cavern, are its vaſt laboratories. The inviſible atmoſphere which ſurrounds us, and of which we breathe, is a *mixture* of different airs. Water, in all its forms, is a compound of hydrogenous and oxygenous radicals. Every animal and plant can be reſolved into numerous gaſes; and the ſolid remnant of both is triflingly ſmall, when compared with the aërial products. Even *minerals*, ſuch as ſtones and metals themſelves, hold in combination different portions of elaſtic fluids; ſome of which, when diſengaged, leave the ſtone in a ſtate of cauſticity, as in quick lime; and others, being added to metals, oxydate them, and give them their medicinal or poiſonous qualities, according to the quantity combined. Some of theſe

airs are the *pabulum,* or ſupport of life; others deſtroy it, and have received the name of *azotic.* Such are the enchanting views this ſubject opens to the mind of the philoſopher! Such is the utility which it brings with it to the arts which cheriſh and embelliſh life!

The generation of hydrogenous gas, or, as it is otherwiſe named, inflammable air or *fire-damp,* in coal-mines, is rendered familiar to us by modern chemiſtry. The decompoſition of water, into two kinds of air, accounts ſatisfactorily for their production: the fine experiments of LAVOISIER on this ſubject are deciſive. The firſt and ſecond experiments of that celebrated philoſopher, to be found in chapter viii. page 83, of his Elements of Chemiſtry, are an epitome of that proceſs of nature which is continually going on when *carbonaceous* matter, or *coal,* comes in contact with *water,* and is ſuffered to ſtagnate. The conſequence muſt be the decompoſition of the moiſture; the light

hydrogenous gas, or *fire-damp,* flies off, or aſcends, from its ſpecific gravity being ſo much leſs than atmoſpheric air, as 13 to 1, or 16 to 1, if perfectly pure; and the more ponderous carbonic acid gas, or *choak-damp,* from being of greater ſpecific gravity than common air, falls to the bottom. It is *caloric,* or the matter of heat, which enters their compoſition, and preſerves them in the ſtate of permanent elaſtic fluids. The baſe or radical of the hydrogenous gas, or *fire-damp,* is a ſimple element: but the carbonic acid gas, or *choak-damp,* is found to be compoſed of *carbon and oxygen;* the firſt it receives from the coal, and the latter, being a conſtituent part of water, from the water it receives it: they are in the proportion of 0.26 of carbon, to 0.74 of oxygen.

This is the ſimpleſt method of accounting for the production of theſe airs; and wherever ventilation is imperfect, it is plain that they muſt accumulate in great quantities. All

corners and crevices, where a current of wind cannot be directed in full force from the ſhaft, muſt be ſpeedily occupied by the noxious gaſes. It appears, in the late diſaſter at Hebburn colliery, that a door was opened by a man carrying a light in his hand, which door led to an apartment filled with *fire-damp*, which immediately burſt into flame, and exploded.

The analogy between a ſhip's hold and a coal-mine, in the production of theſe noxious gaſes, is thus to be explained:—The hold of a ſhip, like the mine, is cloſe and warm; the water in the well, what may leak out of caſks, or what may fall from the decks, coming into contact with the timbers, ſoon ſtagnates, emits a fetid ſmell which flies upwards, diffuſes itſelf over the decks, and wherever it comes near white paint, tarniſhes it, turns it black by decompoſing the metallic oxyde, or calx of lead, of which white paint is made. This fetid ſubſtance is called the *bilge vapour*, be-

cauſe it riſes from the water in a ſtate of putrefaction. Now while this volatile gas aſcends from its levity, and is perceived by its ſmell in the decks; another gas, with very different qualities, is generated at the ſame time. The oxygen diſengaged, which is another conſtituent part of water, is attracted by the carbonaceous principle of the wood, and thus forms carbonic acid gas; and from being very heavy, it falls to the bottom; and often floats on the ſurface of the well, till it accumulates in ſuch quantity, that in foul ſhips the carpenters have frequently been ſuffocated in deſcending to let in freſh water to ſweeten the hold. The firſt of theſe airs is the hydrogenous gas of modern chemiſts, or the *fire-damp* of mines: the other, is the carbonic acid gas of the chemiſts, and the *choak-damp* of mines. But while this decompoſition of moiſture is going on in the ſhip, there is this difference from the coal-mine, that the hold being much more ex-

poſed to the influence of ventilation, the *fire-damp* can never be accumulated in ſuch quantity as to be in danger of combuſtion, for it flies off as it is formed. Seamen are familiar with this kind of air in long voyages: when the water becomes putrid in the caſks, they amuſe themſelves by taking out the bung and ſetting it on fire. The water of the Thames is more liable than any other river water to undergo this change; which is owing to the animal and vegetable filth that mix with it, and facilitates the decompoſition: but when this gas is once diſpelled, the Thames water is ſaid to keep better than the others.

We alſo ſee in ſhips, as it muſt likewiſe happen in coal-mines, that different ſubſtances of a vegetable nature, but particularly ſugar or molaſſes, beer or ſpirits, leaking from caſks, greatly promote the decompoſition of the moiſture, and cauſe a quicker generation of the foul vapours. Salt-water thus becomes ſooner

putrid than river water: and when a caſk of ſpirits happens to leak into the hold, the efflu-vium is extremely fetid, from the large propor-tion of hydrogenous gas that is evolved. Hy-drogen is known to be a conſtituent of *alcohol,* or ardent ſpirit, and therefore it is diſ-engaged in prodigious quantities at that time; and there is ſometimes a neceſſity for drench-ing the hold all over, to get quit of the fetor. This is the gas that gives the breath of the *dram-drinker* its ſuffocating ſmell. If, there-fore, any ſubſtance of a vegetable or animal nature, is allowed to mix with any ſtagnant water in a mine, foul air will be more quickly produced. This ſhows the neceſſity for the utmoſt cleanlineſs in a pit. The provender and ſoil of the horſes kept below, may have conſiderable effect in this way, and ought to be carefully ſwept up and ſent above ground.— Such is the ſimple explanation of one of the ſublimeſt operations in phyſics.

Theſe noxious gaſes, "*fire and choak damps*," I believe, are almoſt peculiar to the coal-mine. It does not appear that any like accidents happen to the workmen in tin and copper and lead-mines, as have been lately known in this neighbourhood: but even in theſe, if water were allowed to ſtagnate, and vegetable or animal matter thrown into it, it would ſoon paſs into the ſtate of putrefaction and decompoſition, and yield up the noxious gaſes, till they would accumulate in ſuch a manner as to produce all the dangerous effects which are obſerved in collieries.

That this condition is peculiar to coal-mines may be accounted for from the nature of pit-coal and its chemical analyſis. The origin and formation of this bitumen, are ſubjects on which naturaliſts are not yet agreed; ſome contending for its being formed of animal matter, and others that it is of vegetable offspring. It probably conſiſts of both, which is rather to

be inferred from its analyſis. To the oil which is found in coal, it owes its combuſtibility: it firſt ſoftens, is in a manner half melted, and then burns. When this oil is partly conſumed, the coal is in the ſtate of coak; enough remains for continuing the combuſtion, but not ſo much as to be diſſipated in a black ſmoke forming ſoot. By heat, this bitumen, in a cloſe veſſel, and a diſtillatory apparatus, affords an alkaline phlegm, concrete ammoniacal carbonate, and an oil, which, as the diſtillation proceeds, takes a deeper colour and becomes more ponderous. There paſſes at the ſame time a large quantity of elaſtic inflammable fluid, which is commonly thought to be oil in vapour, but is properly hydrogeneous gas mixed with azotic gas, with carbonaceous matter diſſolved in it, and with carbonic acid gas.* There remains in the retort a ſcorified carbonaceous matter, which is ſuſceptible of combuſ-

* Fourcroy.

tion, and is what we call *coak*. This coak comes near to the nature of vegetable coal, and is then more fit for many purpoſes of the arts.

Now, in this chemical hiſtory of *coal,* we find all the ingredients which account for the formation of the two noxious airs of which we profeſſedly treat. Theſe airs or gaſes, being diffuſed in the mine, and accumulating in thoſe places leſs liable to be diſturbed or agitated by a current of wind from above, become now objects for new combinations, or in their preſent ſtate deſtructive to animal life.

WATER, that forms ſo important a part in the operations of nature, as to have been conſidered an univerſal ſolvent and a homogenous body, has, by modern chemiſtry, been at once deprived of its rank as an elementary ſubſtance. LAVOISIER, famous in the annals of ſcience, by his talents and his fate, in April 1784, performed the celebrated experiment that proved water to be a compound body, con-

ſiſting of the oxygenous principle and the baſe of inflammable gas. This fact is now univerſally admitted, and it explains many phænomena in nature, till then unknown. The proportion of hydrogen is as 0.15 to 0.85 of oxygen; hence the former derives its name. It has been further proved, whenever hydrogen is burned with vital air, water is produced. Thus pitmen, who have been ſcorched with the exploſions of *fire-damp*, appear as if drenched with water, which is a nice example of the fact.

In artificial experiments, in order to decompoſe water by iron, zinc, charcoal, or oil, as frequently done by chemiſts, it would ſeem that a great degree of heat is neceſſary: but in the coal-mine and hold of a ſhip, or even in marſhes and ſtagnant pools, the hand of nature effects it by the common temperature of the atmoſphere. Theſe articles, according to the language of chemiſtry, are ſaid to have a

ſtronger attraction for oxygen, than oxygen has for hydrogen; they therefore cauſe a ſeparation of them, which is the decompoſition of moiſture. Water is preſerved fluid by *caloric*, or the matter of heat with which it is combined, and when this heat is given out it freezes.

Water in a pure ſtate, as when it is diſtilled, if put into glaſs veſſels, or others not capable of acting on it, and cloſed by ſtoppers, or *hermetically sealed*, would remain ſweet as long as the veſſels laſted. In this manner it was ſhown by a profeſſor to his pupils, after being kept 50 years. But if you put water into a wooden veſſel or caſk, particularly a new one, it ſoon ſpoils, and yields *fire-damp*, which gives it a diſagreeable taſte, and the ſmell of rotten eggs. The new chemiſtry ſuggeſted to me, in the ſummer of 1792, that caſks might be ſeaſoned, ſo as to keep water ſweet for long voyages; and, after many trials, I found that

the beſt practical method was to *char* the ſurface of the caſks, in putting them together by the coopers, both heads and ſtaves. Thus the whole ſurface being already in a ſtate of combination with oxygen, did not act on the water with ſuch rapidity, and it remained pure and ſweet for nineteen months. This is now the method of preparing caſks in the navy.*

The *fire-damp* of mines, from its burning with vehemence, when in contact with atmoſpheric air, and from having been the ſubject of experiment, is known to be the ſame with the hydrogenous gas of modern chemiſts. Dr. Prieſtly firſt collected it, and found it to be a permanently elaſtic fluid, and named it *inflammable air*. When animals attempt to inhale it, they either become convulſed, or inſtantly die. It is commonly perceptible by its fetid ſmell; and its diſpoſition is to take fire when it comes near flame, or by paſſing

* See the Author's Medical and Chemical Eſſays, 2d edition, Jordan, London.

through it the electric ſpark. It has lately become famous by filling balloons—an invention which belongs to the late Dr. BLACK, profeſſor of chemiſtry in Edinburgh. It is only produced where there is water, as in mines or pools putrefying with animal and vegetable matter. From pools, marſhes, and ſtagnant lakes, it has been collected by inverting over them cloſe veſſels. It is ſaid to be the cauſe of meteors in the atmoſphere, where it aſcends; and on being fired by the electric ſhock, it gives the report of thunder, is then converted into water, and falls to the earth in heavy torrents called thunder ſhowers. Hydrogenous gas has the property of *diſſolving and ſuſpending in it,* carbon or charcoal, ſulphur, phoſphorus, and the ſubſtance called azote. Theſe are the articles moſt apt to alter its purity; and in proportion to the quantity of them, its perfect combuſtibility depends. They alſo modify the ſmell, and render it in ſome-

ſituations inſufferably fetid. But in the coal-mines of this diſtrict, it is probably generated in great purity, as is proved by its compleat inflammability and ſudden exploſion. Such is an epitome of the chemical properties of *fire-damp*.

The *choak-damp* of coal-mines is the fixed air of Dr. BLACK, the mephitic acid of MORVEAU, the mephitic gas of MACQUER, the aërial acid of BERGMAN, and the cretaceous acid of BUEQUET. Its diſcovery has immortalized the name of BLACK, as from it we are to date the ſuperſtructure of Pneumatic Chemiſtry. On being firſt known, it was called fixed air, as the ſuppoſed bond of union in bodies: mephitic acid and gas, as being fatal to life, and having the properties of an acid: aërial acid, becauſe it is met with in the atmoſphere: cretaceous acid, becauſe found in chalk: and laſtly, it has been named carbonic acid gas, from being compoſed of charcoal and oxygen,

the acidifying principle. When expelled by heat from chalk, or marble, it leaves them in the ſtate of quick lime; and in the ſtate of mortar, attracts the gas again from the atmoſphere, which gives firmneſs to the wall. It renders all the alkalis mild. It is evolved in great quantity during fermentation, by which cellars are ſometimes rendered uninhabitable: it is produced in the act of reſpiration of animals, and in the decompoſition of all animal and vegetable matter. It is the vapour which kills animals in the Grotto del Cane in Italy; it exiſts in the holds of ſhips, in caverns, and old wells; it diſſolves iron in water, and gives to the latter an acidulous taſte. It is more than double the weight of atmoſpheric air. It contains 28 of charcoal to 72 of oxygen.

Charcoal is one of thoſe bodies that has the ſtrongeſt attraction for oxygen, which accounts for the very frequent compoſition and large production of carbonic acid gas, or *choak-damp.*

We thus obſerve, from the brief hiſtory given of water, and its reſolution into hydrogen and oxygen, how familiar this department of experimental philoſophy has rendered the generation and formation of the noxious damps of mines: and it ſo happens, that the two gaſes muſt always be produced at the ſame time, which ought to excite great caution in all who are employed in theſe deep receſſes, ſo diſtant from a free ventilation.

With this preliminary knowledge, we are now enabled to turn our attention to ſuch prophylactic meaſures as may be neceſſary for ſecuring the workmen.

The purification of a coal-mine conſiderably differs from the ſame intention in a ſhip, an hoſpital, or jail, from its diſadvantageous ſituation. I might ſwell this eſſay to a great bulk, were I to digreſs into theſe ſubjects, or to contraſt all that has been ſaid or written. Even this neighbourhood has lately heard contagion

diſcuſſed in a new ſtyle, without much edification. To be a little methodical, I ſhall, in the

1ſt place, ſpeak of preventing the formation of theſe airs in the mine; and in the

2d place, the means to be adopted for removing them after they are formed.

1ſt, *To prevent the formation of fire and choak-damps.*

The deeper the mine, the more winding and tortuous its area; and the more frequent its pillars of ſupport to the ſuperincumbent ſtrata, it is evident the air below will be more ſpeedily adulterated, and leſs within the ſphere of perfect perflation. But it would appear that one of the great objects in this buſineſs muſt be to prevent the ſtagnation of the water, for where there is no moiſture, there can be no generation of the foul airs. The mine that has the moſt copious flow of water into it, muſt have the beſt

chance of being the moſt pure, as being in leſs danger of its putrefaction: and wherever water is in danger of ſtagnating and giving out vapour, it ought to be a piece of duty ſtrictly attended to, to direct a ſtream of pure water at ſhort intervals into theſe places, ſo as to dilute and ſweeten the whole, that they may be pumped out. Such places will be increaſed in their natural tendency to putrefaction, ſhould pieces of timber, chips of wood, or the ſoil of horſes, &c. as formerly mentioned, be allowed to mix in the water. The temperature of a deep mine is much the ſame in winter as in ſummer, being unaffected by the ſun; but it ought to be known, that increaſed heat greatly favors the ſeparation of the conſtituent principles of the water, and facilitates the new combinations. A number of lights, and the pitmen heated with work, will ſoon heat a ſmall ſpace ſo as to exemplify this fact.

To keep a coal-mine clean, and free from extraneous matter, and to take eſpecial care that no water is ſuffered to ſtagnate, muſt, therefore, be indiſpenſible duties. And if theſe are practicable, the formation of foul air muſt either be ſmall, or entirely prevented. To throw the water out of the mine is the buſineſs of mechanics.

2dly, *The means to be adopted after the fire and choak-damps are formed.*

From the ſhort hiſtory which has been given of the properties of theſe airs, it is obvious that they have very different qualities. The *fire-damp,* or hydrogenous gas, when in its utmoſt purity, is 16 times lighter than atmoſpheric air; while the *choak-damp,* or carbonic acid gas, is double the weight of common air. Agreeably, therefore, to a general law in hydroſtatics, the lighteſt permanently elaſtic fluid will riſe to the roof of the mine, while the more ponderous will ſink to the ground. If

theſe airs do not by their bulk fill the ſpace between the floor and the top of the mine, a ſtratum of aſmopheric air will lie between them, as being neither ſo heavy as the *choak-damp*, nor ſo light as the *fire-damp*. Indeed wherever the latter takes fire, it muſt be from being in contact with atmoſpheric air, as it cannot be inflamed without it.

As one of the characters of the *fire-damp*, I have mentioned its fetid ſmell. It cannot be lodged or accumulated in any quantity, without being detected by an unpleaſant impreſſion on the olfactory organs. It is alſo fatal to animal life; though, perhaps, it is ſeldom in ſo concentrated a ſtate in nature, as to prove fatal to animals by reſpiration; but even in mines it may have the effect of cauſing oppreſſion of the breaſt and a difficulty of breathing. When a perſon feels theſe effects, he ought to retreat inſtantly. I am ignorant of the workmen having any familiar method of their own

for detecting its preſence, beyond what is juſt ſaid.

If any perſon carrying a light in his hand, unexpectedly ſets fire to a column or maſs of *fire-damp*, he ought inſtantly to lie down with his face flat on the ground. If ſafety is to be found, it muſt be in this poſture, as the gas is known to be thickeſt at the roof of the pit, and conſequently there it muſt explode with a fiercer flame. All other perſons near, and obſerving this, ought to fall down in the ſame manner, and to creep, not walk, to a place of ſafety, if ſuch can be obtained.

While the moral world has been convulſed and agitated by the revolutionary ſpirit which has been engendered in France for the laſt ſixteen years, the natural hiſtory of man has alſo, during that period, been marked by diſ-aſter. Fevers of the moſt fatal kind have almoſt depopulated whole cities and diſtricts of Europe and America. The Weſt Indies have

been the grave of numerous armies ſent from Great Britain, by an epidemic diſeaſe. The ſouthern provinces of North America have been frequently viſited by this ſcourge. A peſtilence has thrice raged in Spain, and extended once to the garriſon of Gibraltar. While the thrones and altars of Italy were robbed and pillaged by a military banditti from France, many of the towns and ſtates were victims of contagion. The ſhips and regiments of this country on home ſervice, as well as thoſe of France, have in their turn been infeſted by dangerous fevers; and in Egypt, ſome of the troops of both countries have been cut off by the real plague. Numerous, therefore, have been the theories offered on theſe prevailing diſeaſes; and equally numerous the projectors who have appeared with *balm* in their hands, to prevent or heal the wounds of ſuffering humanity.

Epidemic fevers had long ago been ſuppoſed to owe their origin to ſome quality or conſtitution of the air; and more lately, from the exhalations of the ſick extending the diſeaſe to others, the cauſe has been modified in name into contagion. Acid fumes, in particular ſuch as vinegar and ſulphur, were then employed as correctors of the atmoſphere; and the preſent times have added the nitrous and muriatic acid vapours. The firſt is the acid of ſalt-petre; the latter that of common ſalt. In the fleet, the fine diſcipline of the officers, which included the ſpeedy ſeparation of the infected, pure ventilation, and cleanlineſs in perſon, clothing and lodging, were found all that was required. In the courſe of nine years, 150 ſhips, under different degrees of infection, were ſucceſsfully cleared, without ever one of the number going into harbour to take the ſtores out. I am under the neceſſity of mentioning theſe circumſtances, becauſe I am about

to recommend to the coal-mines what I oppoſed in ſhips and hoſpitals.

The nitrous fumes being much inferior in power, and leſs volatile and expanſile, than thoſe of the muriatic acid, for arreſting and ſubduing hydrogenous gas, I ſhall not touch upon them here. The latter, though firſt uſed by an Engliſh phyſician, the late Dr. JOHNSTONE, in a fever raging at Kidderminſter in 1757, have become famous, and of great notoriety, from the authority of GUYTON MORVEAU, the celebrated French chemiſt. But in introducing this chemical agent into the mines, I do not mean to withdraw a ſingle ſentiment which I have elſewhere uttered againſt *fumigation* for deſtroying contagion. The preſent ſubject is purely chemical, and chemical facts ſhall alone ſupport my reaſoning and practice here.

Had MORVEAU lived in a *coal district,* this eſſay of mine might have been anticipated.

His active revolutionary genius could not have with patience heard on the ſpot, of hydrogenous gas burſting into flame, and deſtroying thirty or forty men at a blaſt, without adverting to ſome meaſures that would either prevent or alleviate ſuch occurrences in future. Though with FOURCROY, and other philoſophers, he is a paſſive ſlave to the preſent tyrant of France, his otherwiſe enlightened ſpirit deſerves this acknowledgment from a Britiſh phyſician. Sordid and ſelfiſh, indeed, muſt be the tenor of life in that profeſſional man, who can traverſe the aeres of this neighbourhood for daily bread, and not do one kind action *gratis;* or ſometimes caſt a ſympathizing look below to thoſe induſtrious miners, who toil amidſt darkneſs and dangers, whoſe labour gives the firſt ſpring to that commerce which is the beſt nurſery of our ſeamen, and which brings back to the ſhores of the Tyne and the Wear, wealth of incalculable magnitude.

The late Dr. BROWNRIGG, of Whitehaven, a philoſopher who devoted much of his ſtudies to promote the arts in his neighbourhood, has written a ſmall tract on the noxious airs of coal-mines. But he has not offered any plan beyond the common means for diſlodging them. Indeed, at that time, Pneumatic Chemiſtry was in its infancy.

It has been long ago remarked, that, notwithſtanding the folly and the abſurdity of the *Alchemyſts,* by the patience and ardour with which they proſecuted their inquiries, many collateral facts were eſtabliſhed, and many valuable inventions and improvements in the working of metals, were the conſequence of their labours. And it may with equal juſtice be ſaid, during the reign of *Empiricism,* in which ſo many philoſophers have ſtept forward with antidotes againſt contagion, that means almoſt certain are now known for annihilating thoſe foul damps, or airs, which

ariſe in various departments of nature, the reſult of theſe experiments. To employ chemical agents in ſick apartments, muſt at leaſt be ſuperfluous; becauſe pure air, and ſoap and water, can be eaſily obtained to prevent the generation of unwholeſome vapours. I object to their uſe in ſhips for the ſame reaſon; but theſe objections do not apply to the mine, as the depth from the ſurface renders ventilation imperfect. That it is not perfect, is confirmed from the frequent fatal accidents which happen.

An Engliſh chemiſt, I think it is Mr. WATT, in ſome of his communications to Dr. BEDDOES *on Factitious Airs,* was ſo convinced that the matter of contagion was ſome form of a gaſeous fluid, that he tells his correſpondent that he was afraid of ſtumbling upon the noxious gas that produced Typhus fever; and, under the impreſſion of this dread of being infected, he ſtopped the farther proſe-

cution of his experiments! MORVEAU, an adept in Pneumatic Chemiſtry, did not carry his enthuſiaſm ſo far. He aſks, "What then "is the nature of thoſe inviſible *corpuscles*, "which, like organic beings, poſſeſs the power "of reproduction, and of aſſimilating to their "own eſſence every thing with which they "come into contact, and which ſeem to aſſume "*life*, but for the purpoſe of propagating *death?*" Such is MORVEAU's creed on contagion; and if any meaning can be drawn from ſuch a confeſſion, he muſt have believed in an *animalcular* theory. But we muſt at the ſame time remember he was not a phyſician: yet he certainly ought, as a chemiſt, to have explained the nature of the new combinations formed by the muriatic acid vapours. This, like the author of the Nitrous Vapours, he withheld; probably by foreſeeing that it would lead to inconſiſtency, and an open avowal of *quack-*

*cry.** That the ſubſtance of contagion is not *fire-damp*, the ſalubrity of mines and health of the pitmen ſufficiently teſtify.

For the putrefaction of animal and vegetable matter, moiſture in ſome form and quantity is abſolutely neceſſary, and then only can we perceive by the ſmell thoſe gaſeous products evolved by this proceſs. The difference between animal and vegetable putrefaction is, that, in the former, ammonical carbonat or volatile alkali is produced, although ſome vegetables likewiſe yield this ſubſtance, or rather the two ingredients which compoſe it. When ſpeaking of the properties of hydrogen, or *fire-damp*, I mentioned the power it poſſeſſed of diſſolving and ſuſpending in it, carbon, ſul-

* Both theſe authors of fumigation claimed credit to their reſpective *fumes*, in the fever which raged in Andalufia in 1800. But another fever appearing in the ſucceeding ſummer, and a third in the ſummer of 1804, extending to the garriſon of Gibraltar, their *puffs* ſeem to be ſilenced. Like the epidemic of America, theſe fevers appeared at a regular period; and it is notorious, that they declined *only* from the cooling ſhowers of Heaven, and the commencement of a cold ſeaſon.

phur, phoſphorus, and azote, when any of theſe happened to be preſented to it; and from theſe articles it derives the nomination of *hydro-carbonat*, *hydro-sulphuret*, &c. Now theſe compound gaſes have all been examined chemically; and wherever we meet with foul ſmells from animal or vegetable putrefaction, they are invariably found to be derived from them. In order to deſtroy theſe ſmells, we have only to employ ſome of the ſtronger acids in a ſtate of vapour, ſuch as the acetic, nitrous, or oxygenated muriatic. Theſe acid vapours ſeize the hydrogen or *fire-damp*, which ſuſpends the others, and the fetid efflu-via immediately diſappear. And ſhould the hydrogen be diffuſed in the atmoſphere in a pure ſtate, the acid fumes ſtill arreſt it to the point of ſaturation. The chemical theory of this union between the acid vapours and the *fire-damp*, is accounted for in this manner. In the expanſile ſtate of the acid gas, its oxy-

gen quits the radical or baſe of the acid, and attracts the hydrogen; water is thus recompoſed; but as ſo great a quantity of heat, or caloric, is diſengaged during the combination of the oxygen and hydrogen, the *water* is converted into *ſteam*, and cannot be condenſed ſo as to be ſhown in its due form. This is the whole ſecret of deſtroying hydrogenous gas or *fire-damp*.

Chemiſts have not been minute in aſſigning their reaſons, why the acid in a ſtate of vapour is ſo apt to impart its oxygen to the hydrogen or *fire-damp*, as in this proceſs. It probably depends on the repulſive power of the *caloric*, or matter of heat, which is neceſſary to expand the acid, and preſerve it in a vaporific form; which, while it leſſens the attraction between the oxygen and the baſe of the acid, muſt alſo, by multiplying the points of contact between the oxygen and hydrogen, facilitate their combination to form ſteam.

The oxygenated muriatic gas being a condition of the acid, where there is a quantity of oxygen beyond the point of ſaturation, muſt greatly favor the new combination, and accelerate the deſtruction of the *fire-damp*. This addition to the fumigation is the improvement of the late Mr. CRUIKSHANK, chemiſt to the Ordnance at Woolwich.

Any perſon who has the curioſity to try, may ſoon ſatisfy themſelves of the oxygenated muriatic acid gas being a corrector of foul air impregnated with putrid exhalations, by uſing the ingredients as hereafter directed. This may be done over a foul kennel, privy, or any ſink of corrupting matter. The fetor will diſappear, till new vapours accumulate to renew the ſmell.

The following experiment on deſtroying *fire-damp* was made in a ſhip. A ſloop of war, French built, when cruiſing, became very leaky, and required frequent pumping out.

She arrived at Spithead in warm weather, where, by lying in ſmooth water, ſhe ceaſed to leak. But it was now obſerved, that her hold became very foul, and the bilge vapour extremely offenſive in the decks, ſo as to blacken all the white paint. This veſſel had no pipe for letting in water to ſweeten the well, and the captain, having heard much of fumigation for deſtroying contagion, immediately ſet to work, and found the *fire-damp* diſappear, and the ſmell and effect on the paint ceaſed from its uſe. This he repeated often, while the ſhip lay at Spithead; but when he went to ſea, the water from the leaks made the hold ſo ſweet, that it was not found neceſſary to continue the fumigation.*

Now this trial of the officer is juſt what ought to be done on a large ſcale in a coal-mine. And were the proceſs for diffuſing the muriatic acid vapours kept conſtantly up, *fire-damp* could never be dangerous; it would

* Med. Naut. vol. III,

be deſtroyed as ſoon as it was formed. The ingredients for the purpoſe being ſo very cheap, the largeſt mine could not conſume one hundred pounds in the year by keeping the fumigation in conſtant uſe day and night.

Where *fire-damp* is confined or pent up in ſuch a cloſe ſituation as has recently happened in Hebburn colliery, it would be neceſſary to ſurround the ſpot with a number of veſſels giving out the gas, and to open the door leading to it by ſlow degrees. The veſſels might then be carried nearer and nearer, till the whole *fire-damp* was annihilated.

The utenſils required for this buſineſs are ſmall flat ſtone diſhes, made thick, about two inches deep; and a glaſs funnel for pouring in the acid of vitriol. The ingredients are—common ſalt (it ought to be Bay ſalt), oxide of manganeſe, and concentrated acid of vitriol, which, in common language, is the ſtrongeſt oil of vitriol.

Proportion for one fumigation.

	oz.	dr.	grs.
Take of common Bay ſalt	3	2	10
Fine powder of black manganeſe	0	5	17
Water	1	2	33
Strong ſulphuric acid	1	7	50

After pounding the ſalt and manganeſe together, they may be put into the ſtone ware diſh, and the water poured upon them; and afterwards the ſulphuric acid, ſlowly, through a glaſs funnel. This quantity is ſufficient for a ſpace of 16 feet by 12; but the frequent employment muſt depend on the manner how the *fire-damp* is evolved.

I have mentioned Bay ſalt, which is marine ſalt obtained from ſea-water by ſpontaneous evaporation, or the heat of the ſun. Salt of this country is much inferior in quality, either for the preſent purpoſe, or for preſerving meat; for much of its acid is exhaled during the preparation. Any perſon may learn the whole of this proceſs in a few minutes.

The *choak-damp* of coal-mines, which is fatal to life when inhaled, and not to be perceived by ſmell or ſight, is always found on the ground. It is a compound body, conſiſting, as has been ſaid above, of carbon and oxygen; but their union is ſo ſtrong, that it is in vain to think of effecting the ſeparation by re-agents. The moſt practicable method for diſlodging it is by water. Water, about the temperature of 40 of Farenheit, is found to diſſolve equal parts of its bulk; but as the water of a deep pit is commonly above 50°, it will take up two-thirds of its bulk only. In order to effect this mixture with water, I would recommend the common fire-engine, ſuch as is uſed in the caſe of fire. The workmen might for ſafety ſtand at a diſtance, and by directing the mouth of the tube to the ſpot where the *choak-damp* is known to lie, the water may be ſo diffuſed as to take up the whole. The water will then taſte acidulous; and lights will

burn and animals breathe in the place whence the vapour was diſlodged. That the diffuſion of the water might be more ſpeedy in diſſolving the *choak-damp*, the tube might be fitted after the manner of a garden watering pot, ſo as to ſprinkle and break the fluid into a ſhower.

This kind of air being ſpeedily attracted by quick lime, by mixing that article in the water which is to be diffuſed would ſtill more effectually diſlodge the *choak-damp;* and in places where it happens to be collected in great quantity, ſuch a mixture would be highly ſerviceable.

It ought to be remembered, whenever either *fire-damp* or *choak-damp* are detected in coal-pits, that there will be reaſon to fear a collection of the other near the ſpot, if not powerfully ventilated: for it is without doubt, that they are invariably generated by the ſame proceſs, and at the ſame time.

I have been told, that particular places in theſe works are frequently deſerted, on account of the foulneſs of their atmoſphere rendering it dangerous for pitmen to approach them. If this be owing to either *fire* or *choak-damp*, or both, it does not ſeem beyond the power of art to annihilate them, and reſtore purity to the air, by which means property of immenſe value may be ſaved to the owners.*

Having thus endeavoured, in as familiar terms as the ſubject would admit, to explain

* In thoſe ſituations and places where *fire* and *choak-damps* are lodged together, it would be adviſeable, firſt to uſe the plentiful diffuſion of water, as it is known that water will alſo diſſolve a large proportion of *fire-damp* along with *choak-damp*. It would then be proper to employ the fumigating materials, till the whole of the inflammable air is annihilated. The *choak-damp* being deſtructive to life, ſome animals, ſuch as birds or mice, might be kept in ſmall cages, and, for making experiments, ſo fixed to long poles, as to be held with ſafety at ſufficient diſtance by a workman. If the animal die, no human being could then proceed without the utmoſt danger; and this might be conſidered as the teſt for uſing the engine to diffuſe the water.

the production of *fire* and *choak-damps* in coal-mines, and to apply chemical facts for deſtroying them; with much pleaſure I can obſerve, that the treatment of Burns, from theſe dreadful exploſions, has lately been reduced to a ſcience, by the ſpirited Eſſays of Dr. EDWARD KENTISH. The invention of the *ſtimulant* practice, it is ſaid, belongs to Mr. HUNTLY, ſurgeon in this neighbourhood; but that will not detract from the well-earned reputation of Dr. KENTISH, who has explained the doctrine on the juſt principles of a correct PATHOLOGY, and ſo connected it with MEDICAL PHILOSOPHY, as to reſcue this department of *Surgery* from *Primœval Empiricism*. The workmen in coal-mines have reaſon to bleſs his labours, and poſterity will receive his improvement with gratitude and thanks.

P. S. *Nov.* 1. This eſſay was originally intended for publication in a Newcaſtle newſ-

paper; but, from the explanation of the ſubject, it has neceſſarily extended to a greater length than was at firſt expected, which made the author print it in the preſent form.—The author will be very happy to give any information in his power, to ſuch as may wiſh for it, on the ſubjects here treated of.

FINIS.

[From the preſs of J. Mitchell, Newcaſtle.]