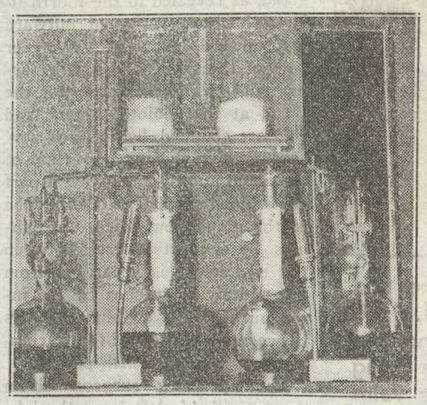
Science Puts Curb on Oxygen, Sleepless Enemy of Industry

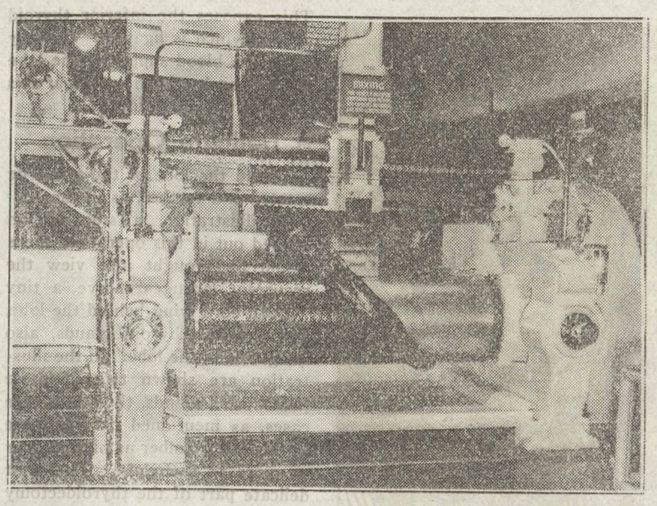
By Thomas M. Beck

THE layman seldom realizes that air is one of the chief trouble-makers in modern industry, but such is the case. As every schoolboy knows, one-fifth of its volume is oxygen, a gas most essential for life, but unfortunately a very reactive and corrosive substance. This property is the source of much that is good, but it is difficult to control. The most noticeable misbehavior of air is seen whenever a house burns down; the house is simply combining with air in a highly spectacular fashion.

However, a fire can usually be extinguished by the firemen, but there is a very slow, invisible burning going on all the time around us and destroying much that is good and useful. The grocer is reminded of it whenever soap or oil turns brown and rancid, and the druggist finds out about it when he must replace certain drugs, usually of the more expensive variety, that have deteriorated on his shelves. The chemist curses it long and bitterly whenever he finds that some rare chemical on which he has spent a great deal of labor has turned gummy and useless.



Apparatus in Chicago World's Fair exhibit showing the rubber antioxidation process.

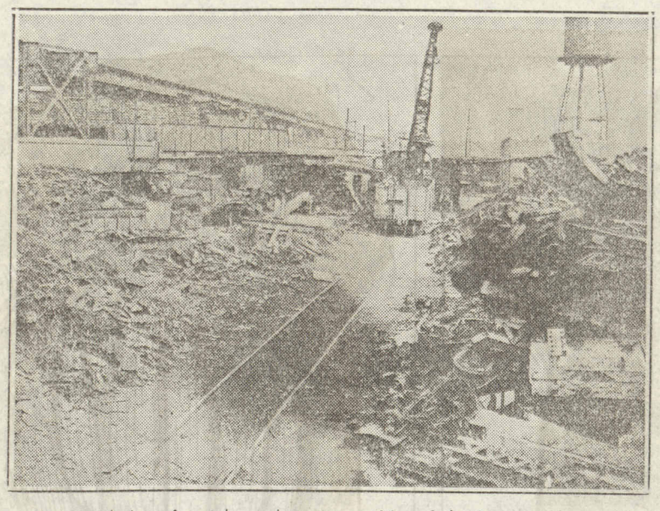


Rubber mixing machine in the World's Fair exhibit of the Firestone company. Antioxidants are added to the rubber in this process.

But it is the motor industry that is most exposed to the ravages of oxidation. Its two chief organic essentials, rubber and gasoline, are especially susceptible. Everyone knows how a rubber band that has been vacationing for some time in a corner of a desk drawer will break instead of stretch. The air is to blame for that. And gasoline is especially vulnerable these days when so much cracked gas is being used for its anti-knock properties. Prolonged exposure to air not only cuts down on the anti-knock rating of such a gasoline, but also increases the amount of damaging gums present.

There are a number of other factors that assist air in its evil work. Light is a notorious offender in this respect. And then there are certain common metals which when present even in almost infinitesimal amounts will speed up some of these oxidations enormously. For example, it is said that the mere contact of a small piece of copper with rubber during its processing will ruin the whole batch beyond salvage. But most of these factors are ones that can be kept under control. It is the air itself that remains the big trouble-maker.

The chemist's answer to this problem has been the development of substances known as antioxidants. These are certain organic compounds which, when mixed with the product, slow down the oxidation to such an extent that the life and usefulness of the commodity are increased as much as tenfold. And the surprising thing is the small amount of these antioxidants required for the job. Usually only a small fraction of a per cent is necessary. For example, one of the best antioxidants for gasoline is a white solid known as parabenzylaminophenol. If you were to stir some of it into gasoline it would sink to the bottom, and you would say that it did not dissolve. But at the refinery the crude gasoline is passed through a filter of the stuff, and it picks up enough to remain pure and sweet and powerful for a long time.



Rust—oxidation of metal—sends vast quantities of the finest products of industry to the junk heap.

There is still a lot to be found out about this problem. Most of the antioxidants have been found by a method of trial and error. The chemist cannot predict whether a certain compound or class of compounds will be any good or not. He knows that all good antioxidants are reducing agents, that is, compounds that combine with oxygen fairly readily; but it is by no means true that a good reducing agent will be a good antioxidant. In fact, some of the best reducing agents are quite useless for this purpose.

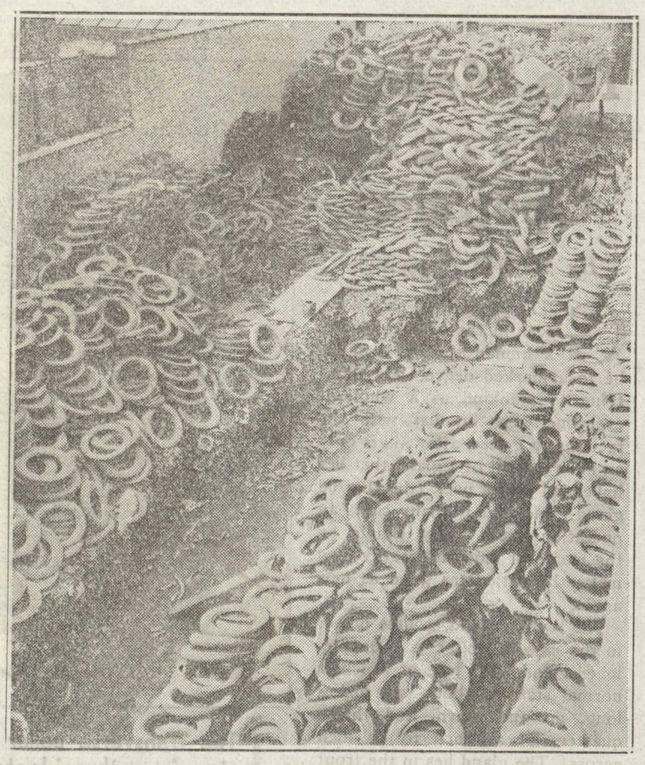
And he would be very happy if someone could tell him the way in which antioxidants act. They certainly do not act by combining with all the oxygen present; they are not present in great enough quantity to do that. Perhaps the best explanation is that most of the oxygen molecules are pretty well behaved, but that there are a very few bad actors among them, which, for want of a better term, are called activated molecules.

These activated molecules travel through the available material, for example, rubber, and whenever they collide with a rubber molecule they wreck it. In doing so the oxygen molecule replenishes its activity with some undefined sort of energy taken from the rubber molecule, and then proceeds on its way looking for more rubber. So it moves from rubber molecule to rubber molecule and at each stop renews its ferocity with its victim's life blood. But if an antioxidant be present the activated oxygen molecule soon collides with an antioxidant molecule, which either combines with it or takes the fight out of it (or, as the chemist says, deactivates it).

Yellowed newspaper clippings from a paper printed in 1902. Note the frayed edges, showing action of the air on the paper.

But while this problem is still awaiting a theoretical solution, there is a pressing need for antioxidants. So the industrial chemists have taken affairs into their own hands. They have devised a method of rating reducing power of compounds numerically, and call this value the apparent oxidation potential. They find that for a given industrial commodity there are certain upper and lower limits of apparent oxidation potential, outside of which a reducing agent will not be an antioxidant. Unfortunately, this potential is measured by a method so thoroughly unsound from the standpoint of pure science that the average thermodynamicist pales with horror at the very mention of it.

But the industrial chemists do not stop at even this. They break up the formulæ of these reducing agents and assign a fraction of the total potential to each part. Then they reassemble these parts into new formulæ and draft plans for new antioxidants. This latter procedure is even more scientifically unsound than the former. About all that the industrial chemist can offer in defense of the procedure is that it gives good results most of the time.



Among tire makers' nightmares: Not only wear, but the constant tear of chemical action.