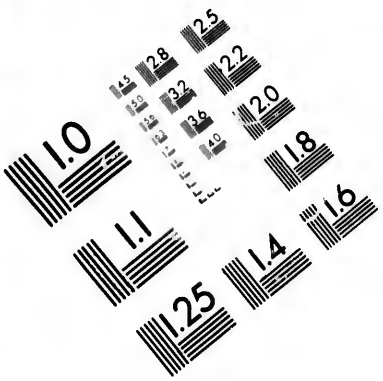

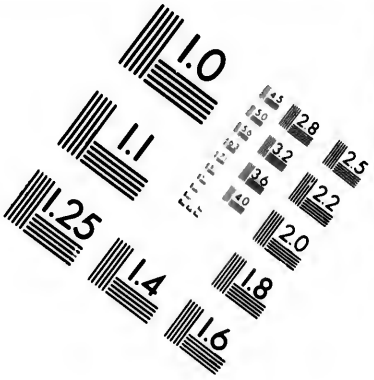

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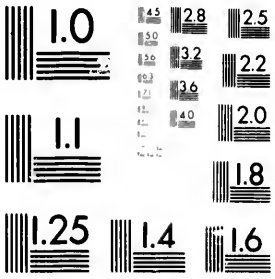

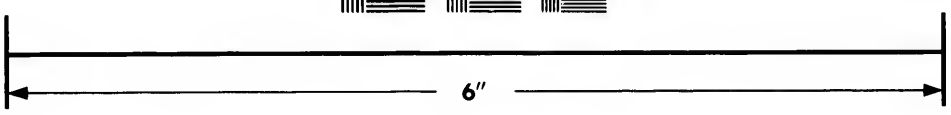

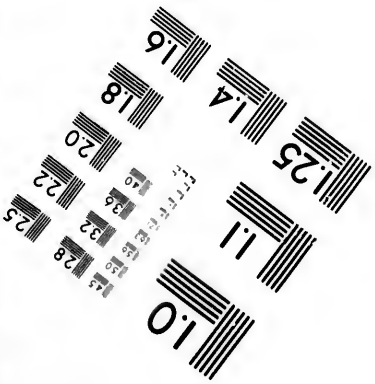

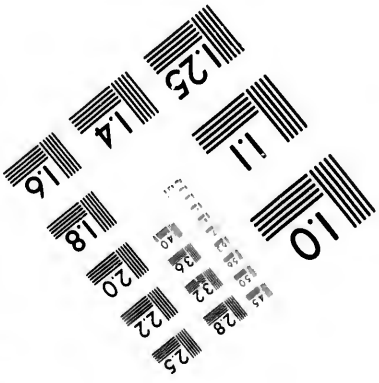

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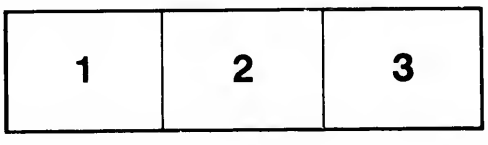

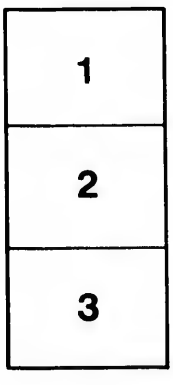

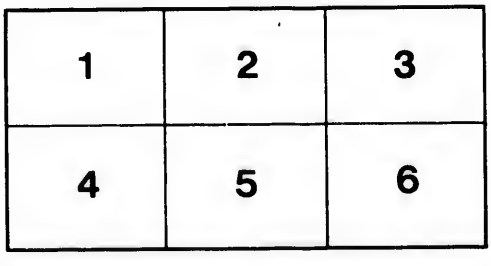

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PROVINCE HOUSE

(*From the Transactions of the Nova Scotian Institute of Science, Session of 1890-91.*)

VI. — Notes on Some Explosions in Nova Scotia Coal Mines.—By E. Gilpin, Jr., *Inspector of Mines.*

The presence of notable amounts of gas in the Nova Scotia coal mines seems to have been noticed first in Pictou Co. Here mining operations were commenced systematically in 1827 in the main seam, from 28 to 35 feet in thickness and dipping at an angle of about one in three. The early workings were from shafts up to 150 feet in depth. As deeper shafts were sunk the height of the working places, nine to twelve feet high, was increased to nearly the full height of the seam, Large quantities of gas were given off, and it was frequently ignited by shots. Numerous explosions took place, until about the year 1870 all these older workings were abandoned and operations in this seam were confined to the Ford Pit shaft about 900 feet deep.

The last of these fires took place in 1867. The eastern district had been for some time giving off gas which had occasionally been ignited on blasting the coal, but had been easily extinguished. On this occasion the gas took fire among the coal brought down by a shot, and the efforts made were not successful in putting it out. The coal caught fire and the water of the East river was turned into the pit.

When the Ford pit was sunk to the main seam and the levels were being opened a shot fired gas and ignited the coal and the shaft had to be closed for some time.

There remains but little information about these fires and explosions. Generally speaking, the workings were damp, except in some of the working places in the lowest deeps. The ventilation, by furnace, with upcasts of about 300 feet, was not able to sweep the huge chambers in this thick coal, and large bodies of gas constantly accumulated. It is probable that the imperfectness of the ventilation, by allowing vitiated

air to mix with the gas, rendered it less explosive. It is stated that on one occasion the exudation of gas was so steady and strong, that on removing it by a heavy fall of water, it fired at the boiler fires on the surface some fifty feet from the shaft. The resulting fire was so strong as to practically fuse and destroy the shaft.

In Cape Breton, up to this date, there had been a few slight explosions but no serious accidents. The Mines Report for 1890, gives special rules in force in Pictou County in 1840 which show that the presence of gas in these mines was regarded as constant.

One explosion before 1870, in the Deep or Cage pit, was undoubtedly of gas only. It took place in the face of a level which was wet for some distance back from the face. The explosion was local, and the timber of the place and the man who fired the shot were badly shattered.

In 1873, at the Drummond Colliery, Pictou County, a shot in the bench coal set fire to a heavy feeder, which could not be put out, and the pit was set on fire and greatly damaged after a series of unusually heavy explosions. It is not believed that coal dust was greatly concerned in this explosion, as it is believed that the gas made by the pit and the fire were enough to account for all the explosions. About fifty-five lives were lost.

May 21st, 1878, an explosion occurred at the Sydney Colliery, Cape Breton Co., by which six men were killed. Gas was fired at the face of a working place, by a party of men, including the overman, who were arranging to start new work. The effect of the explosion was very slight at the seat of the explosion, but its effects began to be felt a few yards away, and for some distance the coal and props were charred, and the latter knocked out. The amount of gas presumably must have been very small, as there was a head within two feet of the face. The workings were dry and the roadways deep in dust. In this case there appears to be no doubt that the coal dust augmented the explosion, which sent dust up the shaft at a distance of nearly 3,000 feet.

The coal of the Cape Breton coal field presents the following

average composition: (from a paper read by me at the Montreal meeting of the British Association):

Moisture	0.75
Volatile combustible matter	37.26
Fixed carbon	58.74
Ash	3.25

These coals coke readily, and yield from 8,000 to 11,000 cubic feet per ton of illuminating gas of from 10 to 16 candle power.

On November 12th, 1880, a very violent explosion took place at the Foord Pit, Albion Mines, Pictou Co., referred to above, causing the loss of forty-four lives. The men had descended in the morning, and the greater number of those employed on the south side had left the bottom, and presumably were gathered at the head of the dip-slants about three-quarters of a mile away waiting for their tools, when the explosion took place. These dip-slants are believed to have been the seat of the explosion, which, reaching the levels, divided, part going to the rise of the upcast and part coming direct to the main shafts, downcasts.

The theory was advanced that the shot firer had fired a shot in one of the places in these slants, which had been left by the outgoing shaft, and that it had lighted gas. No exact account, however, can be given, as no one escaped from that side of the pit and it has not since been entered. There is a possibility that some gas had accumulated since the examination of the foreman, and had been ignited by some of the men going into their places, without waiting for their tools, to load coal, timber, etc., as the time gave scant opportunity for the shot firer to have fired the shot. The mine was pronounced that morning free from gas, except in very small amounts lying away from the district in which the explosion was believed to have originated. From what source, then, started the series of explosions, beginning within an hour from the time the mine was reported entirely safe, and continuing at intervals until the mine became a furnace whose flames could be subdued only by emptying into its burning chambers the waters of an adjoining river. The locality where the men were believed to have been gathered was about

1200 yards from the shaft, but only half that distance could be traversed by the explorers, who entered the pit between the first and second explosions. In this distance were found bodies of men and horses killed by concussion or after-damp; but none bore the mark of fire, nor did the splintered woodwork show any signs of charring, and the flames had not reached this part of the mine. The walls of the main level had been swept clear of timber and of every particle of dust. Volumes of coal dust had been driven into this section by the blast, and lay in waves and drifts, sometimes a foot thick, in the floor of the level.

It was found that little of this dust showed any signs of heat or coking. Clouds of the finer particles had evidently been carried along the main and low levels past the shafts and into the north levels. Here a lamp cabin had been built, in a head between the two levels, a few yards from the pit bottom. There was a secondary explosion here demolishing the lamp cabin, burning fatally the lamp man, and the horses between the cabin and pit, and showing markings of fire, while in the opposite or south side of the pit, as already mentioned, there were no signs of the passage of flame.

Secondary explosions, caused by generated or extracted gases, are usually in the vicinity of primary explosions. But in this case it had apparently taken place at least one half a mile from the first explosion, with the intervening spaces evidently untraversed by flame, and presumably free from gas, as they had been worked many years. The shaft and bottom were very wet, hence the dust as it touched the walls became innocuous, but the fine dry particles of carbon were driven into the lamp cabin.

It had been the custom for years to keep a large open oil light here, as the cabin was near the pit bottom and in fresh air. But on this occasion it would appear that ignition of coal dust caused an explosion comparatively slight in comparison with the one preceding and those following it. It may have been the case that the air and dust were intermingled with some gas distilled by the heat of the primary explosion, but not exploded by it.

The coal took fire presumably near the first explosion, and the shafts were saved only by the most strenuous efforts and the

introduction of water from the East River. The main seam, as worked by the Albion, Acadia, and Drummond Collieries, was always gassy, and became dry a short distance away from the crop. It appears, also, that when shots lighted gas, or upon any explosion, the coal ignited very readily.

The average composition of the coals of this district, taken from the paper referred to, is:

Moisture	1.19
Volatile combustible matter	29.10
Fixed carbon	60.63
Ash	9.34

The coals are firm, and hold a good deal of mineral charcoal. They are generally coking, and yield from 6,000 to 9,000 cubic feet per ton of 12 to 15 candle-power gas.

February 18, 1885, an explosion causing the death of 13 men took place in the Vale Colliery, Pictou County. It was claimed by the management that it was caused by dust alone from a blown out shot. However, a very careful enquiry conducted by the Deputy Inspector, Mr. Maddin, showed that it was with more probability due to a small body of gas extended by dust. I give verbatim his report which was based on our careful examination of the seat of the explosion, a very full enquiry, and the general consensus of opinion of the most experienced mining engineers of the district.

"I was in Cumberland County at the time and arrived at scene of disaster on the 12th, and remained for some length of time investigating the cause of the accident.

"On April 6th I went down the McBean seam to the point where the men had been working at the time of the explosion, examined a hole at that point which was supposed to have been fired on the night of the explosion, and which some of the officials consider caused the explosion. The cause of the explosion at the Vale Colliery is a matter of dispute amongst experts, but the most reasonable solution appears to be as follows: On the west side of the slope, at 1300 feet level, were two (2) check doors, which, when shut, sent the air circulating down the slope,

but if opened the air would rush to the upcast, as an exhaust fan is situated on that side and thus the lower part of mine would be cut off from the air communication which, if allowed for any length of time, would undoubtedly accumulate gas; from appearances I would judge this to have transpired and gas to have been generated in the manner supposed. Gas then having been driven down by the restored action of the air was forced upon Foley's lamp, who was working in a head about 100 feet from sinking face. He was burned almost to a crisp, whilst two-thirds of the men below him had scarcely a singed head. Whilst sinking, they drive heads east and west from back slopes, at intervals of about 60 feet, at right angles to slopes, which are cut again at the face, coming up the hill with shoots. Heads driven up the hill, off the air current any distance, and left standing, will fill with gas. This has been an occurrence before the explosion, and since, which would lead me to believe that the air current must have in some way been tampered with, and the restored action resulted as I have stated. In support of this view I would say that the timbers in the slopes from the head in which Foley worked "downward," that is, toward the sinking face, gave unmistakable evidence that the explosion came from above, whilst the timber above this head gave like evidence that the explosion came from below, until it reached the 1800 feet level, which is some 400 feet above the level; then it expanded east and west, destroying the check doors on the levels, and showing slight signs of the explosion for a distance of 200 or 300 feet in the levels inside the doors, which were from 70 to 100 feet off the slope. The stoppings between the main slope and back slopes from the level up to the 1300 feet level were blown down. Strange to say, the first check door at 1300 feet level, on west side, was found standing open, whilst the inside door was destroyed. At this point there were men employed taking timber from the slope to some point inside of the doors. The explosion had gone in this level a distance of not more than 200 or 300 feet. The stoppings from 1300 feet level to mouth of slope were blown down, and timber and debris were strewed in a confused way all through the slope."

The force of the explosion seems to have been spread over the area I have mentioned, viz.: on the main slope and back slopes, and extending east and west from main slope a distance of from 200 to 300 feet, over which area the timber was in many cases blown down and falls of roof took place, whilst the working faces on east and west side of pit were free from any appearance of explosion and in as good order after as before.

After the mine resumed work and the water was extracted, a hole was discovered at the working face of the sinking. The evidence brought to show that this hole was fired, before the explosion, did not appear conclusive.

On January 15, 1887, an explosion took place at the Third Seam workings, Stellarton, Pictou Co., fortunately unaccompanied by loss of life. This explosion, which was considered one of the most violent ever known, was accompanied by unusual circumstances.

Preparations were made for beginning a slope in the Cage Pit or Deep Seam to the rise of the old shaft, to strike an old balance near the east level workings, in order to win the coal to the northeast of the present workings. This project unfortunately was prevented by the discovery that the fire in the west rise workings of the Cage Pit was not extinguished. The fire had been built off, I think, in 1872, and it was believed by the management to be quite out, especially as the fire in the same mine, caused by the Foord Pit explosion, was found to be out when the mine was re-entered. During the summer, part of the pillars in a balance in the Third Seam workings under the Cage Pit seam had been drawn, the fall of the roof extended up to it, and stythe came into the Third Seam workings. The balance was isolated by stoppings, and at the close of the year no trouble was anticipated. In the beginning of this year, however, fire broke out in the Third Seam with great violence, destroying the bank-head and necessitating the closing of the mine.

The extraction of pillars in the lower seam had broken the roof up to the overlying or second seam. As stythe came down, the panel or back-balance in which the pillars had been drawn was built off as rapidly as possible. For about a month every-

thing appeared to be all right, and the temperature of the panel lessened. Then, one Sunday morning, smoke was found in the return, and shortly after a most terrific explosion occurred, which wrecked the slopes and set fire to the bank-head, which was destroyed in a very short time. The immediate origin of this fire is unknown, but it is conjectured that a fall of roof had broken one of the stoppings, and the admission of fresh air had caused the ignition of gas slowly distilled from the heated shales, etc. Presumably, the explosion was heightened in its effects by dust, although the mine would not be classed as dusty.

I append the following from my report on the explosion at Springhill February 21st, 1891. (See Report of Mines Department, year 1890.)

In the No. 7 balance when the bords were first started, the coal was worked to its full height, having a bench of about 4 feet, then a stone band, and above that about 3 feet of coal. After the bords were driven in a short distance, the fall coal and stone was left in and the bench only was worked. This coal was not worked with powder, but as the face advanced it was necessary to blow down from 12 to 18 inches of the stone, to make room for the tubs to get near enough to the face to permit of their being loaded with coal. The stone was blown down in the low side of the bords, over the rails, and stowed in the high side. A row of props along the middle of the bords held the rest of the stone up. There was consequently little shot-firing done in the balance workings. The stone is about two feet thick, a coarse sandstone, with streaks of coal sometimes 2 inches thick. It was shown in evidence that usually the holes for the shots in the stone were bored in the coal streaks and were in some cases partly in stone and partly in coal.

It was shown that on the day of the explosion a shot was to be fired in this stone in the No. 3 bord in No. 7 balance, and that Thos. Wilson, the shot firer, left the bottom of the slope about a quarter past twelve o'clock, saying he had to go to No. 7 balance. The explosion occurred shortly before one o'clock, a time having elapsed in the opinion of the witnesses sufficient to have allowed him to reach this point, to have made the necessary preparations,

and to have fired the shot. His body was found, with those of the men working in the bord, near the entrance to the place. The shot in the stone had been fired. This, coupled with the direction of the course of the explosion, showed with reasonable certainty that it had its origin in the bord, and that the shot fired by Wilson was the direct cause of the explosion.

The suggestion was made by Mr. Madden, the Deputy Inspector, who was at hand at the time of the explosion, and rendered valuable aid to the rescuing and exploring parties, that the immediate seat of the explosion was to be sought in the stone itself. After examining the bord in question with him, I am of opinion that his suggestion offers the readiest explanation of the source of the catastrophe.

The bord is 14 feet wide, and the stone is carried by a row of props in the middle. These props were set by the miners as they advanced the face, to hold the stone, which was not of a specially strong character, consequently, as the stone was not blown down until it became troublesome to move the tubs, there were always props along the side of the shots, and between the shots and the face. The effect of these props was to partly confine the shots to the low side of the bord.

As the stone was in layers, and had streaks of coal in it, examination showed that it was more or less fissures across the bord, and hung on the props, the natural effect of the shots being to blow in along the layers, to compress the props and to cause the stone to bag between the props and the high side. That this effect was produced is shown by the fact that large quantities of this stone fell in the workings of No. 7 balance, the props being knocked out by the explosion, although very short, and partly supported by the stone stowed in the high side. The hole that was fired in No. 3 bord was, so far as could be estimated, from 2 feet 9 inches to 3 feet long. The end of the hole was in stone. The charge of powder appeared to have filled 18 inches of the hole. The shot threw down about ¾ of the stone it was designed to dislodge, and left the balance split by the heel of the shot, and a prop near the back of the hole. There was a lype in the stone

on the low side of the bord, which may have helped to lessen the desired effect of the shot.

The weight of evidence appeared to be that there had been an overcharge of powder.

It would appear that the expansion of the layers of the stone afforded space for the accumulation of gas, which would not be readily dislodged by the air current,, and there was an unusual opportunity for accumulation, owing to the fact that the pit was idle the preceding day. That the shot gave evidence of having been a more or less flaming one; that it ignited the gas lodged in the roof stone; that this combination of gas and powder flame acting on an atmosphere charged with a small percentage of gas and fine floating dust derived from the lower bords, caused an intense flame sufficient to propagate itself until it reached an intensely explosive state and self supporting, swept the two balances and the adjacent levels.

The evidence of Enoch Cox, who worked in No. 1 bord, on the same balance, supports this view. He testified that some time previous to the explosion a shot was fired in this stone, that filled his working place with flame, and ignited the gas in the stone, so that it required some effort to extinguish it. It is fair to state that the management declare they never heard of this, and that it was never reported to them.

The effect of dust and gas are referred to therein. This is one of the few explosions that have happened on this side of the Atlantic, where an opportunity has offered for an exact identification of the starting point and for an examination into the results produced. The testimony thus gathered appears to agree closely with the results of previous enquiries in this direction in Nova Scotia, and is to the effect that as yet no explosion here can be traced directly to coal dust fired by powder or by an open light. In this connection the evidence given at Springhill (see Mines Report, 1890) seems to show that when flaming shots took place, both dust and gas were present.

The Springhill coal in character resembles that of Pictou, but is, perhaps, most properly described as intermediate between the Cape Breton and Pictou County coals. It is coking, and yields

fair amounts of illuminating gas. The average composition is about—

Moisture	1.46
Volatile combustible matter	33.69
Fixed carbon	59.35
Ash	5.50

In conclusion, I may say that the mines here are as a rule carefully worked,—that individual or insignificant ignitions of gas are rare: that the amounts of gas now visible in the mines are quite small in comparison with the amounts allowed twenty years ago: that during this period great improvements have been made in the amounts of air circulating, and that it may be the increase in the velocity of the air currents and the larger amounts of air now mixed with the gas, and the greater movement of dust, combine to render explosions more violent in Nova Scotia than they were thirty years ago, when large bodies of gas were common in the mines, but existing as diluted greatly with deoxidised air and the products of combustion and breathing.

When the number of shots fired in mines dusty and yielding gas is considered, and the variety of explosions or ignitions of dust or gas is remembered, in connection with the frequent malignity of explosions when they do occur, it may be permitted to speculate if there may not exist certain conditions (applying to gases) rendering the inception and propagation of explosions more ready at one time than another. To the uninformed mind it certainly appears that in our dusty and gassy mines there should be more frequent explosions when the number of shots fired is considered.

If any means could be assigned for an increased readiness for dust particles or gas to ignite at one time more than another, ground might be given for experiment. When the existence in mines is noted of tracts of dry and dusty workings, alternating with others dampened with moisture, it may not be impossible for electrically induced conditions to be set up in a dry district, as influenced by the neighborhood of a damp and better conducting tract, that may at times present unusually favorable

conditions for ready ignition of gas and prompt distillation of coal dust, and an equally prompt propagation of the induced explosions.

In this connection the following remarks on Explosions in Dynamite Factories, from Eissler's work on modern explosives, are of interest :—

"EXPLOSIVES DUE TO EXTERNAL CAUSES.

"Mr. L. J. LeConte holds that dynamite catastrophies are intimately associated with electric phenomena. He has for the past ten years noted the circumstances attending the accidental explosions which so frequently occur on the Pacific Coast of North America, and he has found that, with the exception of such as occur during thunderstorms, the explosions take place during the violent, desiccating, north wind storms peculiar to the winter and spring months in California, but occasionally happening in midsummer.

"These winds, it must be remembered, have a velocity of 50 miles per hour, and a relative humidity of about 20 per cent., but frequently as low as 15 per cent., though seldom as low as 5 per cent. During the prevalence of the winds a prodigious amount of electricity is developed by the friction of clothing, especially when walking against the wind. One can thus easily generate a spark half an inch long. The phenomenon is also strongly marked in horses at work, the electricity causing their manes and tails to bristle to a remarkable extent. Mr. LeConte finds in the electricity the exciting cause of these explosions, and in the dust that prevails in the work, the medium through which explosion is propagated, a dust explosion always preceding the explosion of the mass of powder.

"The explosions occur on the third or fourth day of the storm.

"To test the theory, he made four predictions in 1882 and 1883, and in each case an explosion of considerable magnitude occurred. To guard against these accidents, he suggests the use of steam jets, such as have been so successfully applied in cotton and flour mills, and in coal mines.

"As explosions during thunderstorms are caused by the return

shock, it should be a fundamental precaution that all good conductors of electricity be prohibited from entering any building where explosives are stored or manufactured; and it would be a wholesome rule not to allow such conductors to be anywhere near the premises."