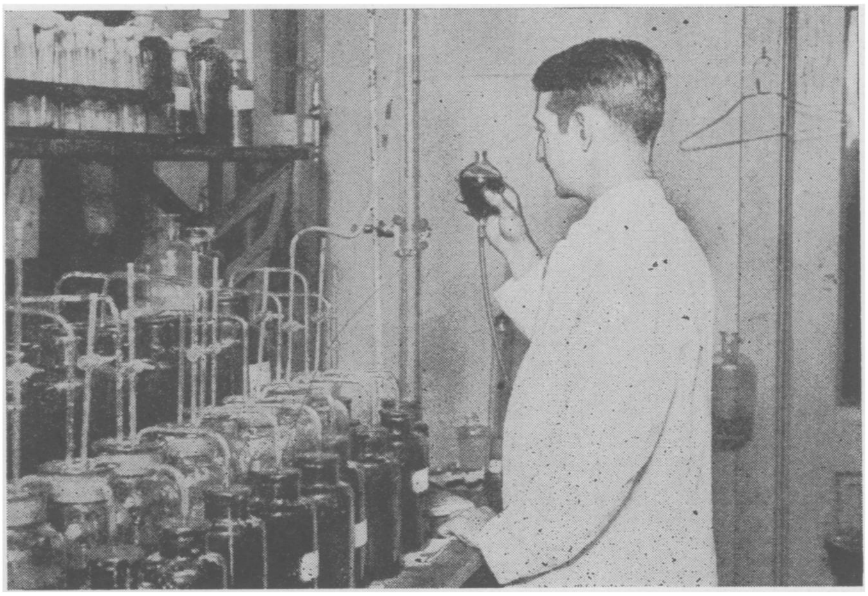
Making Gas from Cornstalks

Chemistry

By FRANK THONE

In the good old days when the gas light suddenly began to flicker we would send Johnny downstairs to put another quarter into the meter. But now John, somewhat more grown up, will probably be asked to go out behind the barn and shovel in a few more pounds of ground-up cornstalks.

For this is chemistry's newest contribution to the problem of farm relief—making gas for cooking, lighting and industrial uses from the hitherto despised cornstalk, the most conspicuous waste produced on millions of acres of midwestern and southern farm lands. At the Minneapolis meeting of the American Chemical Society a short time ago a brisk and energetic professor of chemistry from the University of Illinois, Dr. A. M. Buswell, told how he and one of his research students, C. S. Boruff, have succeeded in producing paying quantities of methane, a gas of high fuel value, from nothing more costly than cornstalks, water and sewage sludge.



C. S. BORUFF measuring the output of cornstalk gas in the laboratory at Urbana

The thin cornstalk porridge is dumped into a tight-topped tank, the digested sludge product added, and the bacteria in the sludge do the rest. They ferment the cellulose in the cornstalk pith into two gases, methane and carbon dioxide. The former is of value as a fuel and the latter has a host of industrial uses. Compressed until it becomes a liquid, it is sold to soda fountains and soft-drink factories, to become the "fizz" in pop and soda-water. Still further condensed, it becomes an extremely cold frosty-looking solid now widely used under the name of "dry ice" for refrigerating purposes.

But it is the methane that the two Illinois chemists are really after. Methane is the same stuff that is known to coal miners as firedamp. To them it is a deadly menace, for it is odorless, and without their knowing it they may run into a place where it is sufficiently concentrated to ignite and cause a disastrous explosion. Methane also occurs naturally in wet and boggy places, arising in bubbles from decaying vegetation under the water. In such places it is known as marsh gas. When it takes fire, as it frequently does, marsh gas burns with those eerie flames known for ages as the will-o'-the-wisp or *ignis fatuus*.

For many generations methane was known only as a product of nature, useless or even dangerous. But when men came to light their houses and cook their food with gas, they discovered that this same stuff was in the pipes that brought their fuel. Common illuminating gas is a complex mixture of a number of substances, and methane is one of them. If there were more methane in the gas we buy from the gas companies we might like it better, because according to Prof. Buswell's calculations a 50-50 mixture of methane and carbon dioxide gives almost as much heat as coal gas. And all the heat in the mixture comes from the methane, for carbon dioxide has no value whatever as fuel. Methane, therefore has a higher fuel value than an equivalent amount of coal gas.

The discovery that this valuable fuel can be fermented out of cornstalks has come more or less as a by-product of Prof. Buswell's work on getting gas from city sewage. Prof. Buswell's regular job is with the Illinois State Water Survey. From the work of earlier chemists he knew that disposal plants give off considerable quantities of methane, which can be used for heating and lighting. This looked promising; perhaps towns could get their gas supplies from their own wastes. But a further quantitative study showed that only enough gas for one-fifth of the population of a given community could be had by the most efficient possible handling of its entire sewage.

The difficulty lay in the amount of material available for the bacteria whose fermentative activities produce the gas. There were plenty of the "bugs", but the city waste did not give them enough stuff to work over into methane and carbon dioxide. Wasn't there some other waste lying about that could be thrown into the tank and used by the willing micro-organisms?

The most obvious waste in the middle west is cornstalks. The farmer has to raise about a dollar's worth of stalk for every dollar's worth of corn he harvests, but until recently he couldn't sell that dollar's worth of cornstalk for a cent. Aside from what he could feed his livestock as silage or rough dry fodder, he had to let the rest go as a dead loss. Stalks were of minor value as fertilizer even when they were plowed under.

Of recent years a number of researchers have been seeking possible industrial uses for cornstalks, and a few promising outlets for the product have been developed. Prof. O. E. Sweeny at the Iowa State College at Ames has made a good grade of wall-board out of the stalk fiber, as well as a substitute for the ground cork used in insulating refrigerators. At Danville, Ill., a few miles from Prof. Buswell's laboratory at Urbana, the first factory in America for the production of paper pulp from cornstalks has been (*Turn to next page*)

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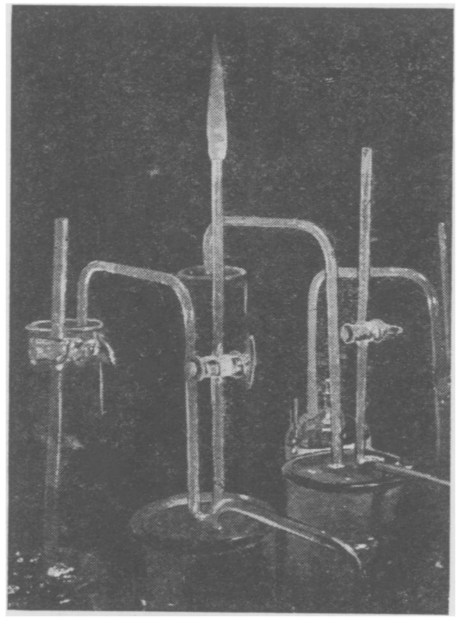
built and is now operating. But even when these industries have reached their fullest development they will account for only a small fraction of the total cornstalk production of the middle west. There will still be cornstalks to burn.

Prof. Buswell decided to see whether they couldn't be burned, at a profit. For chemical science has become very much Yankee-minded during the past generation or two, and likes to look for eventual dollars and cents at the bottom of its test tubes.

There was no good chemical reason why bacteria should not make good fuel gas out of cornstalks as well as out of sewage. Cornstalks are made pretty largely out of cellulose, which is a complex chemical arrangement of carbon, hydrogen and oxygen. For methane one needs only carbon and hydrogen; the oxygen is gratuitous, really in the way, something to be got rid of. The bacteria of decay that live in sludge are able to split cellulose apart in such a way that half of the carbon hooks up with all of the hydrogen to form the methane, and the other half takes on all of the oxygen to form the carbon dioxide. The second half of the carbon in the cellulose therefore becomes simply a sort of chemical dump-wagon to cart off the troublesome oxygen.

So much for the chemical theory with which Prof. Buswell started. Like all theories, it had to be tested. The apparatus which he and his assistant Mr. Boruff rigged up in their laboratory does not look much like the gleaming and mysterious arrays of glass traditionally supposed to be the equipment of chemists. On the contrary, it looks very decidedly "haywire". A row of wide-mouthed brown bottles, hooked up to a second row of bottles with glass tubing through their stoppers, a few glass stopcocks to let out the gas when you want a sample—that is about all there is to it. Inside the brown bottles a mess of ground-up cornstalk soaking in water, with bubbles rising to the top every now and then.

Those unexciting-looking bubbles are really the exciting part of the whole business. They are the products of the breathing of the bacteria, and they are made partly of the same carbon dioxide that we ourselves let go of when we breathe, but partly also of that very useful fuel gas, methane. Certain kinds of bacteria have the ability to breathe without



A FLAME of cornstalk gas

free air. They get their oxygen by breaking down compounds in which it is combined. In the present case, they get it from its prison in cellulose. But such bacteria can combine oxygen with other chemical elements only so far as the oxygen goes; and if there are any other elements left over after such airless breathing they have to be let go "as is" or turned into other compounds which do not contain any oxygen. In the present instance the bacteria combine the oxygen in the cornstalk cellulose with the carbon as far as it lasts, and then take the leftover carbon and combine it with hydrogen before letting it go. That is why we get methane as part of the product. If there were enough oxygen to go around all we would get would be more carbon dioxide, plus water. The success of the work depends on keeping the bacteria without an air supply.

The bacteria ask wages for this work, but after all they are very low wages. The heating value of the gas produced is six and two-thirds per cent less than the amount theoretically possible from the cellulose. The bacteria take that much for their work, as old-time millers used to exact as toll a certain fraction of the grain they ground.

Cellulose is the daily bread of these bacteria. In addition, they also demand their daily meat. They must have something containing nitrogen, which is not present in cellulose. Nitrogen might be given them in the form of various nitrate salts, or as ammonia, or in a number of other chemical products. But a much cheaper source can be found in the various disagreeable stuffs we lump together under the malodorous name of sewage. This is rich in nitrogen, and the bacteria, having no noses and no imaginations, take to it like so many pigs. Prof. Buswell suggests that when his method of gas-making is once established in small, one-farm plants all the waste products of both cornfield and house can go into the same tank, to emerge after fermentation as good clean cooking gas.

After Prof. Buswell and Mr. Boruff had settled to their satisfaction that methane could be generated from cornstalks in their array of glass bottles, they proceeded to work on a slightly larger scale. They had a small sheet-metal tank made, modeled on the ones which Prof. Buswell had already been using successfully in his sanitary work. But it was still of laboratory size; a couple of feet high, suitable for operation on a chemist's workbench. They called it the "iron stomach". As it stands in the laboratory at Urbana there is something of the "haywire" flavor about it also, for they haven't taken the trouble to get it nicely nickel-plated or enameled; and the collecting tank consists of a wooden keg with a big glass bell-jar inside, perched on an old packing-box. But this "iron stomach" digests cornstalks and produces methane, and that's the essential thing.

Now there is a larger "iron stomach", in a rough wooden shed a little distance away from the university campus. This one is on a real gas-making scale; it should turn out enough methane to keep the average family gas stove burning. It is eight feet in diameter and about ten feet high, though half its height is sunk into the ground. The top part is cylindrical, and the bottom slopes, funnel-fashion, to a point. The left-over stuff settles down into the bottom of this funnel, whence it can be removed by a pump. To keep the cornstalk mass from wadding into a solid lump, there is a second pump, which removes water from the middle of the tank and squirts it back in at the top and side when necessary thereby preventing clogging.

Prof. Buswell has done some figuring on the (*Turn to next page*)

Pan-American Highway Nearly Finished

Engineering

Less than 120 miles of roadway is all that will remain unopened at the end of 1929, of the new Pan-American highway between Laredo, Texas, and Mexico City, it is reported by the National Highway Commission of Mexico.

It is now possible to go from Laredo, via Monterey, to Ciudad Victoria, capital of Tamaulipas, and by the end of the year the road will be open to traffic, though not completed, as far as Valles, in the state of San Luis Potosi. Working north from Mexico City, the road is now open to Zimapan, state of Hidalgo, and by the end of the year, automobiles will be able to go as far as Jacala, a point farther north.

The portion between Valles and Jacala is being saved for 1930, as it is the most difficult part of the road of a very mountainous region, which will require much engineering to bring through.

South of Mexico City, the Pan-American highway goes through Puebla, a sector that is already complete, but from there on no official work has as yet been carried on. Work, however, will be begun on this southern sector in 1930. The road will lead from Puebla south to Huajuapan, and from there to the city of Oaxaca, an inaccessible region much broken up by mountains.

From Oaxaca, the road leads to Tehuantepec on the isthmus of that name, and from there to Tuxtla Gutierrez, capital of Chiapas. Then it goes to Tapachula, on the Mexican side of the Guatemala border, through a region of Chiapas but little known.

Road construction was first begun seriously in Mexico in 1925, when four state capitals, Cuernavaca, Toluca, Pachuca and Puebla, were connected with Mexico City. Because the traffic on these roads is heavy, they are largely macadamized, but it is the policy of the Road Commission to produce long mileage at low cost, until traffic is denser.

More than 1200 miles of highway have been opened to motor traffic in Mexico since 1925, and over 21,000,000 dollars have been spent. Gasoline consumption in 1928 was about 212 million liters. Although Mexico is one of the world's leading oil producing countries, gasoline prices are several times higher than in the United States.

A motor trip to Mexico will be of geographical and ethnographic value to the tourist. He will pass through deserts, rich tropical villages, semitropical towns at a medium elevation, and then as he approaches the central state of Hidalgo, he will go higher than 10,000 feet, where it is always cold and scrub pine and oak are the only trees.

He will pass through the Huasteca region of Indians that are the puzzle of anthropologists, because they are apparently related to the Maya Indians much farther south. Then in the state of Hidalgo are the Otomies, and around the region of the valley in which Mexico City lies, are the Aztecs. After Puebla comes Huajuapan, where Mixtec is spoken, and farther south near Oaxaca City there are Zapotec towns, while in the state of Chiapas are Indian groups related to the Mayas. Each of these Indian groups has largely retained its own language, though frequently in addition to the national Spanish; and the costume, too, varies as one passes from region to region.

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gas-producing possibilities of cornstalks on the average farm. He calculates that a ton of stalks will yield from ten to twenty thousand cubic feet of gas. Taking the lower figure, a ton of cornstalk would furnish gas for 400 people for one day, allowing 25 cubic feet per person per day. In the corn belt, where at least one-third of the land is always in corn, a circle 16 miles in diameter would produce enough stalks to supply a city of 80,000 inhabitants with gas.

Since cities cover a considerable area of ground themselves, the fringe of land about them that would supply their domestic gas requirements would be even narrower than eight miles. So even after the maximum use of cornstalks is attained on the present basis of gas consumption, there will still be great quantities left over. This opens up the possibilities of the development of cheap power in parts of the country not blessed with cheap water power nor underlain with beds of high-grade coal, oil or natural gas. It may be that corn itself will be one of the most potent influences tending toward an industrialization of the corn belt.

There are two other angles to the new corn-gas making process, one agricultural, the other industrial. The dreaded European corn borer spends the winter lurking in old cornstalks and stubble, emerging as a trouble-spreading adult moth only when the weather begins to warm up in the spring. But if the farmer has a good dollars-and-cents reason for clearing his fields of all the stalks he can get, either for fuel for his own house or for sale to the city gas-works, the corn borer will be out of a winter home.

The industrial advantages of the bacterial digestion of cornstalks are of promise to paper makers. Not all of the cornstalk is digested in the tank. The long, tough fibers are left, and they are apparently about as tough and strong when they come out as when they go in. Now this is exactly what the paper manufacturer wants. The short, crackly cells of the pith are more or less nuisances to him; the bacteria can have them and welcome. But the long fibers, which the bacteria do not want, can be washed, fluffed out, and then compacted into high-grade writing and print paper.

Cornstalks are not the only material that may be handled to advantage by the bacterial digestion method. One of the largest manufacturers of wall-board has already expressed his interest in the method as a possibility in the working of sugar cane bagasse, which is his raw material. Sugar cane is much like cornstalk in its structure—a thick, pith-filled grass stem with numerous fibers running through it. This manufacturer thinks that he may possibly be able to get gas for power in his factory from the pith cells, which are at present more or less in his way, and then use the power to press into wall-board the residue of the stalks from which it came.

The old boast of the Chicago packer, that "we use all of the pig except the squeal", now bids fair to be equalled by the cornstalk chemist, who will utilize all of the stalk except the rustle of its leaves.

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