

1921.
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VICTORIA

R E P O R T

OF THE

BOARD OF INQUIRY

INTO

EXPLOSION OF GASHOLDER

AT

PORT MELBOURNE.

PRESENTED TO BOTH HOUSES OF PARLIAMENT BY HIS EXCELLENCY THE LIEUTENANT-GOVERNOR'S COMMAND.

[Approximate Cost of Report.—Preparation, not given; printing (300 copies), £11.]

By Authority:

ALBERT J. MULLETT, GOVERNMENT PRINTER, MELBOURNE.

2ND S.—No. 16.—[9d.]—17352.

(Extracted from the Government Gazette of 9th April, 1920.)

BOARD OF INQUIRY INTO EXPLOSION OF GASHOLDER AT PORT MELBOURNE.

His Excellency the Lieutenant-Governor of the State of Victoria, by and with the advice of the Executive Council thereof, has, by an Order made on the 9th day of April, 1920, appointed

Orme Masson, Esquire, M.A., D.Sc., and

Bernhard Alexander Smith, Esquire, M.C.E.,

a Board to inquire into, and, if possible, to determine the cause of the bursting, wreckage, or destruction, on the morning of Sunday, the 4th April, 1920, of a gasholder, the property of The Metropolitan Gas Company, situated in the municipal district of Port Melbourne, and, in due course, to report the result of the inquiry, with the opinion of its members as to the cause of the explosion.

F. W. MABBOTT,
Clerk of the Executive Council.

At the Executive Council Chamber,
Melbourne, the 9th April, 1920.

REPORT.

To His Excellency the Honorable Sir William Hill Irvine, Knight Commander of the Most Distinguished Order of Saint Michael and Saint George ; Lieutenant-Governor of the State of Victoria and its Dependencies in the Commonwealth of Australia, &c., &c., &c.

MAY IT PLEASE YOUR EXCELLENCY :

We, the undersigned members of the Board appointed by Order in Council, dated the 9th April, 1920 (a copy of which Order is prefixed hereto) "to inquire into, and, if possible, to determine the cause of the bursting, wreckage, or destruction, on the morning of Sunday, the 4th April, 1920, of a gasholder, the property of the Metropolitan Gas Company, situated in the municipal district of Port Melbourne, and, in due course, to report the result of the inquiry, with the opinion of its members as to the cause of the explosion," have the honour to report as follows :—

1. THE INQUIRY.

The Board held a preliminary meeting—which was in private—on the 12th April, 1920. At this meeting it was resolved to request Mr. Lewis, the Chief Inspector of Explosives, to meet the Board in conference, as it seemed at that time not a remote contingency that some explosive substance, possibly used with criminal intent, had occasioned the destruction of the gasholder. Mr. Lewis conferred with the Board on the 14th April, 1920 ; and thereafter kept in touch with the Board, accompanying the Board on various visits of inspection to the gasholder, and finally appearing as an expert witness before it.

Between the date of its appointment and the holding of the first meeting of the Board for the reception of evidence, the Board sought information, by correspondence and otherwise, as to previous occurrences in connexion with other gasholders similar to the occurrence which they had to investigate.

Mr. A. C. Fairhall, of the Crown Law Department, acted as Secretary of the Board.

Applications by various bodies and persons as to representation at the public sittings of the Board were also dealt with, and on the 28th April, 1920, the Board held its first meeting for the reception of evidence.

Mr. D. Claude Robertson appeared to assist the Board.

Messrs. J. G. Latham and W. L. Ham appeared to represent The Metropolitan Gas Company.

Councillor Owen Sinclair appeared to represent the Port Melbourne City Council, in the municipal district of which the gasholder was situated.

Mr. C. Crofts, the Secretary of the Federated Gas Employees Industrial Union, represented the Union at certain of the public meetings of the Board ; being relieved from time to time by Mr. W. Sherriff, the President of the Union ; and Mr. Steele appeared to watch the proceedings in the interests of a client who was alleged to have sustained injuries through the destruction of the gasholder.

The Board held in all eleven public meetings, and received thereat the evidence of 35 witnesses. The dates of such meetings were—

(a) 28th and 30th of April and 7th May :

(b) 1st, 5th, 8th, 9th, 12th, 15th, 18th, and 19th November.

It will be noticed that the dates of the public sittings of the Board fall into two groups, separated by an interval of some months. This was unavoidable. It was seen, at an early stage of the inquiry, that the witnesses who would appear to give evidence would fall into two classes, viz., eye witnesses of the actual occurrence, and persons who would give evidence as to the condition of the gasholder before the occurrence, on the one hand ; and, on the other hand, witnesses who would give evidence as experts, and present theories as to the cause of the occurrence—this expert evidence and these theories being based on the recorded evidence of the former class of witnesses and on observations of the gasholder made by the experts.

This being so, the Board deemed it wise to procure the evidence of the former class of witnesses as early as possible, while the events and facts as to which they would testify were fresh in their memories. These witnesses were heard on the dates in April and May set forth above.

When the evidence given by this class of witnesses had been exhausted there was an inevitable wait before the expert evidence was available, as the members of the Board, and also the experts, desired to inspect the collapsed gasholder effectually before the evidence was taken. This inspection was impracticable until the well of the gasholder had been emptied of water, and the wrecked gasholder had been, in large measure, demolished.

The delay thus caused was increased by the strike of gas employees; and it was not until November that the expert evidence was available.

The Board inspected the gasholder on several occasions, and also visited the gasholder (of similar design) of the Metropolitan Gas Company, situated at Fitzroy. In addition, numerous individual visits were paid to the gasholder at Port Melbourne.

2. DESCRIPTION OF THE GASHOLDER.

The gasholder was situated in Port Melbourne, about 20 chains from the beach, in a special enclosure bounded by Graham-street, which bears S. 62° E. (Magnetic), Pickles-street, bearing S. 28° W., Danks-street, bearing N. 64° 36' W., and Johnston-street, bearing N. 28° E. All these streets are 99 feet wide. The gasholder is surrounded on all sides by a brick wall, about 12 feet high.

It was designed by Mr. R. O. Thompson, Engineer of the South Melbourne works of The Metropolitan Gas Company, in 1888.

The construction was carried out by Messrs. Clayton and Co., of Leeds, and the work was completed in 1890.

The holder was constructed of steel, in three lifts. The inner or top lift was 193 feet in diameter, by 35 feet high at the sides, with a rise of 10 feet in the spherical crown. At the bottom of the cylindrical surface the plates were bent into a U shape, forming a "cup" about 10 inches across, by 18 inches deep on the outside, and 30 inches deep on the inside. This cup contained water to a depth of about 18 inches, and was of $\frac{3}{8}$ -in. plates. The bulk of the plates in the crown and sides were $\frac{1}{8}$ inch thick.

The middle lift was 195 ft. 6 in. in diameter, by 35 feet high at the sides. A "cup" similar to that of the inner lift was provided at the bottom, and a "dip" or "grip" of similar construction, but of course inverted, at the top to engage with the cup of the inner lift.

The outer or bottom lift was 198 feet in diameter, and 33 feet high at the sides. It was provided at the top with a "dip" or "grip" similar to that on the middle lift, and was stiffened on the bottom by two angle irons 6 inches x $4\frac{1}{2}$ inches x $\frac{5}{8}$ inch, with a 7-in. x $\frac{1}{2}$ -in. plate, forming a channel-shaped ring, of which the plate was vertical and the angle irons outside.

The holder was placed in a cylindrical concrete tank, 200 feet in diameter by 35 feet deep, sunk about 25 feet in the ground, and standing about 10 feet above the natural surface. This tank was kept full of water to within about 6 inches of the top.

Each lift was provided with 22 rollers at the top and 44 rollers at the bottom. The top rollers ran in channel iron guides, $6\frac{1}{4}$ inches x $3\frac{1}{2}$ inches x $\frac{5}{8}$ inch, attached at 5 feet vertical intervals to 22 massive vertical steel standards, which were braced together by three horizontal rings of girders, also of substantial construction, at 35 feet, 70 feet, and 105 feet above the top of the tank, and also by diagonal cross bracing in every bay.

The bottom rollers ran in suitable channel iron guides, attached to the interior cylindrical surface of each of the lower lifts and to the interior of the tank respectively.

The full capacity of the holder was about 3,000,000 cubic feet.

The weights of the lifts were as follows:—

Inner lift about 200 tons.

Middle lift about 140 tons.

Outer lift about 140 tons.

The corresponding pressures in the gas are—

When the inner lift alone is raised, 3 inches of water.

When the middle and inner are raised, 5 inches of water.

When all three lifts are raised, 7 inches of water.

For reference during the inquiry the vertical standards have been numbered from 1 to 22. The centre of the channel iron guide on standard No. 1 is 35 feet from Danks-street, and 47 feet from Johnston-street, and the numbering runs clockwise on plan from this standard.

The gasholder has been frequently painted externally—the last occasion was in February, 1920.

Leaks have occurred from time to time, chiefly in the crown; these leaks were patched in the customary manner by cover pieces bolted on to the plates. The largest leak was a crack about 12 feet long in the crown, which was repaired in July, 1919. About half-a-dozen smaller leaks were also repaired at the same time.

No internal inspection had been made prior to the collapse of the holder, *i.e.*, for about 30 years.

3. HISTORY OF THE EVENT.

The holder collapsed at about 10.30 a.m. on Easter Sunday, 4th April, 1920.

At 10 a.m. the contents of the holder were about 2,180,000 cubic feet, and at this time the valveman, R. Ellis, shut off the supply; so that the contents would probably be about the same at 10.30 a.m., the top of the outer lift would be about 4 feet above ground level, and the top of the inner lift about 74 feet above ground level, *i.e.*, 3 or 4 feet above the middle row of horizontal girders on the standards.

The charts, which record the pressure in the mains beyond the governors, show that at 10.30 a.m. there was a sudden drop of pressure, which fell from the standard amount, 4 inches, to zero, and remained at zero till the gas was turned from the West Melbourne works into the mains, when it rose again to the standard pressure, and continued normal from that time onwards.

4. ACCOUNTS OF EYE WITNESSES.

The most complete account of the course of events during the collapse was given by John Irvine, a carpenter in the employ of the Metropolitan Gas Company.

This witness observed the occurrence from a point marked 9 on plan, Appendix No. 1, about 250 yards to the west of the holder, from which point he had an almost uninterrupted view. He states that his attention was drawn to the holder by a sharp report, like a rifle shot or two steel plates knocked together, and that, on looking up, he saw a flame shoot across Danks-street just above the wall of the gasholder yard.

He also saw a rent like a vertical split in the side of the holder. After that it appeared as if the holder rose a few inches, and tilted. The top then lifted off, and the holder settled down with a crash. Immediately it started to settle down the top tore away, and, after the holder had settled down, the gas lit up above the crown. The photograph, Appendix No. 2, was a splendid likeness of what took place.

The photograph No. 1 in Appendix No. 3 was taken from this witness's view-point, No. 9 on plan, Appendix No. 1.

W. J. Moxham, an employee at Joshua's Distillery, witnessed the occurrence from the distillery yard, about 120 yards from the centre of the holder, in a south-westerly direction, at the point marked 5 on plan, Appendix No. 1.

The accompanying photograph, Appendix No. 4, and marked "Moxham's view of holder," was taken from the point marked as above.

The view from this point was somewhat restricted by buildings, but was otherwise quite clear.

Moxham states that he was walking towards the holder, and noticed it descending. He had "never seen it do anything like that before." After the holder had descended 2 or 3 feet the top gave way on the north side, and the holder came down with a rumbling sound. It descended as rapidly as a ship would do coming off a slipway. He did not observe any flames before the top came off.

Thomas Page was standing on the south-west side of Reed-street, about 40 feet from Pickles-street, *i.e.*, about 150 yards from the centre of the holder, at the point marked 16 on plan, Appendix No. 1.

The accompanying two photographs, Appendix No. 5, marked "T. Page's view No. 1" and "T. Page's view No. 2," were taken to show the witness's view-point. No. 1 was taken from the point marked 16 on plan, Appendix No. 1, but, as this includes a building erected since the

occurrence, which cuts off a considerable portion of the field of view, the second photograph was taken from a point on the eastern side of Pickles-street, in a line between Page's view-point and the centre of the holder. This second photograph shows nearly enough Page's view at the time of the collapse.

Page's attention was called to the holder by a rumbling noise like thunder. He turned towards the holder, and immediately the crown seemed to be coming right up, as if on a hinge. He then saw a flash, like lightning, coming right across Pickles-street from the direction of the company's works (at the south-east corner of Graham and Pickles streets) to the holder, "and of course then there was a burst of fire."

These three witnesses appeared to give the best account of the occurrence, and we accept their evidence as being substantially correct.

Moxham and Page are in apparent conflict with Irvine as to the exact moment of ignition of the gas, but, as the whole occurrence was only a matter of seconds, it is quite possible that the flash across Pickles-street, described by Page, first ignited the gas escaping round the cup of the middle lift, as described by Irvine, and that then almost simultaneously the gas escaping through the top of the holder was ignited from the flame in the cup.

5. CONDITIONS OBSERVED AFTER THE COLLAPSE.

On examination, the following facts were disclosed:—

- (1) The outer lift had settled down without serious injury.
- (2) The cup of the middle lift was broken in several places.
- (3) In two zones on opposite sides of the holder, viz., on the northern side, from about standard 5 to standard 10, and on the southern side, from midway between standards 15 and 16 to midway between standards 21 and 22, the bottom portion of the middle lift had, as the holder descended, canted inwards towards the centre of the tank, and, on reaching the bottom, had been pushed by the impact towards the centre, so that, when the inner lift descended, the bottom portion of the middle lift was very severely distorted and broken by the inner lift descending on it.
- (4) Several vertical rents occurred in the cylindrical surface of the middle lift, one of them in the place described by Irvine.
- (5) Several of the guide-wheels had been displaced from the guides during the descent, as shown in the photographs in Appendix No. 6, and some were broken off.
- (6) The guide channel irons on several of the standards were distorted into a wavy form for a height of about 20 feet above ground, but above this were undamaged.
- (7) Considerable corrosion had occurred in the interior of the holder, amounting in some of the $\frac{1}{2}$ -in. curb-sheets of the crown to about 1/10th inch, and in many of the $\frac{1}{8}$ -in. crown sheets to 1/16th inch. Along part of the main tear in the crown the thickness had been reduced from $\frac{1}{8}$ inch initially to 1/32nd inch before the time of the collapse.
- (8) On test, the average breaking strength of the plates was found to be under 20 tons per square inch, as against about 26 tons per square inch for new plates, while one of the old plates failed at less than 11 tons per square inch.

Appendices Nos. 3 and 6 are a series of photographs, which give a clear idea of the state of the holder after collapse.

6. THEORIES UNTENABLE OR DISPROVED.

(1) Any idea that the catastrophe was caused by explosion of the gas in the holder may be dismissed at once as untenable. It is impossible for gas to become ignited or to explode unless mixed with at least three and three-quarter times its own volume of air (this minimum proportion varying slightly with the composition of the gas); and it is certain that no such admixture of air could have occurred under the working conditions which obtained prior to the accident.

(2) The hypothesis that the holder was wrecked by means of a charge of gun-cotton, gelignite, or other powerful explosive, deliberately placed in position, and fired with criminal intent, called for careful investigation. The wreckage of a large gasholder in Glasgow in 1883 was due to such criminal action; and Colonel Majendie, who carried out the official investigation, had no difficulty in proving the fact. His report, which we have read, gives a full account of all the evidence in that case. In the present case we have found no such evidence of a criminal

explosion ; and, in fact, no explosion occurred. We base this conclusion on our own observations, and particularly on the evidence of Mr. R. J. Lewis, Chief Inspector of Explosives, who investigated the question very fully at our request.

(3) The theory of criminal causation by purely mechanical means calls for separate discussion. We have seen no record of any such occurrence elsewhere ; but it would doubtless be possible to wreck a gasholder by placing a sufficient obstruction in such a position as to hold up one of the lifts at one point in the course of its descent, thus tilting it, opening the cup, causing gas to escape, and producing abnormal stresses, which would rend the structure. The obstruction would have to be sufficiently strong to withstand the crushing effect of a great weight (about 140 tons in this case), and we do not think that such an obstruction could find its way accidentally into the exact position where it would be effective. We hold, also, that the catastrophe could hardly have been brought about in this way, whether accidentally or intentionally, without leaving some definite evidence that it was so. No such evidence was found after the event by ourselves or by the company's engineers, nor were any facts elicited from Detective Mulfahey, who was detailed to make investigations immediately after the event, or from any other witness during the inquiry, which would justify a finding of criminal action.

In this connexion, however, reference must be made to the anonymous letter which was addressed to the Secretary to the company, and received the day before the catastrophe, *i.e.*, on Saturday morning, 3rd April. It was opened in his absence by a subordinate official, and set aside with other letters, to be dealt with in the following week. It was placed in the hands of the Chief of Police, Sir G. Steward, on Wednesday, 7th April. His death occurred soon after, and, so far as our information goes, there was no result of any inquiry made by him or his officers. The letter was put in as evidence by the company's counsel on 5th November. It is as follows (transcribed without change in spelling, &c.) :—

“ March 31st

To the Secretary
Metropolitan Gas Company

Sir

I am a student of Occult Science and it as come to my knowledge that during or about April 25th there will be an attempt to blow up this company's Gasometer at south melbourne. (perhaps more) the *trouble is outside not in.* feeling the responsibility heavy upon me I am writeing to warn you so that means may be taken to prevent if possible this awful thing. It is purely and simply through the devine will this came to me. Other knowledge which came to me through the same channel as proved correct. (such as the war). on the 14 June before war was declared. Scappa Flow incident which took place 6 weeks later. also Sydney railway strike. these things I proved to be true. hence my anxiety for our city and people. trusting you will go in to the silence and ask your soul is it true and then let the *search light* of intelligence sweep the heavens ”

It may be noted that the writer foretells the catastrophe for on or about Sunday, 25th April, whereas it happened three weeks earlier (Sunday, the 4th), and the very day after the receipt of the letter. The claim to supernatural power of foreseeing future events stamps the writer either as a deluded crank or as a person desirous of disguising his identity. In either case, the partial correctness of the prophecy must be put down to chance. In the latter case, the writer may have had some reason for warning, or perhaps attempting to frighten, the company. In these times, discussions as to the merits or demerits of “ direct action ” may often take place, and the writer may very likely have overheard or taken part in such talk. However that may be, the fact remains that, apart from this anonymous letter, no evidence was obtained in the course of our inquiry that would support the theory of criminal action ; we have, therefore, determined to disregard the letter.

7. PROBABLE SEQUENCE OF EVENTS.

We believe that the sequence of events was as follows :—

- (1) Breakage of the cup of the middle lift nearly simultaneously, at four places, the ends of the two zones of distortion referred to in section 5 of this Report, followed rapidly by the vertical splitting of the plates of the middle lift.
- (2) The breakage of the cup of the middle lift allowed the water to run out and the gas to escape, with the hissing and bubbling noise described by the witnesses Balford and Ellis.

(3) Two theories as to the cause of the ignition were put forward—

- (1) That it was due to a spark generated by friction of metal on metal;
and
- (2) That the gas was ignited at the works of the Metropolitan Gas Company.

We have come to the conclusion that the ignition probably arose at the works, particularly in view of the evidence of the witness T. Page.

The flame probably caused the ignition at the cup, as described by Irvine, and the main body of gas was then ignited from this flame.

- (4) The settling down of the holder, as described by Moxham, "like a ship leaving a slipway."
- (5) The tearing of the crown sheets on the northern side, giving rise to the apparent tilt described by Irvine.
- (6) During the rapid descent of the holder the crown was lifted off as though caught in a high wind—this event not occurring until the fall had become comparatively rapid, thus allowing the gas in the holder to behave like a strong wind. Only the lower cross bracing was damaged by the falling crown sheets.
- (7) During the descent of the holder the northern and southern segments of the broken middle lift canted inwards, and, on reaching the bottom, were bumped towards the centre, and then crushed, as shown in the photographs in Appendices Nos. 3 and 6, by the inner lift falling on them.

8. INITIAL CAUSE OF COLLAPSE.

(A) THE COMPANY'S THEORY.

The theory advanced by the company is that some obstruction was placed either accidentally or wilfully at column 14 or 15 so as to tilt the holder and allow the water seal to be broken. This allowed an escape of gas, and also caused the upper rollers to press against the channel iron guides in the columns or standards on one side, and the lower rollers to press against the channel iron guides on the opposite side, this action setting up a tension on the opposite diameter at right angles to the direction of the force.

No calculations were given of the magnitude of the stresses which would have been introduced by this obstruction, but, as the bottom lift weighs about 140 tons, it is obvious that they would be considerable, and that any effective obstruction would have had to be fairly substantial.

The forces introduced would necessarily have caused considerable distortion of the channel irons near the top of the standards. There was no such distortion, except near the bottom of the standards, and no evidence was given of the existence of any obstruction. We are, therefore, compelled to reject this theory.

(B) TEMPERATURE EFFECTS.

The effect of temperature in causing distortion of the holder was referred to by Mr. Lewis, Chief Inspector of Explosives for the State of Victoria, but it was not dealt with in evidence by the experts called by the Gas Company.

It is to be observed that a rise of temperature of 100° Fahr. causes an expansion in iron or steel of about $\frac{3}{4}$ inch per 100 feet, *i.e.*, in a holder of 200-ft. diameter a rise of temperature of 133° Fahr. will cause an increase of 1 inch in the radius or 2 inches in the diameter, and, of course, a smaller temperature change will cause a correspondingly smaller increase.

We must consider, first, the effect of a rise of temperature on the 22 vertical standards.

If these were disconnected from one another, they would merely expand and contract up and down with the temperature changes, but would remain parallel to one another, and, say, 200 feet (really 201 ft. 6 in.) apart from top to bottom, wherever the distance between the pairs of standards was measured.

But the standards are connected together by means of three rows of horizontal girders at 35 feet, 70 feet, and 105 feet above the ground; and these girders also expand and contract with changes of temperature. The bases of the columns are, however, securely built into the ground; so that the bases must remain at the invariable distance apart of 200 feet, and the columns must remain vertical near the base.

Now, if the rise of temperature is such as to cause an increase in the radius of 1 inch, the effect is as follows:—At the base there is no displacement, at the first row of girders the standards are pushed out to the extent of .4 inch, at the second row of girders to the extent of 1.07 inches, and at the top row to the extent of 1.02 inches. (See Appendix No. 7.)

Next, consider the effect of the same rise of temperature on the holder. It will cause the diameter to increase by 2 inches in the lifts which are exposed to the temperature changes, but if one of the lifts is submerged or nearly submerged in the tank, as was the case with the bottom lift on the occasion of the collapse, then this lift will hardly be affected.

In ordinary work, if the holder is nearly full, the inner or top lift expands and contracts practically to the same extent as the standards, and, so long as the middle lift is above the lowest row of horizontal girders, it suffers relatively little distortion, whilst the outer or bottom lift, being generally submerged, also suffers comparatively little.

If, however, the middle lift is kept near the ground level—and the general tendency will be for this to occur—then the bottom cup is subject to very severe distortion, for it is freely exposed to the sun, and on a hot day may be 60° or 70° Fahr. above the mean temperature of the water in the tank, whilst the standards compel it, at 22 points, to remain unchanged in diameter. The effect of this is to cause the cup ring to assume a wavy form (see Appendix No. 8), and this puts a severe strain on the material of the cup, of over 20 tons per square inch for the temperature rise of between 60° and 70° Fahr., referred to above. This is sufficient to account for the breakage of the butt strap, as to which evidence was given before us. The butt strap itself being produced in evidence; and, furthermore, it is quite likely that the fractures of the straight portions of the butt strap were old, and had been caused by a similar action during preceding hot weather.

Now, the experiments made—as to which evidence was given before us—show that, whilst new plates are capable of withstanding this stress, the old plates of the holder are incapable of doing so. We conclude, therefore, that this simple fact is sufficient to account for the failure, and that the tearing of the crown was a secondary effect, due to the fall of the holder.

9. CONTRIBUTING CAUSES.

Whatever may have been the exact sequences of events that constituted the primary cause of the catastrophe, it is highly probable that the result was helped by two contributing causes, both of which tended to weaken the structure.

In the first place, iron and steel undergo slow molecular changes, which, in course of time, tend to diminish their strength; and an examination of the results of tests carried out at the University, and submitted in evidence, shows that such changes had undoubtedly affected the plates of which the gasholder was constructed. In the second place, it was found that it had undergone a large amount of actual corrosion internally, which had in some places actually reduced the thickness of the metal to one-half of its original thickness, or even less. This rusting is due mainly, at any rate, to the combined attack of oxygen, moisture, and carbonic acid gas, of which moisture is necessarily present, and oxygen and carbonic acid gas are always contained to a small amount in coal-gas, though they are not desirable ingredients. The extent to which internal rusting had occurred in the 30 years since the holder was erected was unknown and unsuspected till inspection revealed it after the accident. The chief engineer of the company, in his evidence (pp. 274–6), said that he was surprised to find so much corrosion, and that he would in future favour the adoption of precautions for the protection of the metal, and also a system of internal inspection every ten years.

When designing structures, engineers allow for all normal stresses, and for a considerable margin of safety, to provide against the abnormal or unexpected. They base their calculations on the specified strength of material, and it is always considered essential that such specification should be closely adhered to, even comparatively slight deviations being objected to. It is obviously even more important that a large and progressive weakening of the metal by corrosion after the structure has been built should be prevented if possible, and that, at all events, it should not be allowed to go on uninspected and undetected. In the present instance the tests have shown that the original assumed “factor of safety” of about 7 had been reduced to about 3, and this was partly, though not entirely, the result of corrosion. To that extent the structure was less able to withstand the effect of abnormal or unlooked-for strains, such as we consider were the primary cause of the accident.

10. FINDING OF THE BOARD.

We find, as the result of our inquiry, that the destruction of the gasholder was due to the breakage of the cup of the middle lift, and that this breakage was the result of temperature stresses, for which provision had not been made in the design of the gasholder. We find also that the holder had been considerably weakened, mainly by internal corrosion, during its 30 years' service, and that this was a contributing cause.

11. RECOMMENDATIONS.

In the course of a very able address Mr. Latham pointed out that the Board had not been appointed for the purpose of making recommendations as to the construction or location or management of gasholders.

We feel, however, that we should fail in our duty if we did not point out the desirability, in the light of the evidence given at the inquiry, of having a regular inspection of gasholders, as is done in the case of steam boilers, say, annually, so far as the exterior is concerned, and about once in ten years for the interior of holders.

12. We desire to acknowledge the great assistance we have received from the officials of the Metropolitan Gas Company, and particularly from its Chief Engineer, Mr. Reeson, who has done all in his power to facilitate the inquiry.

We also wish to express our obligation to the Chief Inspector of Explosives, Mr. Lewis, for his valuable help; to the other scientific witnesses, to the counsel for the Crown and the company, and to the gentlemen who assisted in the case on behalf of other parties.

All of which we have the honour to submit for Your Excellency's consideration.

Witness our hands this 7th day of January, 1921.

ORME MASSON, }
B. A. SMITH, } Members of the Board.

A. C. FAIRHALL, Secretary.

LIST OF APPENDICES.

APPENDIX No. 1.

Plan showing points from which certain witnesses viewed the destruction of the gasholder.

APPENDIX No. 2.

Photograph of the mass of smoke and flame above the gasholder on the occasion of its destruction.

APPENDIX No. 3.

Collection of photographs of portions of the gasholder after its collapse.

APPENDIX No. 4.

Photograph showing witness Moxham's point of view of the occurrence.

APPENDIX No. 5.

Photographs showing witness T. Page's points of view of the occurrence.

APPENDIX No. 6.

A further collection of photographs of portions of the gasholder after its collapse.

APPENDIX No. 7.

Calculation as to the effect—in thrusting out the standards of the gasholder—of a rise in temperature such as to cause an increase in the radius of the gasholder of 1 inch.

APPENDIX No. 8.

Calculation as to the deformation of a circular ring.

APPENDIX No. 9.

Plans (1) showing the position of the lifts and crown-sheets of the gasholder after the collapse;
(2) showing the positions of the inner and middle lift cups after the collapse.