SPONTANEOUS COMBUSTION.

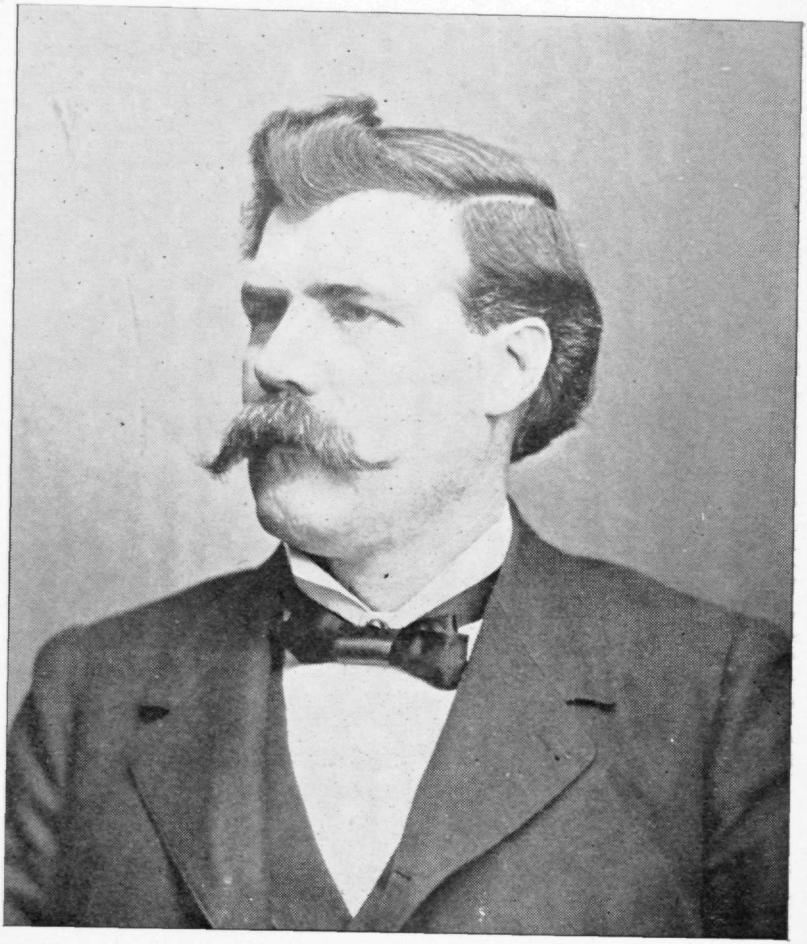
JOHN P. JONES, N. LAWRENCE, OHIO.

Mr. Chairman and Gentlemen of the Institute of Mining Engineers:

As the title of the subject which has been assigned me is one that may convey different ideas to different minds, it may be well at the onset to define as fully and clearly as possible what is implied and understood by the term, "spontaneous combustion." Webster defines spontaneous combustion as combustion produced in a substance by the evolution of heat through the chemical action of its own elements. I may add to his definition by saying that combustion of any kind in the ordinary acceptation of the term is produced by the energy with which oxygen seeks to enter into combination with material which is inflammable. It may take place from the abnormally rapid oxidization of coal dust in a very dry mine, which under favorable conditions may evolve sufficient heat or generate sufficient force to cause ignition. Explosions from this cause are generally of far reaching and disastrous nature. Coal dust mixed with air, with or without the presence of fire damp, set into sudden and intense vibration by a heavy powder blast, a fall of roof, or other means, may explode with greater destructive force than even fire damp is capable of. Fortunately such explosions are not frequent, all the conditions necessary being rarely present at the same time.

Another frequent cause for spontaneous combustion of a kind which may result in explosions in mines is that arising from oxidization of iron pyrites in heaps of coal, aided by the chemical effects of moist air. Iron pyrites are composed of one atom of iron and two atoms of sulphur. Moist air decomposes it, the decomposition is attended by a liberation of heat and if the heat is not absorbed and carried off with sufficient rapidity, ignition of the sulphur takes place. This fact has of late years occupied the attention of shippers of coal as well as that of coal owners. A common cause, too, of this phenomenon in veins of coal not usually given to ignition, is the enormous pressure at times of the roof upon the veins, thereby igniting the shale by the heat engendered.

Heaps of loose coal exposed to a moist atmosphere accelerate



JOHN P. JONES.

oxidization and consequent fire, and may be described as another cause for spontaneous combustion, though there are other forms in which it may occur in mines, such as those springing from substances saturated with oil, etc. Those of the character mentioned are probably all that concern us in their relation to explosions.

It is at all times difficult to determine whether explosions in coal mines are due to causes of the kind described, or to carelessness in the handling of naked lamps, or to the sudden liberation of pockets of gas which may be ignited in any one of the thousand conceivable ways; but it is fair to assume that the portion of such explosions have their origin in some one or other of the ways that spontaneous combustion may be induced. This phenomenon may, of course, occur and sometimes does occur. A case of this kind happened in Stark county in the No. 6 seam of coal, in 1859. The owner of the colliery in question, speaking of the event, informed me that for days before the fire broke out he was puzzled by a peculiar and somewhat pungent, all-pervading odor resembling that of burning carbon oil. This would appear to indicate that gases related to the latter product were being distilled in some way from the exposed surface of the coal, and that when mixed in certain proportions with the atmosphere they ignited. I may say that this is the only case of the kind of which I have ever heard and it is probably unusual.

It may be permissible here to say that with due caution and diligence on the part of the miners and coal owners there can ordinarily be but little danger of explosion from causes here discussed. We have seen that dry coal dust under certain conditions may be exploded in a way rendering death to the workmen and destruction to the property inevitable. It is obvious that if the main passages are kept sprinkled with water there would be absolutely no danger from this source. In the case of explosions caused by the heat evolved in the process of oxidization of iron pyrites in heaps of broken coal in a moist atmosphere, the remedy is equally clear and plain; viz., remove as far as practicable all such heaps or accumulations from the mine to the surface. Against pockets of gas, we cannot so well guard. Explosions from this cause, however, though I have mentioned them, do not perhaps belong to or come under the head of spontaneous combustion. (Applause.)

PRESIDENT ORTON: We have listened to the paper of Mr. Jones with much pleasure. Are there any here who would like to discuss the subject of spontaneous combustion in mines, either

affirming or controverting the views which Mr. Jones has advanced?

MR. BROPHY: I want to ask if all coals are liable to spontaneous combustion?

MR. JONES: I assume that under the necessary conditions they would be, but the question of their being liable to spontaneous combustion depends largely upon their containing iron and sulphur. That is, a coal containing iron and sulphur ignites more readily than a seam which does not. But I assume that in any and every vein where the conditions necessary exist that is possible, though they rarely ever do.

PRESIDENT ORTON: Are there any further remarks?

MR. WEST: I would like to ask a question. I find at Dell Roy we have two varieties of pyrites. We have the cubic and rhombic, of which the chemical symbol is the same, Fe S_2. We find one does not cause spontaneous combustion and the other does. I would like to know which it is Mr. Jones refers to.

MR. JONES: They are both the same.

MR. WEST: I know they have the same chemical symbol, but one contains forty-seven iron and fifty-three sulphur, and the other forty-five iron and fifty-five sulphur. Which variety causes the fire?

MR. JONES: I assume that both did.

PROFESSOR LORD: There are two varieties of iron pyrites, the white and the yellow, or cubic and rhombis. The cubic, or white, is oxidized much more readily than the other, and a comparatively short exposure to the air and moisture will convert it into ————, and of course will develop the same amount of heat as sulphur if burned in the ordinary way. So that with the white pyrite there is more danger. Numerous cases have occurred of the ignition of coal containing a good deal of iron pyrites. The conditions favorable to spontaneous combustion are the accumulation of large amounts of the coal and a freedom of conditions

which can dissipate the heat. If you have a certain per cent. of iron pyrites in the coal, when it is oxidized by the air and moisture it will give out a certain amount of heat. Under many conditions where the coal is exposed to the air or drainage of water, or other cooling influences, the development of heat is so slow that it does not produce any perceptible rise in the temperature. But if the elimination of this heat is prevented, if the coal is so situated that the currents of air or circulating water cannot carry off the heat, if the coal has to lose its heat by pure conduction, the travel of the heat is excessively slow, so that the heat rapidly accumulates and the interior of the mass of coal is heated rapidly. The larger the mass, the more widely distributed the particles of sulphur, the more rapid the heating. The temperature once passing a certain point, rapid oxidation of the coal sets in. The coal itself begins to oxidize quite perceptibly at a temperature but littel above boiling water. So, if the oxidation of the pyrites can bring the coal to that temperature, then the oxidation of the coal will take place. Those are the conditions that establish spontaneous combustion in coal. This is the reason they had trouble at the shipping docks, when the coal was stacked in large amounts in situations where the heat was not carried off by air or by water.

MR. KANE: Is there any known cause for the greater abundance of sulphur in the rhombic pyrite as compared with the other?

PROFESSOR LORD: I don't know. I can't state what the reason for that is. Perhaps Doctor Orton can tell us.

DR. ORTON: No; I cannot tell.

PROFESSOR LORD: Another factor is the fineness with which the sulphur is distributed. A block of the pyrites will oxidize very slowly, but if it is in the form of a powder, it will oxidize much more rapidly. The action is on the surface and the more finely it is powdered, the more the surface increases. Hence the white sulphur found in coal is inclined to oxidize more easily.

PRESIDENT ORTON: I can state, as illustrating the action that has been mentioned, that I had occasion at one time to visit

the mouth of an old mine in Coshocton county,—I think it was the old Beach Hollow mine, which had not been operated probably for five years or so. At the time I was there the entry had caved in and there was only a small hole left, too small for a man to get through. There was a strong flow of water coming out of the entry, and as I had had a hot climb getting up to the hole where it came out, I put my hand in, thinking to cool off. I drew it out as if stung by nettles. The water was so impregnated with the iron pyrite that it was literally green as it came out of the hole, and as it absorbed oxygen it became red and deposited a fur of red down the hillside. But where it came from the mine it was green in color and unoxidized, and so strong that it would attack the bare skin of a man's hand on a summer day. I don't know whether the flow of water was permanent or not, carrying out the pyrite and abstracting its heat, and carrying the heat units away so there was no fire in the mine. I saw another case of a pile of slack coal which had been brought out from a mine, where the pyrites occurred in the form of a fine leaf, not niggerheads. This slack coal would oxidize with such violence that it would take fire piled outside of the mine. I found the most beautiful examples of clear sulphur crystals carried up and condensed on the outside of the pile by the outside air. That illustrates where the effects are alleviated, but the conditions present, as alluded to by Professor Lord. Where the water or air can carry the heat away there will be no fire, but it will occur where the coal is in a pile on the outside of the mine and heat enough is generated on the inside of the pile to break up $Fe S^2$, which does not usually break up under several hundred degrees.

MR. KANE: I will ask what are the means of prevention usually taken against this occurrence in large bodies of coal?

PRESIDENT ORTON: Is there any member here who can answer that question from a practical point? The means to prevent mine fires—

MR. KANE: Not necessarily mine fires, but I will include that. The question was directed to large bodies of loose coal deposited in storage, for instance. It occurs in that case, I suppose.

PROFESSOR RAY: Mr. Chairman, so far as preventing spontaneous fires in mines is concerned, the way would be not to leave any of the fine coal in the mine. That is a point that they have to observe in some of the Illinois mines,—not to leave any of the fine coal in the mines at all. If they do, they suffer from mine fires. Another precautionary measure is to have perfect ventilation. As to fires in coal piles on docks, the operators from experience have ruled out certain kinds of fine coal, and as a precaution use iron cribs that allow the air to pass all around the coal.

MR. KANE: What is the construction of those cribs?

PROFESSOR RAY: I never saw them but I judge they are like a perforated boiler, so the action is similar to chimneys placed frequently through a pile of coal. Anything to keep the body of coal open, which can be accomplished in various ways. I don't know of a certainty whether this plan was adopted, but I know that one company was considering it. When smoke commences to issue from one of these piles and they dig down to it, the fire may not be larger than a man's hat, but if left alone long enough, it would spread.

SECRETARY HASELTINE: In reply to Mr. Kane's inquiry, which is evidently directed more particularly to piles of coal upon docks, I will say that a year or two ago, they had considerable trouble in the Northwest, arising from the shipping of run-of-mine in large quantities instead of that usually shipped, which is three-quarter coal. They found at one dock, I think at Ashland, a pile of perhaps one hundred and twenty-five thousand tons which was on fire in a number of places, and each place where the appearance of fire made itself manifest was around the posts which carried the conveyors. In dumping the fine coal evidently had run down around these posts. In investigating the cause, they channelled through the piles of coal at right angles and as close to these posts as possible, and found in all these places a number of fires around the posts. They found the fires from the size of a bushel basket to that of the size of a man's hat up and down the pile of fine coal around the posts, and in no case were they united.

The oxidation had gone on only in small portions of the pile, and the idea in cutting through was to open up the channel and allow the air free circulation. I think the answer to the question is to give plenty of fresh air to carry off the heat where it will not ignite.

MR. JONES: I noticed in Tuscarawas county, where the No. 6 vein is, that outside all the tipples there was waste matter from the mines burning. I saw also in a paper an article discussing the preventatives of spontaneous combustion in ships, where they experience a great deal of difficulty. In the hold of the ship where they carry large deposits of coal for immediate use, it has been taking fire so frequently and the Royal Commissioners have recommended, as they can agree on nothing which will make a voyage comparatively safe, that a tube be driven down into the coal and an indicator arranged in some convenient part of the ship so that they can tell whether enough heat is being generated to make spontaneous combustion probable.

SECRETARY HASELTINE: I would like to ask Professor Lord a question. Will coal ignite that is absolutely free from iron pyrites?

PROFESSOR LORD: I never saw any coal that was absolutely free from iron pyrites. I don't know. I don't know of any figures that would answer that at all. It is almost an invariable constituent of coal. I have never seen any coal—and I have analyzed hundreds of samples—that did not contain iron pyrites. The only point I think of as bearing on it is that coals undoubtedly oxidize more or less at comparatively low temperatures. I mentioned that coal would oxidize at a temperature appreciably little above boiling water. If you heat it to a temperature of one hundred and twelve degrees, or a little higher, it will lose weight steadily as long as it is losing moisture, and after a while it will gain weight. This can only come from oxidation. It will gain in weight after it reaches a temperature of two hundred and twelve, or a few degrees above it. If oxidation is a production of heat and that can give rise to combustion, all I can say is that these facts would indicate that ordinary coal, free from iron pyrites, might give rise

to spontaneous combustion at a temperature about that of boiling water. There are a few facts that indicate the possibility of the ignition of coal at ordinary temperatures, but I know of no facts that prove it, and none that disprove it.

A MEMBER: Is it natural for gas to generate in fire clay? I visited a mine where the seam of coal is four hundred feet from the surface underground, and there is gas generated in that mine and it all comes from the fire clay,—they all claim it does. All I ever met came from coal or the roof, but in this particular case, they claim the gas is generated in the fire clay.

PRESIDENT ORTON: Can anyone answer that question?

MR. WEST: Possibly there is a small seam of coal beneath that, indicating that the clay is giving it off. A small vein of two or three inches will probably be found below the clay.

MR. KANE: I can add to Mr. West's testimony. I have had experience where they have had a fire clay bottom and have had water on the bottom, both on the surface and the bottom saturated with it, and all the time there were continual bubbles of gas rising from the bottom, apparently from the fire clay, but whether it was from the fire clay, or from a seam of coal underneath that, I can't say. I know there were seams of coal underneath, and my own opinion is that there is no condition in the fire clay to generate fire damp, but that it must proceed from somewhere where the conditions exist and we all know they exist in coals.

A MEMBER: The conditions of which the gentleman speaks do not exist in this mine. The mine is so dry they have to sprinkle it to keep down the dust, and I don't know that there is any seam of coal anywhere near it. This question was discussed in the Illinois Institute of Mining Engineers about a year ago, and these people argued that this gas came from the fire clay. I always doubted it and do yet, and want to know if anyone here knows whether it can come from the fire clay.

PROFESSOR ORTON: Peroleum is one of the commonest

substances in nature. Petroleum is scattered everywhere, through limestones, sandstones and shales. It accumulates in porous rocks wherever there is a chance. Petroleum and gas are one thing. Gas springs naturally from petroleum: it rises from the decomposition of petroleum, and you don't need a coal seam underneath to give rise to petroleum or gas. A sandstone may hold it. The fire clay there would be an obstruction to the passage of these substances, but will not entirely prevent it. At the mines this side of Bellaire, they took out enough petroleum from the mine to run the machinery. They gathered it by the barrel. That comes from a sandstone or limestone not far below. I don't think it is necessary that there be a coal seam in connection with the gas, because we know a source which is so widely diffused that we can't go amiss of it much,—petroleum in the rocks.

MR. LOVE: I don't know of any mine that generates fire damp where the gas comes direct from the coal. As Professor Orton says, a great deal of it comes from the sand rock above or below. When it comes from below, where the fire clay cracks down to this rock, then it permits the gas to escape, whether dry or wet.

MR. KANE: Must we infer from the professor's statement, and from what Mr. Love says, that the gas is not really in the fire clay itself, or underneath the fire clay?

PRESIDENT ORTON: There is nothing in the clay, as such, which by its oxidation can generate any considerable amount of gas. Occasionally pyrites are found, but not to cut any figure as to compare with coal. We also find in clays from time to time carbonaceous matter which imparts a cloudy color to the slates beneath it or above it. But as to whether the clay itself is a source of the gas, I would say it is improbable. There are so many other sources to attribute it to first.

MR. DALRYMPLE: I believe Mr. Jones said there were many serious explosions from spontaneous combustion igniting the carburetted hydrogen gas. Can you point to one case where such an explosion occurred?

MR. JONES: I think I did not say that, Mr. President.

PRESIDENT ORTON: You apparently misconstrued Mr. Jones' paper, Mr. Dalrymple. Are there any further remarks, gentlemen? We have arrived at the end of the afternoon's program, and it is necessary either to adjourn or take up the work for the evening. What is your wish?

Upon motion meeting adjourned till evening.

EVENING SESSION.

PRESIDENT ORTON: The Institute will come to order. The first thing on the regular program for this evening will be a paper by Hon. Andrew Roy, of Glen Roy, Ohio, the organizer and first president of this Institute.

MR. ROY: Mr. President, I got this meeting mixed up and thought my paper was due to-morrow. I have not yet finished my paper and intended to finish it in the morning, and if you will excuse me, I will read it then.

PRESIDENT ORTON: We will transfer Mr. Roy's paper to to-morrow's program.

SECRETARY HASELTINE: Mr. President, I have here an invitation which has been handed me, which reads as follows:

To the Ohio Institute of Miniug Engineers:

GENTLEMEN:—The faculty of the Ohio State University in special meeting assembled voted unanimously to tender to the Institute a cordial invitation to visit the Ohio Sate University during your session in this city, and appointed the undersigned a committee to extend the courtesies of the institution to the members.

(Signed), N. W. LORD,
C. N. BROWN,
EDWARD ORTON, JR.

PRESIDENT ORTON: Gentlemen, you have heard the communication read by the secretary. What will you do with it?

On motion of Mr. Jones, by unanimous vote the invitation extended by the faculty of the Ohio State University was accepted.

SECRETARY HASELTINE: While on this subject, I would like to say that the Jeffrey Manufacturing Company sent a representative over last evening and very urgently requested that we set apart a small portion of our time, if possible, to visit their works. They have some new developments and some new machines which would be very interesting to the members, and they are very desirous that we should come over and inspect them. I did not encourage them very much, for I knew we lacked time, but if we can find the time I think it will be very profitable for all the members to spend at least a couple of hours at the Jeffrey Manufacturing Company's works. If we decide to go at any time, I would like to know before so that I can communicate with them by telephone and they be ready to see us.

PRESIDENT ORTON: You have heard the matter which has been presented by the secretary. As the meeting is now mapped out, we have a business meeting for to-morrow morning and a visit to the State University planned for the afternoon. What is your pleasure in regard to this proposed visit to the Jeffrey Manufacturing Company's works?

On motion it was decided to visit the Jeffrey Manufacturing Company's works, if time permits.

PRESIDENT ORTON: I suppose the matter is to be left in the hands of the committee to determine. We will now resume the program at the point we left it. We will now call on Mr. John E. Short, formerly mine inspector at Carbon Hill, Ohio, to read his paper on "What I Witnessed While District Inspector of Mines."