

- be covered and held together with a green silk braid.
4. The strap will be of nickel-plated steel, covered with a thin coating of black hard rubber.
 5. Each receiver will be fitted with pneumatic ear cushions of approved type.
 6. Weight of set not to exceed 15 ounces.
 7. Each set will be supplied with one extra cord complete.
 8. Each telephone will be tested for receiving qualities and must give results equal to standard sample.

ELEVEN YEARS OF AUTOMOBILE DEVELOPMENT.

BARON DE ZUYLAN DE NYEVELT, having been requested by the Echo of Paris to summarize the progress that has been made by the automobile since he has presided over the destinies of the Automobile Club of France, has sent to that journal the following very interesting article:

"I had scarcely left the university in 1879 when my first business was to visit the establishments of mechanical construction where I made known my plans of driving carriages mechanically to the engineers commissioned to receive me. It is useless to add that these scientists looked upon me askance and answered that my idea was ridiculous and impracticable.

"Despite these disinterested opinions I employed the greatest part of my time and income in having different types of carriages constructed, some of which, I must confess, ran worse than the others. The last in date was constructed in 1893. It was provided with a gasoline motor, but could never make more than five kilometers (3.1 miles) an hour.

"I had reached this point in my experiments, when, in July, 1894, being in London, I read in the Petit Journal that at the initiative of MM. Marinoni and Pierre Giffard, a great competition of mechanical carriages was to take place between Paris and Rouen.

"I took the first train and reached Paris just in time to see the automobiles get under way.

"I organized four relays of carriages drawn by trotters so that I reached Nantes long before the first automobile. I afterward took the train and reached Rouen to witness the entrance at full speed of the steam brake driven by M. Bouton, and carrying, if I remember rightly, M. de Dion and Capt. de Place. I then proceeded to the Hotel d'Angleterre, where the rendezvous took place, and, approaching Count de Dion, I congratulated him upon his success and said to him: 'My dear friend, we must really organize a great automobile race and offer some very important prizes in connection therewith. If you are willing to open a subscription list you can write my name at the head of it for any amount you desire.' 'Very good,' said the count, 'but I had conceived the same idea as you, and this very morning Mr. James Gordon Bennett desired me to write his name under the same conditions.'

"We afterward exchanged ideas as to what such a race should be (the most arduous one that had ever been organized, 744 miles without stop either day or night). A committee was formed, at the head of which were placed Mr. Bennett, Count de Dion, Marquis and Count Chasseloup-Laubat, Georges Berger, and MM. Depres, Menier, Marinoni, Empair, Giffard, Meyan, Recope, de la Valette, Varennes, Vanderbilt, etc., and the manufacturers Levassor, Peugeot, Jeantaud, Bollée, etc. The Paris-Bordeaux race took place June 11, 1895, and was won by Levassor, who never left his carriage for forty-eight hours. The enthusiasm was indescribable; Levassor was carried in triumph. We had succeeded in rousing the public from the lethargy in which it had been slumbering for ages, and a bond had just been established between manufacturers and their future customers—the adepts of the new locomotion. The automobile industry was born.

"The fellow-feeling that had been engendered between the members of the Paris-Bordeaux committee was so warm that Count de Dion declared that to allow such forces to become scattered would be a capital crime.

"The first meeting took place at Quai d'Orsay between MM. de Dion, Paul Meyan (then editor of Figaro) and myself, in order to lay the base for the foundation of a club. A second meeting, at which MM. de Dion, Meyan, Recopé and I were present, was held at Avenue Jena for the elaboration of the by-laws. A third meeting took place in one of the rooms of the Café de Paris; and, finally, on the 12th of November, 1895, the entire Paris-Bordeaux committee was called together by Count de Dion at his Quai d'Orsay house in order to proceed to the definitive foundation of the Automobile Club of France.

"The gathering did me the honor to select me as its president. I observed to my friends that while this mark of esteem touched me deeply, it created in me a delicate feeling, for I was of Belgian nationality. Notwithstanding this, however, I was elected by acclamation. It was the wish of M. de Dion, whom I had proposed for the presidency, to accept the office of vice-president merely. I have been particular to recall these remote reminiscences because I attribute to the accident of my meeting Count de Dion at Rouen on the 22d of July, 1894, a preponderant influence on the future of the new locomotion. It was, in fact, dating from this moment that the automobile industry finally made its exit from the exclusive domain of inventors in order to enter the triumphal path on which our successive manifestations have placed it.

"I may remark, moreover, that it was the programme elaborated in July, 1894, that has been followed step by step during the past eleven years. I cannot finish this article without offering an homage

of gratitude and admiration to the early laborers who so greatly contributed to the triumph of our ideas. I cannot name them all here, for want of space, but I must at least mention those of Count Gaston Chasseloup-Laubat, Levassor and Forestier, whose memory will ever remain green in our hearts.

"Constant mention is made of the 500,000 persons in France living directly or indirectly on the automobile industry, and of our exports to the amount of a hundred million francs; but I am persuaded that such prosperity is nothing as compared with what the future has in store for us.

"It is merely necessary to glance at our streets, highways, and boulevards and to contemplate the thousands of horses still traversing them to see that if all do not disappear in one day, the most unfortunate at least will soon cease to sadden us by the sorry spectacle of their slow agony. The automobile industry is to-day a classified one, more prosperous than many others because it responds to more pressing needs. It is therefore the moment for the founders of the Automobile Club to contrive to advance to the front and to persevere in the contest that they have undertaken against prejudices and routine.

"What a fine programme still remains for them to carry out! How much progress has not been obtained, solely because the indifference of men has not constrained the genius of inventors to occupy itself therewith!

"By the same processes that we have employed for the last ten years I should like to see a development of the following ideas, which are to the highest degree worthy of attracting the attention of men who are young enough, rich enough, and intelligent enough to hasten the realization thereof.

"(1) Aerial navigation by flying machines.

"(2) Very rapid maritime navigation by means of turbine, electric, and gasoline motors.

"(3) The carriage of travelers at great speed by subterranean tubes and by aerial electric tracks (say a minimum speed of 125 miles an hour).

"(4) The creation, by automobile societies and syndicates, of special roads permitting of the use of very swift carriages. A like demand has been submitted to the House of Commons for the creation of a road between London and Brighton. A project is also on foot for a road between Biarritz and Arcachon."

OUR COAL.*

By F. Z. SCHELLENBERG.

THE United States has produced 6,000 million tons of coal, and the annual rate now is 400 millions, against 200 millions in 1897 and 100 millions in 1882.

Besides our annual production of 80 million tons of Pennsylvania anthracite, we get 200 million tons of bituminous coal from Pennsylvania and the adjoining States of Ohio, West Virginia, and Maryland; the sixth part of which 200 millions is made—in Pennsylvania and West Virginia—into coke, being fully 25 per cent of the country's production of coke. Alabama, Virginia, and Colorado make another 15 per cent.

The annual production of coke has quadrupled in the last twenty-five years and is now about 33 million tons. Nine-tenths of all is yet made in bee-hive ovens. Coke is mainly used for smelting iron ore, in a total production for the United States of 23 million tons of pig iron last year.

Around the heads of the Ohio River cluster the grosser manufactures dependent primarily on cheap fuel. Of the 35 million tons of coal mined in the Pittsburgh district the one-half is consumed there, a combination of freight tonnage and surplusage unequaled in all the world.

The coal from the mines of Western Pennsylvania and adjacent is all of the flaming soft coal or bituminous varieties of the market; whether it has come from the Pittsburgh seam, or from the Freeport seam which lies nearly 600 feet lower in the series of rock measures, or from the Kittanning seam 175 still lower, or from the less broadly prevalent prolific seams occurring between or above and below the three named.

The newer of these seams give a decidedly reddish brown streak in rubbing lumps together, while anthracite is really black. We are reminded that full burned charcoal is really black and burns without smoke or flame, but that for some gunpowder-making there has been used a less charred wood coal, the more inflammable *charbon rouge*.

Unlike the anthracite beds with their hardest conchoidal fracturing stone coal in those most uptilted, we have the softer coal of the seams at the east, in the more inclined positions; but like the anthracite the percentage of fixed carbon reduces—from 75 to 50—with flatter lay as we come northwest from the mountains across our carboniferous table land. As was the composition affected to lessen the fixed carbon and have increased proportion in volatile matter, so was the texture, by the crowding movement from the southeast that had been mountain-making farther back east and gradually weakened northwestward.

At the west we have the lumps breaking from the coal vein rather according to the bedding joints, in long flat pieces.

But about Pittsburgh we have a preferred raw fuel, the gas coal, in large firm sharp-edged cuboids, as selected lumps after careful mining separating out the well-defined slate bands of the vein.

Then, at the east in the coke region proper, we find the same vein, thicker and softer or more tender, easily dug promiscuously to slack or frail lumps of crumbly small cubes, and thus hardly separable as pure coal

from the intermingled earthy matter which is scarcely segregated there into plate slates—the coal seam there being vertically fissured through closely and made columnar in grain.

All the differences noted as in geographical sequence agree as consequences of the later side pressure change westward over the whole body of rock strata, originally deposited flat, warping it into basins, etc., with decreasing rate of the dips and the cleavages less near together.

We have here the cleavage direction in parallels ranging 65 deg. to left of the meridian (as the line of smooth faces or "bord" in the coal veins) across the basins; and the normal, 25 deg. to right of meridian, is the easiest for quarrying or mining out product (called in the mine "on the face of the coal") which direction, with the other along the cleavage "on the butt" of the coal, makes a rectangular system of development by entries in the coal seam.

But the gradients in such straight mine drifts cannot be regular, for "the strike" or level line in the stratum is affected by the pitch of the basin on the trend of its trough axis (the synclinal), extendedly showing more at the surface by the anticlinal crests between basins being on broken lines and undulating in elevation with a general rise northeastward of 20 feet to the mile; in less complication, but adding to the variations in position, the stratigraphic cross-section northwestward shows a profile of reduced waves and declining as to its surface line from the erosions, until the covering glacial drift is met.

In a flat coal mine, besides such rectangular system of face entries (on the face) and butt or cross entries there are apt to be other diagonal drifts, perhaps nearer the conforming contours, for drainage or transport favored by gravity, or as long straight avenues graded in refinement from the natural drift elevations.

The charting of the mine workings required every six months to show, on scale not smaller than 200 feet to the inch, the open and closed spaces mined out, needs only to be on the horizontal plan. On these maps the entries are seen to be in pairs, so driven particularly to have the air current making the round by short cut-through every 40 yards. The air's turn may be extended to the face in its progress by carrying forward from the last cut-through a temporary partition, in the entry along the "rib" (pillar) of canvas or boards and called a "brattice"; the cut-throughs being closed successively by "stoppings" to have only the last one open for the air current thus directed.

The coal seams are found to be thicker in the trough or depressions, and thinner over the next connected hills, than the extensive normal thickness, and the contrast appears within short distances in the "swamps," the small sub-basins only likely found in the practical progress of a mining venture.

Away from here much more frequently than in our Pittsburg field do we find "pinching out" of the vein's top measures uncertainly alternating with upper extra thickening; but we have "clay veins" as dislocations from bottom to top with twisting of the measures centering about the joint filled in with indurated clay, etc.

These are not dignified as "faults" because not markedly affecting the general uniformity of size and position.

The most important, the Pittsburg coal seam, is wonderful in its persistence and the resemblance of its cross-section of measures throughout its great width, although gradually changing dimensions. It has the bands as two thin slates with a few inches of coal between, about the middle of the height of the section, under the bands it has the double bottoms, partially or wholly contributing to product; underneath is fire clay which, as often very hard from contained iron nodules, is erroneously called the bottom limestone; above the bands is the good coal; the breast and atop is a fire clay about a foot thick about here where it has to be regularly taken down in mining, is called the draw slate, and is in some localities all saved for the manufacture of refractories. Above this part of the section that makes the regular open work in the mine, is the roof coal, rarely mined for product.

The proper mining out of a seam is a kerfing or undermining along the bottom of the face or above in a softer measure of the section, or below in underclay; secondly is the shearing, a vertical kerfing at the side, or middle it may be in wide face; both preparatory to blasting with light shots, instead as formerly the taking down by wedge and light pick and as might be the taking up of bottom with heavy hand pick; all with the purpose of securing lump coal as a specialty.

Blasting from the solid face is reprehensible. Especially so where the heavy shots flaming and in volleys are directly dangerous, and where in hard coal with narrow room pillars these are shattered perforce. The difference in the manner, in the extra labor and less powder of real preparatory mining, is to have a "loose end" or loose bottom, or both, made by the kerfs extending back 4 to 6 feet, with the care to have the two or three shot holes across the face not deeper.

Power machines have largely superseded the hand pick for making the under cutting, and with them is the tendency to rob the pillars (even to thinness, allowing them to go to waste) in widening the advancing room face instead of leaving the pillars full width intact for complete withdrawal (by some hand work) in the retreat which should be a recovery of all the coal left as support along the advance, but should also in systematic detail of procedure be for a controlled settlement of the roof strata. And further, as entry driving is work paid for on the tonnage basis wholly, or partly only on lineal yardage, the entries are made too wide—more than the 8½ feet width ample for

*Engineers' Society of Western Pennsylvania.

track, etc., and the roof is made unstable, hardly to be corrected by a row of posts objectionable anyhow, and giving space presently to be occupied by dirt under its general definition of matter in the wrong place. Trouble is entailed to add to the coming "squeeze" when in automatic settlement of the overburden in wide room areas left half open, the stresses are shared around to be magnified, and involve even some near solid coal areas in strain prohibiting future mining there; the integrity of the whole upper stratification being widely impaired.

In the interior of our mines, as not very deep, the temperature is constant at about the average of the year at the surface, here 57 deg. F. Small outcrop mines have natural ventilation as upcast at higher openings in the winter and downcast there in the summer, or baffling between day and night, at the two seasons of the year when the outside temperature is the same about as the inside.

Artificial ventilation, generally now compulsory, has become scientific. It is by furnace, giving a heated motive air column, or exhaust power fan, to draw out the laden vapors or by blowing power fan to force in air, at one or two inches water-gage pressure difference, and thus having circulating air currents, directed and so "split" inside, between cared-for openings outside opposite, as intake (downcast) and return (up-cast).

Coal mines where explosive gas has been detected are classed as gaseous mines, and a reading of the Bituminous Mining Laws of Pennsylvania, providing for the lives, health, safety, and welfare of persons employed therein, is interesting as to this class of mines distinctively.

Natural gas found in the coal seam itself has come from the part extending below water level to exude in the mines palpably at the advance faces on the solid ahead of ventilating excessive air current, or it may come in from higher carbonaceous strata broken into by fall of roof, or be tapped in abandoned gas and oil borings which reach deep, here 2,000 feet below the Pittsburgh coal seam, to coarse—but tightly covered—strata, holding as reservoirs those fluid hydrocarbons.

In the mines the gas from fresh broken coal face diffusing into the atmosphere can generally be lighted at its source quietly in the presence of excess of air; and as firedamp, the admixture of the gas with air, is as low as 2 per cent, detectable by its elongation of the flame in safety lamp held up, in test of the accumulation at the roof. In imperfect ventilation with gas exceeding 20 per cent the lamp goes out. The explosive range is in mixtures of one gas to five air and one gas to fifteen air; the mean of 1 volume of pure gas to 9.6 volumes of pure air is the most explosive.

We have this gas heating our houses, and seek to have that mean of dilution giving a blue flame, from perforations in burner box supplied by gas jet surrounded by air mixer; the distribution in street pipe system being finally at $\frac{1}{4}$ to $\frac{1}{2}$ pound pressure per square inch, as reduced from high pressure—even of hundreds of pounds—in the main conveying pipe lines.

Natural gas as nearly light carbureted hydrogen (CH_4 , specific gravity 0.56) has half the gravity of air.

Black damp of the mines is carbonic acid gas, nearly carbon dioxide (CO_2), and has one and one-half times the gravity of air. It is in all the atmosphere of the earth at 3 parts to the 10,000 of air, equal to 0.03 per cent.

Alex. Silverman ("Proceedings of the Engineers' Society of Western Pennsylvania," December, 1903) found the air in Allegheny schools about May 1, 1902, to contain 0.04 to 0.20 per cent carbon dioxide. And it is declared ("Treatise on Ventilation and Heating," B. F. Sturtevant Company, Boston, Mass.) that assuming the external air to contain 0.04 per cent dioxide, the dilution by the supply of 100 cubic feet of fresh air per minute to each person in inclosed space will keep the vitiation to the tolerable content of 0.05 per cent of dioxide; there being an accepted production of 0.6 cubic foot of dioxide per hour by an adult at rest, the calculation for the increment of 1 part in 10,000 is 0.6 divided by 0.0001 equal 6,000 cubic feet per hour. It is stated that only $4\frac{1}{2}$ cubic feet of fresh air per minute are required if the 400 parts dioxide in 10,000 parts in spent air of the lungs be immediately removed without contaminating the atmosphere.

Having in mind that the diffusion of gases is inversely rapid as their specific gravities, we see that black damp is less easily removed than firedamp; it lies in low areas of half-open abandoned places (where, too, firedamp may lurk) it is a product of all slow but complete combustion of organic or mineral carbon decay, and animal respiration; and rapid, of fire.

As regards humidity, the healthful limit in air of the mines would be $1\frac{1}{2}$ per cent; for a pound of saturated air at 32 deg. F. contains 25 grains of water vapor and at 60 deg. F. 100 grains.

White damp is the name given to carbonic oxide (CO) and as monoxide from the addition of one atom of carbon to the dioxide, its presence signifies imperfect combustion. We get it cold from fresh coal on a grate or hot from a blown-out shot in the coal vein. It is, of course, inflammable, as being ready in its affinity for an increment of oxygen; it reaches for this with energy when heated. It is the most noxious to the animal economy, not merely suffocating like the rest but a deadly poison on inhalation.

About dust alone being explosive, there is difference of opinion; but doubtless it will, as it is heated, propagate explosion.

On explosion of gas there results nitrogen, steam, and carbonic acid as the suffocating afterdamp mix-

ture, and there is deposit of soot on the cooling with that quick expansion showing for only limited dusty spaces being involved.

The suffix "damp" in firedamp, black damp or choke damp, white damp, and afterdamp is in origin the same as *dampf*, the German word for steam or vapor.

A gas explosion in the mine from accumulation meeting the air and fire, or in the street from a leaking pipe, is a double one; the vacuum created behind induces a quick flow from the source and indraft from the atmosphere for a second weaker detonation than was the prime one which had come after filling a space and pushing to air current.

The mining law requires the circulation of 150 cubic feet of air per man per minute and as much more as will dilute, render harmless, and carry off the noxious gases generated in the mine.

Variations of the barometer indicate changes of the atmosphere's weight constantly; the extremes of pressure differ here during every year by 100 pounds per square foot on all open surfaces. High barometer may mean a penning in of the gases in the strata, and then lowering barometer their quick release at open faces.

Locked safety lamps only are used for mining in the presence of gas, as for making the initial air-ways through the solid to conduct the ventilation in circulation from intake to return air-ways. And these lamps are necessary when the roof is to be broken; as it should be under control for proper settlement in retreat work at the beginning of drawing room pillars, because the subsidence of the roof strata may bring down some gas; and the lamps are necessary, precautionary, where gobbled old places are to be broken into.

There are mines in which locked safety lamps are exclusively used, by order of the remoter management of the business or periodic inspector, in warding off responsibility, rather than by the competent officer in charge of the work. The Wolf safety lamp, made in Germany, burning naphtha with somekeless light, and openable only in presence of a large magnet, is preferred for such general use.

But the common worker in the coal mines ought not to find gas to hurt him if his place and the whole panel of workings is properly inspected daily and ventilated, and he ought to carry the center of his sphere of illumination on his cap to guard him up, down, and around, in greater scope of open quantity of light than does the safety lamp lantern. (Fatal accidents inside are now from falls of roof and sides 67 per cent, from gas 9 per cent, and from explosives 4 per cent.)

The changes for greater tonnage are with more machinery in every place inside and outside, with men of the Slavonic races, and blasting powder in quantity experimentally flameless, and not yet everywhere resulting in safe economic extraction of the coal seams, but with continued waste of the store in the ground.

Socialism, management by the State of coal mining and transportation is being continually called for, unfortunately; but some of us think that fundamental justice simply applied in taxation of land values, *only*, for the public's benefit that collectively makes these values, should lead off and would in equity do away with the need for invoking the governmental interference between capital and labor. The very existence of a community of men (society), with individual liberty in right relation to it and each other is at stake, some say. Politically, we should be wise and happy to see carried out the democratic doctrine of "equal rights to all, special privileges to none," and maintain free discussion with social order.

The fatalities in the bituminous mines of Pennsylvania were last year 444 killed inside and 35 outside; that is, one life was lost out of every 345 employed, or as the comparative statistics for the years have it, 2.90 lives per 1,000 employed, or one life for every 249,000 tons of coal produced. The total for the year was 119,361,514 tons of bituminous coal. This country throughout has had an increasingly bad record as compared with others in accidents in mines, etc. But Pennsylvania last year showed some improvement.

For the year 1905 the list is:

Killed from falls of coal.....	52
Slate and roof.....	246
Mine cars.....	57
Machinery	9
Explosion of gas.....	29
Explosion of dynamite and powder.....	7
Explosion of blasts	9
Suffocation by gas.....	10
Falling into shafts.....	5
Miscellaneous	20
	—
	444
Outside	35
	—
Total killed	479

Of all, gas accidents are 8 per cent; from falls, percentage has increased in thirty years, 40 to 62. Last year's electricity column is vacant.

The marketing of our bituminous coal is generally in the four grades straight or variously mixed together: The *lump*, run over screen of $1\frac{1}{4}$ -inch spaces between parallel bars; the *nut*, through, then run over $\frac{3}{4}$ -inch straight spaces, or bumped over such less inclined shaking screen, or through holes in revolving screen; the *slack*, that falls through both; and the *run of mine* of the three unseparated, but mostly misnamed so hereabout as the first screening is required with stop

to weigh the lump for the miner's pay and then one or both the screenings, on their way in the chutes, may be brought in and the grades together loaded into the railroad cars under the tippie; or the grades can be directly separately loaded according to the demand of the market. Here, screened coal apportioned about 66 per cent lump, 14 nut, and 20 slack. The solid coal weighs about 80 pounds per cubic foot.

The comparison of freedom from large and small size impurities of the coal vein, as differences in the grades depends upon the manner and means of mining. Heavy blasting from the solid face in the mine, that is, without preparatory mining, among other results bad, generally prevents the selection which is feasible inside (owing to the great regularity of the measures of a vein) with discriminative pick mining or partly machine undermining (all that the power machine can do) and partly hand pick work, as preparatory to lighter blasting and selective loading of the product into the mine cars—unlike this the anthracite is cleaned of slate outside the mine, after the breaking between power rolls; the slate being picked out before and after the various screenings over spaced bars and through square-meshed revolving cylinders, to have a numerous series of clean uniform sizes kept separate.

Among the impurities the sulphur seen everywhere, as brassy iron pyrites (Fe S_2) incrusting the "clean coal" is of less import there than it is generally in the "binder" slates it makes heavy. There occur sulphates of lime and of alumina as curiosities. Organic sulphur, as compounded with carbon and hydrogen, is not in evidence except by analysis, adding to the percentage of sulphur, nor does it clinker the ashes separating as the waste in fires. Sulphur as a fuel has about one-fourth the value of carbon.

In the present coke regions separation of the earthy matter, the slates, is scarcely required, and what is wanted in the ovens is the smallest lumps to favor the charring to homogeneous coke; the vein readily yields a friable product to pick or powder.

In the coke region in contradistinction to the gas coal region, the working of mine rooms is narrow (of 4 yards width, with one row of props, against the 7 to 10 yards in the hard coal) and the retreat is of wide room pillars (even exceeding 20 yards) taken, drawn out, totally obtained as product—together with the "heading" (entry) pillars from the inner end of a section of the mine in diagonal line running between face and butt in range of the faces working, for systematic exhaustion and closing in, with purposed subsidence of the roof and relief therefore from "squeeze" as extended pressure hanging over, or "creep" as raising of the entry footing and tracks from displaced soft clay forced into the open from under the weighted pillars alongside, by live roof.

The burning of bituminous coal we all understand is not necessarily a smoke nuisance. At replenishing of the fire the heavy hydrocarbons dislodged at the start give out brown tarry vapors and then as they split up, water vapor and burned gas; but with the great absorption of the heat this vapor is in the vesicular form of steam and blackened by particles of condensed carbon; and the cloud of smoke coming only for a minute, and it may be only once in fifteen, unfurls to stain the environs. After our Prof. Trinks the case may be stated thus: Ample supply of pre-heated air above the fire of the boiler furnace to burn the carbon as well as the hydrogen at the time of stoking, is the preventive. That supply automatically issuing from pipes placed for the purpose, at the proper time, prevents also the non-conducting soot deposit on the shell, and there is a raising of heat effect from 72 per cent to 82 as the fuel's total yield to the boiler. The theoretically perfect, even dosing of sized coal upon the shaking grate of the mechanical stoker may, at a vacancy letting extra cooling air leak through and preventing combination of all the carbon with oxygen, in defective working, show small but steady smoking at the stacks' top in amount aggregating to that of the other intermitted but imposing smoke cloud so very patent. The waste gases allowed to escape by forced or chimney draft should carry 13 per cent carbonic acid and be at 290 deg. F., the temperature of the steam boiler.

Of especial local interest it is that we have here above the river level, the geologic horizon of the Crinoidal Limestone, midway between the Pittsburgh coal above and the Freeport coal below, marking by the fossil remains the ending of the marine old life and the beginning of the fresh-water deposits and organisms. Another change in the plant remains is seen when the rocks 700 feet higher are reached atop the Waynesburg coal seam—of which, however, only a remnant is left in Allegheny County, in Bethel Township—where we first meet in going upward in the series of these sedimentary groups of limestone, fire-clay, coal, shale, and sandstone, a modern flora—higher than the ferns, of which 600 species had become extinct in these Paleozoic formations below, which are so defined at their top, and from which their extent of thickness is a mile or two down vertically through Carboniferous, Devonian, and Silurian formation strata.

We are here at the surface as our ground, on the eroded terraces of the Lower Barren division and of the Upper Productive, of the Carboniferous formation.

We believe now that the old ranker vegetation had little directly to do with giving us the store of fossil fuel, the coal beds; but that like the formation of the peat bogs continuing in our day, lowly mosses an inch or two high in quiet growth at the spot, made these coal measures of even thickness so extensive.