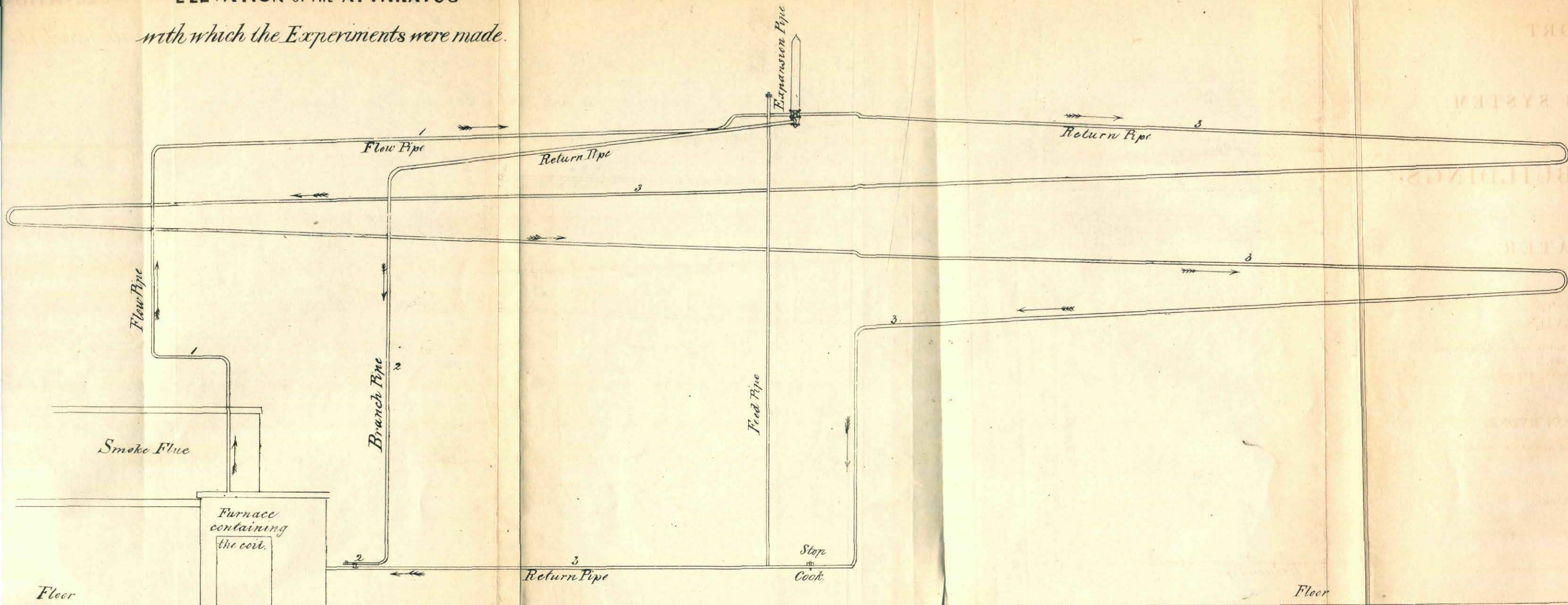
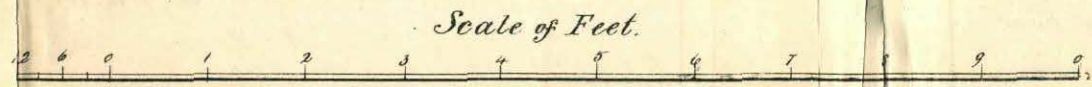


ELEVATION OF THE APPARATUS

with which the Experiments were made.



George Vardon Ryder. Surveyor.



REFERENCE			
No.	1.	2.	3.
	Circulation during 1 <sup>st</sup> Series of experiments		
"	1.	2.	do
	2 <sup>d</sup> " do		
"	1.	3.	do
	3 <sup>d</sup> " do		

REPORT  
ON  
PERKINS'S SYSTEM  
OF  
WARMING BUILDINGS  
BY  
HOT WATER.

BY  
JOHN DAVIES,  
LECTURER ON CHEMISTRY IN THE ROYAL SCHOOL OF MEDICINE  
AND SURGERY,  
CONSULTING AND ANALYTICAL CHEMIST, ETC.

AND  
GEORGE VARDON RYDER,  
SURVEYOR TO THE MANCHESTER ASSURANCE COMPANY.

10th MARCH, 1841.

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MDCCCXLI.

MANCHESTER ASSURANCE OFFICE,

11th March, 1841.

TO THE BOARD OF DIRECTORS OF

THE MANCHESTER ASSURANCE COMPANY.

Gentlemen,

*The Committee appointed by your Resolution of the 11th ult., "to inquire into the nature of the accidents which have recently occurred from the use of Hot Water Apparatus in Buildings, and to report thereon," beg to state, that, as a preliminary measure, they directed Mr. Ryder, the Company's Surveyor, to make to them a statement, in writing, of such cases as had come under his personal inspection.\**

*Mr. John Davies, the Chemical Lecturer, was requested by your Committee to attend their Meeting, and after much discussion upon the subject, was directed to institute a personal investigation of some of the cases therein referred to, and to make such experiments in the matter as might tend to satisfy his mind as to the causes of the accidents which had occurred.*

\* See Appendix A.

*He and Mr. Ryder have since then been much engaged in pursuing these inquiries, and they, yesterday, laid before your Committee the accompanying Report, which your Committee now submit to your Board, as, together with Mr. Ryder's previous Report, embracing the whole of the matter referred to them.*

*We are, Gentlemen,*

*Your obedient Servants,*

*JAMES WOOD,*

*CHARLES SMITH,*

*F. R. HODGSON.*

REPORT  
ON  
MR. PERKINS'S SYSTEM  
OF  
WARMING BUILDINGS BY MEANS OF  
HOT WATER.

---

ASSOCIATED in the observations and experiments, we have presumed that we might, with advantage, present a joint Report.

Before we proceed to detail the experiments which we have made, we shall briefly describe the appearances observed, and the information obtained at a few of the principal places which have been visited. We shall then be enabled not only to confirm but to extend the statements in Mr. Ryder's first Report.\*

It has been found, on inspection, that Birch Chapel has, at various times, since the occurrence alluded to in the former report, sustained much damage. Wood, matting, and cushions have, in a variety of places contiguous to the hot water pipes, been charred to an alarming extent. X

With respect to Mr. Barbour's Warehouse, farther inquiry has fully corroborated the previous statements of its having been on fire, close to the pipes, at different times and in different places. X

\* See Appendix A.

Of the Unitarian Chapel, in Strangeways, the Directors are already in possession of information from both Mr. Ryder\* and Mr. Rawsthorne;† and this information seems to leave no doubt as to the injury which has resulted from the use of Mr. Perkins's hot water apparatus.

X The heat in the Natural History Museum having been repeatedly stated to vary in different parts of the pipes, and to become, in some cases, the greatest at places remote from the furnace, the fact has been confirmed by our own observations and by our subsequent experiments. As this circumstance has excited much interest, and been generally questioned, we shall presently endeavour to assign the cause.

The apparatus, which it may be proper to notice in reference to its general form and construction, consists simply of a long, endless iron tube, carried, in different directions, from a furnace to which it returns, and in which about one-sixth of the whole length is inserted and formed into a coil, so as to be sufficiently exposed to the action of the fire. The tube is, at the commencement, filled, or nearly filled, with water, which, by the application of the heat, soon begins to circulate, and, in that way, to impart an increase of temperature to the apartments which it traverses. The dimensions of the pipes are such that, on the average, eleven feet in length will contain one pint of water. Connected with the principal pipe are two others, seen in the diagram, which are opened by a screw, one to allow for the ultimate expansion, and both subservient to the introduction of water.

As far as lay in our power, we have made such experiments as occurred to us, repeatedly, and under every variety of circumstance.

Not having any instruments which would furnish speedy and adequate criteria for the determination of high temperatures, we have resorted to the inflammation of combustible bodies, and the fusion of others, depending on the recent and

\* See Appendix A.

† See Appendix B.

high authority of Professor Graham for the degrees which they indicated.

In the Natural History Museum we applied our tests, but were enabled to do so only to a very limited and unsatisfactory extent. Mr. Walker accompanied us to the establishment of Messrs. Vernon and Company, engravers, where we had the opportunity of trying the system rather better, but still imperfectly. Finally, Mr. Walker acceded to our request to have put up, on his own premises, a suitable apparatus, which was to be submitted entirely to our control. It consisted of an iron pipe upwards of 140 feet in length, 26 of which were coiled in the furnace, 20, at least, being freely exposed to the full action of the fire.

In addition to the apparatus, as at first fitted up, we had a branch pipe and a stop cock, which enabled us, by cutting off at pleasure a great portion of the circulation, to perform our experiments on a contracted scale, and under a variety of modifications.

Mr. Walker, being from home at the time, placed his Foreman entirely under our directions, so that we had the opportunity of pursuing the investigation to any extent which we might think proper. It is but justice to state that this person rendered, very willingly and with much practical skill, all the assistance which was required.

The apparatus having, on Friday the 5th instant, been fitted up, and found, on trial, to be in proper condition, the experiments were commenced on the following morning, at ten o'clock, when the apparatus had arrived at a suitable state.

I. *First class of experiments, viz., those made with the whole length.*

1. The pipe from the furnace became very soon sufficiently hot to singe and destroy small feathers resting upon it.

2. Speedily afterwards, the same pipe exploded gunpowder.

3. On the highest pipe, within a foot of the expansion pipe, bismuth was readily melted, denoting a temperature exceeding  $470^{\circ}$ .

4. Feathers were singed instantly, and matches lighted, at the same place.

5. Gunpowder inflamed readily in various parts of the flow pipe, and on the expansion pipe.

6. Blocks of wood, of five different species, were charred: from the deal wood the turpentine issued profusely.

7. Other combustible materials were also severally much charred.

*II. Class of experiments, with the shorter circulation. By this change a greater pressure was immediately observable, as the expansion pipe and several of the joints emitted steam, and admitted the escape of water.*

1. Cane shavings, on the pipe above the furnace, readily inflamed.

2. Lead melted at the same place; and the temperature must, therefore, have exceeded  $612^{\circ}$ .

3. Different wood shavings inflamed on the upper pipe.

4. Cotton ignited freely at the same place.

5. Matting inflamed at the same place.

6. Cotton, hemp, and flocculent matter, collected from Mr. Schunck's fustian room, ignited on the returning vertical pipe.

7. The blocks of wood, tied to different parts of the tube, were much acted upon and charred in a very short time.

Observing the expansion pipe to be in a state of considerable agitation, and warned of an explosion, the temperature was reduced, and the experiments were, for the time, suspended.



The pipes having, before three o'clock, been refilled and screwed up, for the express purpose of an explosion, the following experiments were made in the progress of the preparation.

1. Mungeet was readily ignited.
2. Different sorts of paper and pack thread were destroyed.
3. Bismuth fused instantly.
4. Cotton inflamed.
5. Sheep's wool became speedily charred.
6. At five o'clock the sheet lead, affixed to the upright pipe, freely melted; steam issued violently from the bend in one of the upper horizontal pipes, and, in three minutes afterwards, the explosion occurred in the furnace pipe, at the top of the seventh coil, which presented, on subsequent examination, a lateral aperture about two inches long and about one sixteenth of an inch broad.

In the lapse of two or three minutes after the commencement of the explosion, the furnace was entirely emptied of its contents, which were propelled, in a divergent direction like one mass of fire, so as almost to fill the apartment. The force with which the ignited embers rebounded from the opposite wall, and other obstructions, occasioned them to scatter in profusion like a shower of fire over every part of the place. The noise was so great as to bring to the spot a multitude of people from the adjoining streets. A number of articles in the shop, as, for example, packing cloth, paper, and hemp, were subsequently found to be on fire in different parts of the premises.

These appearances, and their immediate effects, seem to have been precisely similar to those which are said to have been witnessed at the explosion in the warehouse of Messrs. Crafts and Stell, and would, evidently, have been adequate, in the same situation, to produce all the consequences.

It may be here observed that the experiments clearly prove, that the heat, in different parts of the pipe, is not uniform. Generally it is greatest at the highest elevation, where its superior temperature appears to be of the longest duration under ordinary incidental changes. At the commencement of the operation, however, and a short time after fresh fuel had been applied, the temperature was highest in the flow-pipe contiguous to the furnace. Another circumstance, likely to produce an inequality of heat, may be adverted to: the tubes are far from being of uniform internal diameter; the consequence of which must be, that as the same quantity of water has to pass, in the same time, through every part of the apparatus, the liquid must move with greater velocity at one place than at another, and thus, from obvious causes, develop a greater quantity of caloric. The difference is sometimes so great in the relative bores of the tubes employed, that in some which were examined, one tube had an internal diameter of  $\frac{9}{16}$ ths, and another of  $\frac{3}{4}$ ths of an inch, that is to say, in the ratio of 3 to 4; or, taking the relative areas or sections of the tubes, which represent the relative quantities of fluid contained in a given length, in the proportion of 9 to 16. Thus, taking the velocity reciprocally as the section of the pipe, the velocity of the water at one part of the apparatus being represented by 16 feet, the velocity in another part would be 9, or the rapidity of the current would be at one place nearly double that which it was at another.

It is stated, in a work recommending the Hot Water system, that "the application of heat fills" the ascending or flow-pipe "with minute bubbles of steam which rise rapidly to the upper part of the tube, and become there condensed into water again:" now, as condensed steam, wherever it occurs, produces about seven times as much heat as the same quantity of water at the same temperature, we have, at once, a reason for the heat of the pipe being generally greater at a

distance from the furnace than contiguous to it. This apparent anomaly, which has been repeatedly observed and denied, admits, therefore, of an easy explanation.

The explosion may, under different circumstances, occur from various causes.

1. As water expands in bulk about five per cent. from 40°, its point of greatest density, to 212°, the boiling point, the expansion must be very considerably more when raised to high temperatures. If, therefore, the pipes be nearly filled with water, and the expansion pipe not adequate or in proper condition, an explosion must be inevitable.

2. The conversion of the water into vapour, producing an expansion which is in the proportion of a pint of water changed into 216 gallons of steam, "with a mechanical force sufficient to raise a weight of 37 tons a foot high," must present a pressure upon the tubes sufficient to ensure their destruction.

3. It has been observed, as an ordinary occurrence, by those much accustomed to the apparatus, that, in some cases, a quantity of gas is generated, and has been found to escape, in considerable quantity, when an aperture is made in the upper part of the pipes. The only gases which could be thus obtained are the elements of the water, oxygen and hydrogen. The former, would, probably, be taken up in the oxydation of the metal. Now the hydrogen gas, which would remain, has never been deprived of its elasticity, and never made to change its state, by any compressing force hitherto applied. It is obvious, therefore, that inevitable danger must arise from its production.

4. The last source of explosion to which it is necessary to refer, arises from any casual impediment in the pipes; and it is freely admitted that in frosty weather such an impediment is likely to occur: it has been found to result from other causes, as in the case of extraneous matter accidentally getting into the pipes, an example of which was recently presented in the establishment of Messrs. Wood & Westheads.

In a very obliging letter received, in the course of the investigation, from Sir Robt. Smirke, it is stated that, though he has "never seen the pipes heated sufficiently to ignite wood, except on one occasion," yet, "if a fire is incautiously made when there is a stoppage in the pipes from frost or other accidental cause, the pipe within the furnace may be burst or made red hot near the furnace. I have known the pipe," he adds, "so heated only in one instance, when the red heat extended to a distance of upwards of 12 feet from the furnace."

Sir Robert concludes his letter by suggesting a protective modification of the apparatus. "Therefore," he observes, "to prevent the risk of fire to a building, I would never place the furnace in a room or cellar that is not fire proof, nor would I have the pipes in any part of their circuit in *actual contact* with wood or other combustible material. Security," he continues, "is still more effectually attained by having a safety-valve upon the pipe near the furnace, by which explosion or excess of heat would be prevented."

That which has happened once, may, under the same circumstances, happen again. The exclusion from *actual contact* with combustible materials, could it be permanently ensured, would, when the red heat extended along the pipe upwards of twelve feet, afford, at least, very reasonable grounds for apprehension.

On this system of warming buildings, therefore, danger must be produced from either negligence in the feeding of the furnace, or any stoppage in the pipes: the former evil may be obviated by proper precautions; but the latter, occurring unexpectedly, exists unobserved, and precaution and care must be equally unavailing.

Signed,

JOHN DAVIES,  
GEORGE VARDON RYDER.

10th March, 1841.

## APPENDIX A.

*Manchester, February 11, 1841.*

### TO THE DIRECTORS OF THE MANCHESTER ASSURANCE COMPANY.

GENTLEMEN,—Having been requested to state, in writing, the substance of certain inquiries which I have been led to make into the subject of Fire, as occasioned by the use of Mr. Walker's patent process, of heating apartments, by means of hot water pipes, I beg respectfully now to lay before you the following report:—

The first instance in which my attention was aroused to this danger, was at Birch Chapel, Rusholme, on Sunday the 27th of December last; the floor, which is of oak, had been during the day, on fire, at the distance of several yards from the furnace, which is in a shed outside the Chapel; and I then expressed my conviction, that it had been caused by the hot water pipe which rested on the floor of the pews; and I believe the Churchwardens have since been of the same opinion, though the more important question, how the pipe became so heated, still remains matter of doubt.

The next place to which my attention was drawn was Messrs. Barbour and Brothers' warehouse in Portland-street. This was on Tuesday, the 9th inst., when I heard that it had been on fire, on the previous day, from some irregularity of their hot-water apparatus; and in confirmation of this report, I found that the warehouse had been on fire in not less than four different places, at one and the same time, and in such parts as led me to the conclusion, that the hot-water pipes had unquestionably been the cause. On a personal inspection of the warehouse, and on examining the different persons employed therein, as well as Mr. Walker's superintendent, (Mr. Walker being himself out of town,) I ascertained that the furnace wherein the coil is heated, is fixed in the cellar, from whence the heated water ascends, by what is called "the flow-pipe," perpendicularly through the next, or first story, into the second, where, after travelling to the expansion pipe, it flows on by what is called "the return pipe," (though in reality the same,) round nearly two sides of the room, and descends into the first story, where, after travelling about the same distance, it ultimately returns into the cellar, to the bottom of the coil in the furnace, where, being heated as before, it rises again, and takes the course above described. All this is supposing, at least, that the apparatus is acting correctly, and as intended.

I had, yesterday, occasion to inspect a stove in George-street Chapel, Strange-ways, where I found that hot water pipes had been in use, and on a close examination, I found the floor in several instances, charred black; but how long ago this may have been done, I could not ascertain; and the pipe having burst, some time back, the apparatus has not since been used.

Understanding from Mr. Morton, that there had been some alarm created at the Natural History Society's Rooms, in Peter-street, I this morning visited that building, and found, that on Monday last, the matting on the floor of one of the rooms in the third story, had been so charred by the hot water pipe as to require to have a portion cut off. This charred part Mr. Morton now has in his possession. The floor, also, at the same place, appears to have been scorched, but so far at least, as I was able to examine the rooms, I did not find any other similar effect. The two furnaces in this building are in the cellar, and I understand, that on the pipes being afterwards opened by Mr. Walker's men, a considerable quantity of strong gas was emitted; and the water, when pumped out, was found very black, but bore no indication of the pipe being rusted. Mr. Walker's manager says, that the gas found in these water pipes, will readily ignite, if a light be applied to the aperture through which the gas is emitted.

Being myself unable to account for these fires occurring at so great a distance from the furnace, as was the case at Mr. Barbour's Warehouse, above alluded to, I asked Mr. Walker's Manager for some explanation, but when questioned yesterday, on the subject, he seemed unable to account, satisfactorily, for the peculiar manner in which these different fires had been caused. He, however, distinctly stated, that he has, in company with Mr. Walker, seen experiments tried at the works, upon pipes of this description, when they found, that the pipes may easily be made, if not of a red heat, at least sufficiently hot, to ignite any combustible matter that may be brought into contact with them, and that this effect may be produced, simply, by putting an additional quantity of fuel into the furnace.

The only conclusion which I have yet come to, under all these circumstances, is that the pipes have been so overheated by their contents, as to cause ignition to the combustible materials surrounding them, but how this actually takes place I do not attempt to explain.

I remain,

Gentlemen,

Your very obedient Servant,

G. V. RYDER.

## APPENDIX B.

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*Report, and Replies to Questions put by Mr. John Davies, in reference to the Hot Water Pipes lately removed from Strangeways Chapel.*

QUESTION.	ANSWER.
1. When applied?	In 1839, from Walker.
2. How long used?	Barely two years.
3. Inconvenience experienced?	Deficiency of Heat, great consumption of Fuel, and offensive scent when heated.
4. Reasons for discontinuing them?	Want of sufficient Heat, the bursting of the Pipes, and the danger apprehended.
5. Appearances when the pipes were removed?	The Floor underneath the pipes much charred, in some places nearly burnt through.

### OBSERVATIONS.

These pipes were upon the high pressure plan, and were found very unmanageable; the offensive scent of the combustion of wood occurred to such a degree as to cause the congregation much annoyance; causing many to cough, &c. The floor appeared to be *most burnt* where the joints occurred. At present the Committee are trying two of Arnot's stoves.

The Chapel-Keeper will show Mr. Davies, if required, the effect produced from using the pipes; the charred appearance is general, and the Committee think that the Chapel has had a fortunate escape from being burnt down.

JOHN RAWSTHORNE,  
1, Claremont Terrace, Strangeways.

Feb. 27th, 1841.