tilled a larger or smaller proportion of the subsequent distillate, so as to have either a larger quantity of somewhat higher boiling point, or a smaller quantity of lower boiler point. These two are called respectively 90 per cent. benzol and 50 per cent. benzol—meaning a liquid which is judged, from its boiling point, to contain 90 or 50 per cent. of pure benzol.

BENZOL.

Benzol is a hydrocarbon, of which the formula is C_6H_6 , and it is associated with other substances—namely, toluol, xylol, cumol, and cymol—substances which are homologous with benzol. These substances form a series proceeding in arithmetical progression by a difference of one atom of the carbon and two atoms of hydrogen, the first having the formula C_6H_6 , the next C_7H_8 , the next C_8H_{10} , and so on. They are all mixed together in the naphtha, and they are, to some extent, separated from one another, in the fractional distillation, by the tar distiller. The purest benzol which is ever collected by the manufacturer contains some admixture of the other substances; but I have been lent, by Mr. John Williams, some samples of these different substances in a pure condition. Here are benzol, toluol, and xylol. Their appearance is absolutely similar; all are mobile, colorless liquids; but we should find if we were to place them in a flask with a thermometer, and heat them until they distilled freely, and observed the temperature, it would be in the three cases, 84° , 114° , 126° .

The actual distillates collected at the tar distillery consist of mixtures of these substances boiling at temperatures which differ according as the hydrocarbons of lower or higher boiling point predominate. I have here some samples of the commercial products, which I obtained to-day, through the kindness of Messrs. Blott from their distillery.

The sample next in volatility to benzol is called "solvent naphtha," the purpose for which it is employed being to dissolve india-rubber.

After a time, as the temperature rises, the liquid which comes over is found to be of too high a specific gravity, and unfitted for this purpose, it is called "burning naphtha," and is sold for burning in such lamps as are used sometimes to light stalls in the open air.

CREOSOTE.

The second product of the original distillation—namely, "creosote"—is a pasty mass, which, on standing, divides itself, to some extent, into an oil and a solid, the solid being naphthalene. The chief use of this substance is for pickling timber; especially, I believe, railway sleepers. The pieces of wood are placed in cylinders from which air is exhausted, and then this substance is let in upon them, and forced into their pores by the atmospheric pressure. The wood is thus rendered more capable of resisting exposure to moisture and the attacks of insects than it otherwise would be.

Some portion of the oil which drains from the semi-solid mass is also used for making lamp-black. It burns with a very luminous, fuliginous flame, and the soot which is formed is collected and called lamp-black.

ANTHRACENE OIL.

The third product is "anthracene oil." This divides itself into a liquid and a solid. It is poured upon frames, carrying a filtering material, and the oil runs through, while the solid remains upon the filter, and is afterwards transferred to bags, where it is allowed to drain, and is then more completely dried and freed from the adhering oil by pressure.

Here are the three substances: the anthracene oil, which has a solid layer now settling, the "green oil"—so called from its color—which is used for making grease, and thirdly anthracene.

I have here a pure specimen of the naphthalene, which is the solid substance accompanying the creosote; and also one of anthracene and of carbolic acid.

PITCH COKE.

Besides the three distillates, the tar which is distilled leaves this solid substance called "pitch," which, also, is applied to various purposes, the principal, I believe, now being that of making artificial fuel. It is mixed with breeze, and the pitch serves as a sort of cement to compact together other combustible substances, the whole forming a serviceable fuel. It is also used for making artificial asphalt, and in preparing a kind of felt.

It has also been supposed that by further distillation of this substance a further quantity of the valuable anthracene might be obtained; but I understand that although the substance yielded by the destructive distillation of pitch greatly resembles anthracene, there is found to be some difference between them, which renders it not serviceable as anthracene is. The solid residue of the distillation of pitch is that which I have here—pitch coke—a very pure form of carbon, being almost free from ash, since it is formed by the destructive distillation of a substance which itself has been gaseous.

I have only a few words to add about the substances which are formed from these; but it is the less necessary to go at length into that part of the subject, though it is very interesting and important, because some seven or eight years ago it formed the subject of a course of lectures given here by Mr. Perkin, who is the principal among those who have developed this important and beautiful industry.

HOW ANILINE IS PRODUCED.

One substance directly produced by the destructive distillation of coal is "aniline;" but this is not produced in large quantity; and is not easily isolated. It was found, first, that from benzol, a substance of some use in perfumery, it may be obtained by the action of nitric acid, the product being called nitro-benzol; and it was also found that by the reduction of this substance—that is to say, the replacement of its oxygen by hydrogen—it was converted into aniline. This reduction was first effected by the action of sulphide of ammonium; but it was afterwards discovered that it was effected equally well, and more economically, by the action of acetic acid and iron. So that, though coal and coal tar are the great sources of aniline, it is not obtained directly from them, although it exists there, but indirectly from the benzol, the benzol being first transformed by the action of a mixture of sulphuric and nitric acid into nitro-benzol, and then the nitro-benzol being further transformed by the action of reducing agents into aniline.

MAUVE.

The first great discovery was that, by the action of oxidizing substances upon aniline, it was transformed into a black powder which was serviceable as a dye. By the action of sulphuric acid and bichromate of potash, aniline was transformed into a substance to which the name of "mauve" was given. Subsequently, in the hands of Mr. Perkin and others, this production of coloring matters from aniline received a

very great development, and the consequence was the production of a number of beautiful pigments which are familiar to all of us, and of which I have here some specimens which Mr. Perkin has given me. There is, I think, no more striking or more beautiful result of the application of chemistry than that it should be possible, from such a substance as coal tar, to obtain substances, at the very opposite end of the scale of mineral being, like these beautiful colored products.

ANTHRACENE.

There is one other point only which I would name. From the anthracene oil anthracene is obtained; and from anthracene, by a series of processes which it would take me too far to go into, a substance which has long been used and known—viz., "alizarin." The investigation of madder, some 40 years ago, showed that the coloring matter consisted principally of alizarin and purpurin, of which alizarin was the more important. Then followed the great discovery that by a succession of operations upon anthracene, it can be transformed into the same substance which is the coloring matter of the madder root; so that now actually the use of madder as a dye stuff is, I believe, almost disappearing: its place being taken by what can be produced to greater advantage economically—namely, the very same material produced from coal tar.

This is really the crowning triumph—at least, it is difficult to suppose it can ever be surpassed—viz., the application of chemistry to the arts; and with this I conclude the present lecture.

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COAL MINING AT STEUBENVILLE, OHIO.

By ANDREW ROY.

THE plan of laying out the workings which prevails at the Steubenville mines is modeled after the practice followed in the collieries in the north of England. The pillars left in the English mines are larger and stronger than those in Steubenville, because the pits are so much deeper in the old country, some of these reaching 1,800 to 2,500 feet of perpendicular depth. In Steubenville the rooms are eighteen feet wide, the walls or cross-cuts twelve feet wide, the pillars twenty-four feet in thickness and seventy-two feet in length. The walls and rooms cross each other like latitude and longitude lines; the walls being driven on the butts, and the rooms on the face of the coal. The main entries are ten feet wide. The miners get seventy-five cents per yard, besides the tonnage price for driving entry, but nothing is allowed for wall driving.

The mine cars hold twelve and one-half bushels, and are pushed out from the room faces to the stations on the hauling roads by putters or pushers. In Boreland's shaft, Shetland ponies are used instead of putters. These ponies are only three feet two inches to three feet six inches high. This mine has seven of these hardy and useful animals underground. In the galleries and hauling roads, a foot or more of the fireclay floor is taken up to make height for the hauling mules. These roads are made five feet two inches high above the rail, and the track is laid with "T" iron. The coal hewers dig and load the coal, the deputies laying track and setting props in the rooms. Every digger works by candle light, instead of the ordinary miner's lamp. The candles are made very small, there being twenty to the pound; they are fastened to the pillar side with a piece of soft clay. Three to three and a half of these candles are consumed per day by each miner. These candles give less light than the miner's lamp, but they make no smoke, and miners who are in the habit of using them prefer them to the lamp. The deputies and drivers, however, use lamps.

In mining the coal, powder is used to knock it down, each digger firing three shots per day on an average; two in the top and one in the bottom coal. The workmen fire at all hours of the day, but a few inches of powder suffices for a "shot," and not more than three pounds of powder per man per week is needed for blasting purposes. No blasting is done in the solid coal; a shot is undercut to the depth of four feet if the miner is a skillful workman, the undercutting being made ten feet from the coal floor.

The mine mules are kept day and night underground; the stables being hewn out of the solid coal pillars at the bottom of the pit, and are dry, well aired, and comfortable. The mules are fed at four o'clock in the morning by the fire-viewers. Work commences at six o'clock, an hour is allowed at noon for dinner, and work ceases at five in the evening.

The miners are paid every two weeks in cash, and there are no store orders forced upon them, as is done in many other districts of the State. As the Bustard, the Grand, the Stoney Hollow, the Market Street, the Rolling Mill, the Emrick and Boreland shafts are all situated in Steubenville or its immediate vicinity, the miners live in towns, and a large number of them own the houses and lots in which they live, and have in many cases other property. Fully one half of them take daily newspapers; though, it must be confessed, that here, as well as everywhere else in this Union, not a few spend much of their hard earnings in the saloons in soul-debasing pleasures.

At four o'clock in the morning, the fire-viewers, consisting of the underground manager and two or three assistants, called deputies, go down the pit with safety lamps in hand, and, until they have traversed the mine and signalled back that all is safe, no person under any circumstances is allowed to descend. The fire-viewers, on receiving orders from their chief, start out in different directions and examine the numerous chambers with the safety lamp. If gas is met in any of the rooms, it is usually driven out by the viewer, who, leaving his safety lamp back in the pure atmosphere, takes off his coat and slashes among the gas till it is all driven out and diluted among the common air. Should the gas be so copious that it cannot be discharged, the place is marked, and all persons are forbidden to enter until the air is got up and made to play on the wall face. This condition of a working place is, however, seldom met, so admirable are the ventilating arrangements of these mines. Having made the round of the mine, the deputies meet the manager at one of the stations, previously agreed upon, and report; everything being satisfactory, all return to the bottom and the signal is given to the miners to descend.

The workings of the Stoney Hollow and Market Street mines are holed through on each other, the former shaft workings being in reality an extension of the northern workings of the latter mines, both mines belonging to the Steubenville Coal Mining Company. These pits are about two thousand feet apart, Stoney Hollow being nearly due north of Market Street. The horizon of the coal in the bottom of the Stoney Hollow pit is twenty-two feet higher than in the bottom of the Market Street pit, and this raise occurs in the last seven hundred feet in approaching Stoney Hollow.

There is a continual local waving up and down in the coal floor, though the waves do not interfere with the general dip of the strata; nor does the thin seam immediately above conform to the local dips and rises of the lower and thicker bed. These two seams are sometimes together, and sometimes six and ten feet apart within the area excavated by the Market Street and Stoney Hollow workings. No true line of divergence and convergence can be traced from one mine to the other, as the upper seam, in developing, passes into the roof and is lost sight of, being shown only where the roof has fallen down in the rooms. In the shaft of Stoney Hollow, these two coals are separated by three feet of slate; in the Market Street shaft they are six feet apart.

The Rolling Mill shaft has a pair of entries sixteen hundred feet in length, driven in an eastern direction from the bottom of the shaft. They passed directly under the Ohio river, and were stopped after passing one hundred feet into West Virginia. At this point they encountered a feeder of water, and the coal itself became so soft that it was deemed prudent to stop operations.

The entries dipped all the way from the bottom of the shaft till within four hundred feet of the West Virginia side of the river, the low place or basin being twenty-two feet lower than the bottom of the shaft. From this point until they were stopped there was a gradual raise in the entries.

On the West Virginia side of the river, where these subterranean galleries end, there is a flat or bottom several hundred yards in width, where the river at some former period flowed, and as the present bed of the Ohio is at least one hundred and fifty feet higher than its ancient bed, the coal is doubtless eroded under this flat. It was fortunate for the bold mining adventurers that the ancient river bed was not immediately below the present bed, for, had this been so, the entries might have driven into it, notwithstanding the unusual care and caution exercised in passing under the river. The proprietors of the Rolling Mill shaft own five hundred acres of coal lands on the West Virginia side of the Ohio river.

Several years ago, a creep commenced in the workings of the Rolling Mill shaft. Fifty rooms in the Rolling Mill pit were involved in the creep; which then extended to Emricks, closing the main galleries of that mine for a width of four hundred feet, and overrunning the most valuable portion of the mine, being resisted only by the solid body of the coal at the room faces. The superincumbent strata, westward of these shafts, are fully five hundred feet thick, and are mainly composed of heavy beds of sandstone. The roof and floor of the mine came together by the pillars sinking into the floor, and new roads had to be cut out of the bottom at great labor and expense.

The mining properties of several of the coal companies border each other. By common consent a barrier pillar, forty feet in thickness, is left at the boundary line—twenty feet by each company. This is a wise precaution, and should be required by law at all mines in the State. Already considerable annoyance has been caused in consequence of one mining company working up to, or trespassing upon, the boundary of an adjoining company, and, eventually, serious accident from water or gas will result.

ORTHOCLASE, OR COMMON FELSPAR.

It derives its name from the fact that the crystals have two principal directions of cleavage, which form a right angle with each other. Its hardness is inferior to that of quartz, nevertheless it is greater than that of ordinary spars, since it will make scratches on glass; hard steel will touch it, but with difficulty; its specific gravity is moderate. The crystals in the granite used for the construction of the bridges, etc., referred to above, are mostly orthoclase, and in these cases it will be seen that the crystals are imbedded in a paste. To a rock of this kind the term porphyry is given; if, however, the crystals of felspar are not so very distinct from the rest, but two or three different substances are so distinctly crystallized out, the term porphyritic granite is often applied. Beautiful varieties of this porphyry may be seen in different places; thus the public buildings of Penzance, in Cornwall, are built of a beautiful material of this kind, and reference may also be made to the granite from Shap Fell, in Cumberland, which in the last five or six years has found its way into London for ornamental purposes—columns, etc.; some of the elements of its beauty and utility being its hardness, its pink color, and this porphyritic structure. In the Alps, again, and in the neighborhood of Lago Maggiore, large blocks of granite are thrown from the mountain side on to the plain below by small charges of powder, and often on examining these it will be found that in cracks and cavities the felspar, along with quartz and mica, is beautifully crystallized, sometimes on a large scale. Other notable localities are the island of Elba, and the Mourne Mountains, in Ireland. In some instances the crystals of felspar are more translucent, looking more like glass; and being found in the Alps, in the vicinity of St. Gothard, they have been named "Adularia felspar," from a mountain there known as Adula. In the Island of Ceylon this variety of clear felspar has a tendency to appear rounded, and is found when cut to present a peculiar lustre, something like mother-of-pearl, hence it is usually termed "moonstone," and is much valued for ornamental purposes. Felspar is found in other cases with a yellowish, brownish, or reddish tint, and a green variety, from Siberia, has received the special name of "Amazon stone." Some beautiful examples of this latter variety have recently been found near the line of the Pacific Railway, and the Museum owes some fine specimens to the liberality of a lady. If we look at the composition of this orthoclase, we find that it is a silicate of alumina, with a silicate of potash, one specimen giving on analysis about 65 per cent. of silica, 18 per cent. of alumina, and 14 per cent. of potash, with very small quantities of lime and soda. The presence of potash in this substance is of great interest to the agriculturist, since the soils produced by the decomposition of rocks containing orthoclase will be suited to certain plants, to the life of which potash is so important. There are cases where this kind of felspar constitutes an entire rock, as at St. Stephen's, Cornwall. Certain building stones contain another variety of orthoclase, known as "glassy felspar," and notable amongst these is the trachyte of the Rhine district, while the magnificent cathedral at Bologne may be pointed out as an example of its use.

To another specimen of felspar the name "albite" is given, in consequence of its whiteness. Crystals of this felspar occur generally on a smaller scale than orthoclase, and are almost universally twin crystals, often appearing as if the crystal had been cut in two and one half turned on the other, so as to form a re-entering angle. It is a silicate of alumina and soda, and thus differs from orthoclase in having the potash of the latter replaced by soda. The question arises whether the potash and soda from these two substances—both valuable materials—could not be economi-