SMOKE GETS IN YOUR HAIR!

By GEORGE S. BONN, '35

I NEVER knew just why they called that beautiful range of mountains between Tennessee and North Carolina the "Great Smokies," unless it was because of the bluish haze that seems to cover it. Pittsburgh has frequently been referred to as the "Smoky City," but that was before America discovered Columbus (O.). Then too, it has always been the custom for the enthusiastic "Buy-Build-and-Be-Happy-in-your-Home-Town" men to point with pride (they might also view with alarm) to the many tall, stately smoke-stacks, belching forth their clouds of industrial advertising. "You can see," they say, "how great our industries are." Incidentally, you can also feel, and smell, and breathe these same great industries, to say nothing of the private residences—especially in a university district, where we have student firemen.

Books have been written about it, societies for the prevention of cruelty to vegetation have been formed, Smoke Abatement Leagues have been started, laws have been passed, and some enforced, scientific surveys have ben made, songs have been written about it, poems, mountains, and even horses have been named after it. But, what is this great and wonderful thing, SMOKE ?

If you ask the ordinary person on the street what smoke is he will probably tell you that it's that stuff you see coming out of that chimney. If you ask a chemist he will probably say that it is a colloidal suspension, formed when something burns, or when certain chemical reactions take place. A physicist would possibly say that it is a collection of very tiny particles carried off by the hot gases formed during combustion. If you look in the New Standard Dictionary (1933) you will find that it is the volatilized products of the combustion of an organic compound, as coal, wood, etc., charged with fine particles of carbon or soot. If you include in this definition that it is the product of *incomplete* combustion, then it should satisfy everybody.

This definition very quickly disposes of the popular "smoke screen," which is in the majority of cases a chemical compound, such as titanium and silicon tetrachlorides, phosphorus oxides, or ammonium chloride. These may correctly be called "chemical smokes." Similarly, it eliminates the emissions from lead and zinc smelters or blast furnaces, which are essentially metallic vapors or metallic compounds as vapor carried off by the hot gases coming off the furnaces. These are more properly known as "fumes." Neither *fumes* nor *chemical smokes* are produced by the combustion, complete or incomplete, of any organic compound; therefore, they are not *smoke.*

How It Is Formed

In coal, for instance, there is a large percentage of volatile matter which gasifies rapidly when the coal is heated, and burns to give more heat and light. To burn properly, there must be a sufficient amount of oxygen present to unite with the volatile matter. The equation generally given for the combustion of, say methane, (CH_4) which is in ordinary natural gas, is: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. That is, the methane combines with the oxygen to form carbon dioxide and water. If there is insufficient oxygen, this will not react completely, and carbon monoxide (CO) and carbon will be formed; the carbon is the well-known lamp-black or soot formed from the old oil lamps, gas burners, or coal. The volatile matter in coal has various formulae for its composition, but the same thing happens when it burns completely—it forms carbon dioxide and water. Similarly, when the combustion is incomplete, carbon and other unburned particles go off as solids; this is the smoke we see. A similar theory of burning and smoke formation has been applied to the combustion of wood, but it is generally believed that it is the wood particles themselves which burn, rather than any gas given off when the wood is heated.

This incomplete combustion can be caused in several ways. One is by the forcing of a furnace beyond its capacity; another is by piling too much fuel on the fire, apparently so that it will last until the fireman gets back from class. This latter is the trouble around a university, at least. Both of these choke the fire, and thus prevent enough oxygen from getting to it; so, we have smoke—lots of it.

Where There Is Smoke . . . .

There will be a lot of trouble, especially if there is a lot of smoke. Besides the soot and dirt caused by careless firing, which we are told by Henry Obermeyer in his book STOP THAT SMOKE! annually amounts to "as high as 1900 tons per square mile in exceptionally smoky towns, and seldom less than 125 tons," there comes along with the smoke carbon monoxide and sulfur compounds, especially. Butiminous coal contains a little less than 2% of sulfur, so, as Mr. Obermeyer puts it, "the result of burning some 600 million tons of coal annually is the discharge into the atmosphere of about 20 million tons of sulfur dioxide, which being in gaseous form, would be more appropriately expressed as 400 billion cubic feet of sulfurous gas." He says that this amounts to a constant nation-wide drizzle of sulfuric acid of anywhere from eleven to 190 tons per square mile every year. Unfortunately, it is true that the sulfurous gases do rapidly unite with water or water vapor to form sulfuric acid, and as either the gas or the dilute acid it ruins vegetation and endangers our lives.

During the first part of December, 1930, there descended on a portion of the Meuse River valley in Belgium a very dense fog. It lasted four days. During this time there were 70 deaths and thousands of troublesome cases of poisoning. A commission appointed to investigate the affair reported that in the affected region the factories and homes poured into the air 71.2 tons of sulfur dioxide and 23.6 cubic meters of sulfuric acid, besides thousands of tons of all sorts of other gases and dusts, all in 24 hours. This normally escaped into the higher atmosphere, but because of the presence of the fog, these materials were kept within 100 meters of the ground. In four days they calculated that 100 miligrams of sulfur dioxide per cubic meter had collected; 20 to 30 mgr./cu. m. is considered injurious. Likewise, 154 mgr./cu. m. of sulfuric acid was present; only 4 mgr./cu.m. is considered injurious in this case. The deaths and illnesses were blamed on the sulfur. This condition could probably never exist again, anywhere, with wind, temperature, fog, and smoke just as it was then. But it does illustrate the fact that sulfur is harmful, even in the small doses we generally get in a city.

Another angle of this effect of smoke on living, is that it helps in the formation of fogs and rain. When the air is saturated with moisture, as it often is, and there is a sudden drop in temperature, there will condense out onto any surface present minute particles of water, which may take the form of rain, sleet, snow, or fog. The air is always full of dust particles, so there is always plenty of tiny solid matter on which the moisture may condense. Now, with all the smoke particles present, and especially the sulfurous acids, we see that conditions are more often ripe for fog. We are told that the acid activates the nuclei to a closer affinity for moisture so that condensation sets in at a higher temperature than would ordinarily be the case. Each particle tends to take up the same amount of moisture, and to remain as a tiny unit, instead of combining with other units and falling as rain or snow. All the particles are the same size, so they fall as a condensed vapor cloud, because of their weight. So we have fog, or, as some people prefer, "smog"—artificial fog caused by smoke.

Some Englishmen made studies of weather conditions over thirty-year periods, and discovered that it rained less on Sunday than on any other single day of the week ! They attributed this condition to the fact that factories are shut down on Sundays and are not producing smoke, which could form nuclei for rain drops. This might also account for the awful Mondays we often have, though, of course, for just the opposite reason.

So What ?

In the first place, it stands to reason that the large factories and power plants around the country are being as efficient as possible in burning coal in their furnaces; they can't afford to lose any of their coal up the stack, so the furnaces are controlled closely to insure complete combustion, and thus produce a minimum of smoke. However, it is practically impossible to burn bituminus coal without some smoke, particularly when the fire is being refueled. Most of the statutes prohibiting smoke recognize this fact, and allow the fireman a small amount of smoke for a few minutes out of each hour during the day. Consequently, because of the economic necessity and the legal aspect, there is comparatively little smoke coming out of most industrial stacks.

If these factory chimneys put as much smoke into the air, in proportion to the amount of coal burned, as the majority of private homes, there would be a continual solar eclipse. Most of the outraged citizenry in an industrial town might very well cast the smoke out of its own chimneys before such wailing and gnashing of teeth about the unlawful and infernal doings of the factories. Of course, the fellow next door hasn't the slightest idea how to operate a furnace—just look at his chimney ! In most cases if the righteous one looked at his own chimney more often, there would be much less zeal in minding the neighbor's furnace, and more attention paid to his own. Certain furnaces will make warm friends, but nothing is said about smoke—that is up to the fireman entirely. No household heating plant need smoke if it is operated properly, and the right kind of coal is used. It is not especially good economy to buy cheap coal and then send most of it up the chimney. It is more difficult to burn cheap soft coals without making a lot of smoke and thus losing a lot of paid-for heat, than to burn better grades of coal, such as the hard coals.

In a university district it seems that most of the people use coal that is just barely solid at all; then, most of the firing is done by students, who usually rush madly into the basement, throw another lump on the fire, and then dash off to their eight o'clocks, leaving the fire to shift for itself. This process is repeated at intervals throughout the day, but each house has its own special period, thereby insuring the maximum amount of smoke and soot for a given part of the city at almost any time in the day.

To pass laws prohibiting large amounts of smoke is all right, but to enforce those laws is another matter. The only way to reduce the smudginess of certain cities is to get the people to use hard coal or coke, if they must burn something in a furnace, or, better and cheaper still, is to get the pople to find out how to operate a furnace properly. In a university district it would be a "good thing" if the student firemen were required to take a course—and pass it—in *coal firing and furnace tending,* specializing in the use of soft coals, and emphasizing the results of both good and bad operation. The university controls the housing situation of its students, as to type and general cleanliness of rooms; it might just as easily help further by getting the landladies to employ only those students who had passed M. E. 400, or whatever the furnace tending course happened to be called. Then maybe we would have white snow again.